Narragansett Bay Commission

# OF 210/213/214 Facilities

*Phase III CSO Plan: Contract IIIA-4*

*April 2020*

# BASIS OF DESIGN REPORT

## DRAFT – 30% Design
## - 60% Design

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# OF 210/213/214 Facilities

Narragansett Bay Commission

*Phase III CSO Plan: Contract IIIA-4*

# BASIS OF DESIGN REPORT

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Prepared for: STANTEC

April 2020

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# 1.0 INTRODUCTION

The Narragansett Bay Commission (NBC) embarked on a three-phase Combined Sewer Overflow (CSO) control program in 1998, aimed at lowering annual CSO volumes and reducing annual shellfish bed closures in accordance with a 1992 Consent Agreement with the Rhode Island Department of Environmental Management (RIDEM). The Phase III CSO Control Program focuses on the Bucklin Point Service Area (BPSA) in Pawtucket and Central Falls and includes the design and construction of large diameter conduits consolidating flows from the existing CSO outfalls to the proposed Pawtucket Tunnel (Stantec/Pare, CSO Control Facilities Phase III Amended Reevaluation Report; prepared for NBC, 2017).

The goal of the project (and the program as a whole) is to contain wet weather flows for a 3-month storm and limit the number of CSOs within the NBC system to no more than four CSOs for the typical year (i.e. 1951). The project facilities are designed to have capacity for the peak hourly flow from a 2-year design storm to meet the project goals.

This Basis of Design Report (BDR) presents the design criteria and approach for the Drop Shaft 213 consolidation conduits as defined in the "Phase III CSO Program, Conceptual Design for Consolidation Conduits and Regulator Modifications, Technical Memorandum, January 25, 2019". The project consolidation conduits will direct flow to the tunnel via Drop Shaft 213 (DS-213) from CSO outfalls (i.e. "overflows" or OFs) 210, 211, 213, 214, and 217.

The conduits and regulator modifications for OF-210, OF-211, OF-213, and OF-214 are the subject of this particular "Basis of Design Report" and are associated with the Contract IIIA-4 OF 210/213/214 Facilities package, as referenced in the Technical Memorandum. OF-217 is included with Contract IIIA-5 OF 217 Facilities and is therefore not addressed in this BDR.

This BDR presents the hydraulic, geotechnical and structural designs of the GSS, junction chamber, diversion structures, consolidation conduits and associated connection structures and relief operation. Drawings that accompany this BDR are included under separate cover and include plans and profiles of the consolidation conduits, structural design layouts for the diversion structures, junction chamber, gate and screening structure, and regulator modifications. A list of the Drawings is included as Appendix 1 and a list of specifications has been included as Appendix 2.

## 1.1 CONSOLIDATION CONDUITS

Consolidation conduits are relief sewers with design capacity for the peak hourly flow from a 2-year design storm. The conduits convey that wet weather flow to downstream gate and screening structures and drop shafts. Diversion structures are constructed over existing CSO pipes to direct flow to the conduits. The drop shafts bring the flow from the surface to the tunnel for storage. The consolidation conduits are designed to fully drain into the Pawtucket Tunnel (Tunnel) following each storm event. Peak flows exceeding capacity of consolidation conduits remain to flow to outfall.

### *1.1.1 ALIGNMENT*

Alignment of the consolidation conduits is driven by the location of the Tunnel drop shaft and the related upstream gate and screening structure. The site selected for Drop Shaft 213 (DS-213) is 50 Pleasant Street in Pawtucket. 50 Pleasant Street (Parcel 53-551) is the former site of the Pawtucket Masonic Temple. This Parcel is the location for DS-213 and the upstream gate and screening structure (GSS).

An upstream Junction Chamber, where consolidation conduits from the north (OF-210/211, OF-213, and OF-214) and from the south (OF-217) will converge, is proposed just east of Parcel 53-551. This Junction Chamber is positioned within the north bound travel lane of Roosevelt Avenue Ext./Taft Street with portions extending east onto City property.

Outflow from the junction structure will flow through a single 72-inch diameter consolidation conduit into the GSS before discharging to DS-213. The upstream consolidation conduit extending to the north will range in size between 48-inch and 60-inch in diameter.

The conduit alignment extending to the north, towards OF-214, OF-213 and OF-210/211, is focused on avoiding several underground utility conflicts within Roosevelt Avenue Ext. The roadway contains drainage, water, communications and a significant underground electrical infrastructure. The western side of the roadway (parking lane) is occupied by communications infrastructure. Drainage infrastructure crosses the roadway between curb lines at multiple locations, while the water main favors the roadways' north bound travel lane. A significant portion of the roadway is occupied by the electrical infrastructure originating from the Bridge Mill Power Plant (Pawtucket Substation No. 2) owned by National Grid. Pawtucket Substation No. 2 is located just north of OF-213 and is a designated historic site listed on the National Register of Historic Places by the Rhode Island Historic Preservation and Heritage Commission (RI HPHC).

The underground duct-banks that extend from the substation travel in the southerly direction and contain large electrical feeders serving the City of Pawtucket. For the most part these duct-banks meander within the roadway generally occupying the center of the roadway, the south bound travel lane and portions of the north bound travel lane. Therefore, the consolidation conduit, south of the facility, favors the eastern edge of the roadway. The alignment then transitions to the center of the roadway, north of the Substation, towards OF-210/211, which are located within the intersection of Main Street and Roosevelt Avenue Extension. The proposed conduit alignment produces an unavoidable disruption of the existing watermain for most of its length.

The conduit alignment extending to the south from the Junction Chamber along Taft Street, towards OF-217, crosses beneath the Interstate Rte. 95 and Division Street bridges. The southernmost limits of the Contract IIIA-4 OF 210/213/214 Facilities extend to a point just south of the Division Street bridge. In addition to water, drain, and the electrical infrastructure that continues beneath the bridges, the abandoned foundation for the old Route 95 bridge presents another obstacle to avoid.

### *1.1.2 CONSTRUCTION*

For the most part, it is being recommended that the consolidation conduit be constructed using traditional open-cut trenching methods, except for those locations producing more challenging and restrictive utility crossings. Trenchless construction techniques are recommended at these locations to facilitate construction and limit utility disruptions. Such proposed methods include pipe jacking (four-locations) and utility tunneling methods (one location), that incorporate various levels of hand mining.

Depths of excavation will be as great as 25-feet and will require temporary support of excavation and dewatering systems. The systems will be considered "Contractor Means and Methods" and the methods selected and their design and implementation will be the responsibility of the Contractor but may include a combination of secant piles and soldier pile and lagging. It is noted that Secant pile support of excavation systems are being required for the approach channel, gate and screening structure and Junction Chamber. Based on the subsurface investigations completed for the project (i.e. borings, test pits, etc.), excavations are anticipated to extend below the bedrock surface in three locations. Excavation of rock will be required for installing the 72-inch diameter consolidation conduit that is directly upstream and influent to the GSS, installation of the consolidation conduit and associated manhole beneath the route 95 overpass, and for the installation of the consolidation conduit and related manhole located just downstream of the OF-210/211 diversion structure in close proximity to the Roosevelt Avenue Extension and Main Street intersection.

Dewatering and efforts to control groundwater will also be required and similar to the Support of Excavation systems the dewatering systems will also be considered "Contractor Means and Methods". The dewatering systems selected and their design and implementation will be the responsibility of the Contractor and are anticipated to include wells, sumps within excavations, and ground improvement techniques, such as permeation and jet grouting. Dewatering discharges are anticipated to be directed to the sanitary sewer following treatment to remove sediments and fines. Treatment equipment may include sedimentation tanks and bag filters. Based on a review of groundwater sample analysis, contaminant levels are within the local limits discharge limit criteria for NBC's Bucklin Point, therefore additional treatment through carbon or other measures are not anticipated.

Equipment and materials staging areas will need to be identified and confirmed throughout the project. For Contract IIIA-4 OF 210/213/214 it is anticipated that the use of the Masonic Temple property (Parcel 53-551) will be fully available and maximized for this purpose. Coordination for use of additional space may also be required.

Due to the required depths of excavation, major excavation and support equipment will be required to conduct the work, especially within the roadway. Therefore, any opportunities to maintain one lane or alternating lanes of traffic through the designated construction zones will be extremely limited, if not impossible at times, especially north of Jenk's Way. In addition, it is anticipated that temporary, full road closures will be required occasionally. Prior coordination with the City of Pawtucket (i.e. police, fire, DPW, school buses, etc.) is essential and will need to be initiated and maintained during construction. Naturally maintaining access for emergency vehicles and abutting property owners should have priority.

The elimination of street parking along Roosevelt Avenue Ext., Taft Street and Jenk's Way during construction is an impact that will be required. Combined with the loss of street parking, maintaining access to private parking lots abutting the work zones will need to be coordinated with the individual property owners as a means of limiting the impact. It is understood that access to these lots may be obstructed at times when construction activities are occurring in the immediate vicinity of the entry driveways. Alternate parking sites will need to be investigated and arranged before the start of construction. Potential parking sites will be presented in the 60% design.

Pedestrian traffic will also be impacted. In general pedestrian traffic will need to be limited to the sidewalks on the western side of the roadway until construction approaches the National Grid Substation. Once construction proceeds north of the Substation, signage adjustments will be required to direct pedestrian traffic to Pleasant Street.

## 1.2 STRUCTURES

Project structures include the gate and screening structure, approach channel, junction chamber, and diversion structures at OF 210, 213 and 214. The junction chamber Is positioned upstream of the Gate and Screening Structure and combines flow from the south (OF-217 Consolidation Conduit) and from the north (OF-210, OF-13, OF-214 Consolidation Conduit). Once combined the flow enters the GSS via a 72" diameter pipe.

The GSS, approach channel, junction chamber, Diversion Structures 213 and 214 are proposed to be cast-in-place concrete, the OF-210 Diversion Structure will be precast concrete. Support of excavation systems and dewatering systems will be required for the installations. For cast-in-place structures, a proposed sequence of construction is presented to allow continued use of the outfall pipe throughout construction. Form work will be positioned around the existing pipe and the pipe will become integral to the structure until it is time to divert flow.

### *1.2.1 GATE AND SCREENING STRUCTURE*

The underground Gate and Screening Structure (GSS) will be located within Parcel 53-551 (Masonic Temple property) upstream of the proposed Drop Shaft 213. The GSS will be equipped with a manual trash rack to limit floatables from entering the tunnel. Each GSS has an influent and an effluent isolation gate located on the upstream and downstream side of the GSS, respectively. The purpose of the control gates is to isolate flow to the Pawtucket Tunnel to prevent overfilling. The gates will be operated by a central SCADA system based on the water level in the tunnel. The gates are normally in the open position. The gates are strictly isolation gates and will be equipped with hydraulic actuators. The controls for the operator will be in an above grade building positioned adjacent to the GSS.

The GSS will be designed with ladder access, however no lighting, or ventilation equipment is proposed. Mechanical equipment located within the GSS will be limited to the gates and the hydraulic cylinder for the operator. NBC will need to mobilize temporary lighting, ventilation equipment, air monitoring and personal safety equipment as required for performing a permitted confined space entry. The NBC is required to inspect and clean the trash rack after each storm event.

The GSS will be approximately 34-feet deep. It is anticipated that the excavation needed for installation of the GSS will extend below the bedrock surface, therefore rock removal will be required.

### *1.2.2 DIVERSION STRUCTURES*

Diversion Structures will be constructed at OF-210, OF-213 and OF-214. Diversions structures will be constructed within the alignment of the existing CSO pipes at each location. Due to the limited available space within the roadway, these diversion structures are proposed to be constructed in-line with the consolidation conduit.

OF-213 and OF-214 structures will contain a weir on the downstream end of the structure to divert wet weather flows to the consolidation conduit. OF-210 does not have a weir. Based on model information, the predicted hydraulic grade line at the OF-210 diversion structure will be below the invert of the outfall pipe. At each diversion structure, the existing CSO pipe will remain functional to provide system relief. Flows that overtop the diversion weir will continue to discharge through the existing outfall pipe. Flow is intended to overtop the weir when wet weather flowrates exceed the established 2-year peak hourly flow rate, when the Tunnel is full, and when the gates to the Tunnel are closed. Relief of the consolidation conduit is necessary to avoid surcharge and flooding.

A fiberglass reinforced plastic (FRP) trash rack with a 3-inch apparent opening size (AOS) will be installed above the weir at each diversion structure for floatables control. A flap gate will be installed above the weir in locations where the FEMA flood Plain elevation is greater than the weir elevation.

### *1.2.3 OF-211 Diversion Structure*

The diversion structure associated with OF-211 has been removed from the design. An alternative approach to manage the CSO is being proposed and is different than that presented in Stantec's "Phase III CSO Program, Conceptual Design for Consolidation Conduits and Regulator Modifications, Technical Memorandum, January 25, 2019".

The need for an alternative approach was driven by the number of underground utilities present in the vicinity of the proposed OF-211 diversion structure, as identified in the January 25, 2019 Technical Memorandum. Utilities include electric, telecommunication, gas and water. The size and number of conflicting utilities did not allow for placement of the proposed diversion structure at OF-211. Utiliies include drainage, multiple electric duct banks and communication duct banks. In addition to the expense associated with relocation of electric and communication utilities, there is also very electric for relocation to accommodate the new diversion structure.

The alternative approach considers modification of the OF-211 regulator. Reference is made to the adjacent photograph. The OF-211 regulator is located downstream of the OF-210 regulator and consists of a brick weir constructed within the OF-210 pipe. The proposed modifications include removal of the existing brick weir to allow full flow down the OF-210 pipe. A brick bulkhead is proposed to be constructed to plug the OF-211 pipeline to prevent it from receiving CSO flow. The OF-211 pipe will be isolated from CSO flow but will remain in service for street drainage. The proposed configuration was reviewed by the Program Modeling group and determined to be an effective solution without overflow.

Photograph of OF-210: OF-211 pipe is to the right and brick weir is the regulator

# 2.0 Project Coordination and Preliminary Investigations

## 2.1 Project Coordination

Below is a summary of project coordination that has taken place in preparation of the design to date. Coordination has taken place with the City of Pawtucket, and utility agencies.

### 2.1.1 *City of Pawtucket:*

Drainage Plan Information: The City Department of Public Works and the Engineering Department were contacted to access available roadway and drainage plans in the area.

Pawtucket Bike Path: The City of Pawtucket has a Bike Path project currently moving forward in the design stage. A portion of this Bike Path extending in the southerly direction from Main Street along Roosevelt Avenue Extension and Taft Street will be within the limits of the NBC project. As currently proposed the Bike Path's alignment primarily follows along the east side of the existing roadway and is coincident, or directly adjacent, to the alignment of the consolidation conduit for approximately 1,300 linear feet. This Bike Path is being designed as an off-road facility and as such, will require a narrowing of the existing roadway. The Bike Path's cross-section provides a 10-foot wide paved surface, that will replace the existing concrete sidewalk, combined with a buffering grass strip between the roadway curb-line and western edge of the paved path. The scope also includes installation of new street lighting and water quality features associated with applicable drainage improvements.

Pipeline construction will result in disruption of roadway surfaces, drainage infrastructure, curb-lines, sidewalks, street lighting and retaining walls. The extent to which these elements will be disturbed and replaced to match existing facilities or constructed to be incorporated into the new Bike Path, requires further consideration and coordination between the NBC and the City of Pawtucket. Coordination subjects include construction timeframes, elements and levels of disruption, cost sharing effectiveness, potential project integration, details of bike path design and other project specific elements. Contract IIIA-4 is currently progressing independent of the bike path project.

### 2.1.2 *Pawtucket Water Supply Board*

The construction of consolidation conduit and related diversion structures will impact existing Pawtucket Water Supply Board (PWSB) water mains on Main Street, as well as along Roosevelt Avenue Extension. BETA has met with the PWSB on two occasions as the design has been developed to make them aware of the project and to make sure they understood the extent of the potential impacts to their water mains.

Main Street: The existing water main was constructed in the 1940's and is 20-inch diameter cast iron pipe. Installation of the OF-210 diversion structure will require a temporary disruption of this main. PWSB has indicated that existing valves do not exist to provide an effective means to isolate the main for the construction. PWSB has recommended that an insertion valve be installed on the main just west of the proposed construction. The new valve would allow isolation of the water main in the work area for shutdown and also would allow the remaining portion of water main to remain in service throughout the construction.

Roosevelt Avenue Extension: The water main on Roosevelt Avenue Extension is a 12-inch diameter main that transitions to an 8-inch diameter main just south of Jenk's Way. Most of this water main conflicts with the proposed alignment of the consolidation conduit and will therefore need to be removed and relocated. Such replacement elements are part of the design and are generally presented on the 60%

design drawings. A temporary water main will need to be installed and maintained throughout the construction of the consolidation conduit to ensure water service is provided to adjacent properties. Further design development related to the water main improvements will be incorporated in the 90% design.

### *2.1.3 National Grid*

Electric: National Grid operates a substation located on Roosevelt Avenue Extension, referred to as Pawtucket Substation No. 2. Primary feeders that provide vital electrical service to the City of Pawtucket exist underground throughout the project limits. These feeders are contained within large duct-banks with multiple conduits.

Infrastructure information provided by National Grid was limited and did not include specific information about the Substation, nor did the drawings provided for the underground infrastructure include specifics relative to duct-bank configuration, their material or depths. Due to the number of duct-banks and the number of crossings required to install the consolidation conduit, BETA requested field investigation assistance from National Grid. National Grid indicated that only their crews were authorized to open and if necessary, enter the underground electrical structures (vaults). As a result, National Grid was commissioned to assist with field investigations of their structures within the project limits. BETA accompanied National Grid's crew and provided direction as to the type and level of information required. Photography was not allowed. Information relative to the depths and size of the structures, duct-banks and their configuration within the structures (vaults) were obtained. The overall makeup and condition of these structures appeared to vary.

A follow-up meeting with National Grid was held on February 4, 2020 to discuss required clearances from their infrastructure and the materials and construction methods historically used for their underground facilities in that area of Pawtucket. A specific inquiry was made about an electric vault located beneath the Interstate Rte. 95 bridge on Taft Street. The vault was reportedly constructed of brick and was thought to be constructed without a solid bottom. They indicated that duct-banks in the area can be expected to be constructed with unreinforced concrete and/or brick with the conduits themselves being either fiber (Orangeburg pipe) or cast-iron pipe. A field investigation was conducted by National Grid and the vault was found to have a concrete bottom, but National Grid further advised against construction beneath the vault. The design presented avoids the area beneath the structure, but crossing beneath electrical duct banks cannot be avoided. Pipe jacking is proposed in this location.

National Grid has also been contacted relative to protection of overhead wires in the vicinity of the proposed consolidation conduit. Further coordination is required at Station 3+11(s).

Gas: National Grid was contacted to obtain gas main information for the project area. Coordination related to any required gas main relocations have been through communication with Stantec. Approximately 150-ft of gas main relocation will be required on Roosevelt Avenue Ext., south of Main Street. The gas main is depicted on Sheet C-4 between Station 8+00 and 9+50.

The Gas company also provided their requirements for management of abandoned gas main. Sections of abandoned gas main will require removal to allow for construction of consolidation conduit and water main replacement. Management of abandoned gas mains requires close coordination with National Grid as the abandoned main is known to have PCB contamination. Management options for the Contractor will include contractor transportation of small quantities to a National Grid Facility or large quantities would require hiring of Clean Harbors manage the material. The cost associated with the Clean Harbors and their dumpster would be the Contractor's responsibility and National Grid would be responsible for the cleaning and disposal of the pipe material. Sections of abandoned pipe remaining in the ground would require capping and sealing. The limits of removal and the contractor requirements are incorporated into the design documents.

### *2.1.4 Cable and Communication*

Cox Communications, AT&T and Verizon were each contacted for area infrastructure information.

Verizon has provided BETA with their infrastructure information to a certain degree, however overall coordination efforts have been somewhat mixed. Although basic coordination has been completed to obtain their existing infrastructure plans, requests for follow-up meetings to discuss project specifics have been denied. Without input from Verizon, any conceptual plans for potential relocations must be designed and presented to Verizon for their review and consideration. Once that "design" is received, Verizon will develop a cost estimate to review the "design" and then submit their cost estimate for approval. No plan(s) will be reviewed without approval of their cost proposal. Verizon will not invest time and/or effort associated with the NBC's project until a design has been submitted. Relocation of communication infrastructure is not anticipated.

### *2.1.5 RIDOT*

Record information for the Interstate Rte. 95 bridge over the Seekonk River (Pawtucket Bridge No. 550) and the Division Street Bridge were obtained from the RIDOT plan room. Information relative to the location of existing and former bridge footings were transferred onto the plans and were used to identify potential conflicts.

### *2.1.6 RIPTA*

Rhode Island Public Transportation Authority (RIPTA has a major service terminal located in Pawtucket located on Roosevelt Avenue in the immediate vicinity of its intersection with Main Street. There will be significant roadway disruptions as a result of the consolidation conduit construction. Construction will also impact Roosevelt Avenue Extension and the intersection of Main Street and Roosevelt Avenue requiring roadway potential closures and detours.

RIPTA currently has nine (9) bus routes on Roosevelt Avenue, with up to 20 buses per hour traveling that route depending on the time of day. Most of the buses also have layover time at the Pawtucket service terminal.

RIPTA however has indicated that the NBC's proposed schedule, construction starting later in the 2022 calendar year, may conveniently work out for both parties based on RIPTA's current plans. RIPTA is relocating their service terminal to the new RIDOT Pawtucket/Central Falls Commuter Rail Station and Bus Hub that is being constructed at Pine Street and Goff Avenue. This design-build Contract is being administered through Rhode Works. Construction is being led by Barletta Heavy Division, Inc., and the new train station and bus hub are being constructed together. At this time, the plans are reportedly at the 100% design stage and construction has begun.

RIPTA has not fully developed the service overlay plan related to the new Pawtucket Bus Hub location, but RIPTA indicates that once the new terminal is complete the operating bus service will include one (1) designated route along Roosevelt Avenue, north of the project area, continuing east along Main Street, through the Main Street and Roosevelt Avenue intersection. The bus will run every 45 minutes.

The current RIPTA schedule for relocating to the new location is the end of 2021 with service changes anticipated for late June 2022. Continued coordination with RIPTA is required as both project timelines advance. Update to the status and consideration for provisions will be incorporated into the 90% design submission. Traffic management plans will also reflect provisions as required.

## 2.2 Survey

Survey for the project was completed by Bryant Engineering, Inc. (as a Subconsultant to BETA) in accordance with the following datum:

Horizontal Datum: RI State Plane Coordinate System (NAD '83)
Vertical Datum: National Geodetic Vertical Datum 1929 (NGVD 29)

The survey included topographic survey, location of edges of vegetation, wetland flagging, visible utility covers and inverts for drain and sewer pipes.

## 2.3 Geotechnical

This section presents a high-level overview of the subsurface conditions in the vicinity of the Project and the geotechnical investigations performed.

### *2.3.1 Geologic Setting*

The Project is in the New England physiographic province of the Appalachian Highland physiographic division, lying within the Seaboard lowland section (Denny 1982). The physiographic area is referred to as the Narragansett Basin, the result of a complex sequence of a combination of geosynclinal sedimentation, volcanism, plutonism, and erosion (Quinn 1971). The basin is made up of several thousand feet of non-marine sedimentary rock that has been folded, faulted, and slightly to moderately metamorphosed.

The geologic history of the proposed project area is one of weathering, erosion, and deposition. Periods of glaciation have shaped much of the visible landscape and the Project area is characterized by the adjacent river valley. Glacial and post glacial deposits dominate the landscape and generally consist of stratified layers of sand, silt, gravel, cobbles and boulders.

Drainage in the area is by the Blackstone River/Seekonk River, which trends north to south.

### *2.3.2 Topography and Land Use*

The topography in the area is the result of a long and complex history of glaciation and site filling, which has had an influence on the current site and subsurface conditions. The topography is generally rolling to flat, with less than 200 feet of relief, sloping towards the east. The ground surface along the Project alignment varies from about El. 35 to El. 12 feet, sloping gradually towards the south. The bedrock surface topography is irregular and is expected to range from about 10 feet to 30 feet below existing grade with the highest rock in the area beneath the Interstate (I-95) Highway.

Land use along the Project alignment appears to be generally commercial. It is anticipated that the structures along the Project alignment are founded on spread footings bearing on the Glacial deposits.

### *2.3.3 Geotechnical Investigations*

A geotechnical investigation program, consisting of borings and groundwater monitoring has been completed to obtain information on the subsurface conditions for the Project. The geotechnical investigation program has been augmented by a laboratory testing program. The objective of these programs was to provide an interpretation of the ground and groundwater expected to be encountered during construction of the Project's consolidation conduits, shafts, and near-surface structures. This information will be used by BETA's Design Team to design the underground elements of the Project, and by the contractor to plan, price, and schedule the work. A summary of the subsurface exploration program completed for this project is included as Table 3-1. A figure depicting the approximate locations of the borings is provided below.

Table 2-1 Summary of Subsurface Exploration Program

| Test Boring Designation | Total Depth (ft) | Depth Drilled in Soil (ft) | Depth Drilled in Rock (ft) | No. of Split Spoon Samples | No. of Rock Cores | Observation Wells |
|---|---|---|---|---|---|---|
| B-4A (2) | 8.9 | 8.9 | n/e3 | 5 | 0 | 0 |
| B-4B (2) | 10.0 | 10.0 | n/e | 1 | 0 | 0 |
| B-4C | 35.0 | 29.5 | 5.5 | 5 | 1 | 1 |
| B-5 | 35.0 | 26.0 | 9.0 | 9 | 2 | 0 |
| B-6 (2) | 4.0 | 4.0 | n/e | 2 | 0 | 0 |
| B-6A (1) | 31.0 | 26.0 | 5.0 | 6 | 1 | 0 |
| B-7 | 29.2 | 29.2 | n/e | 10 | 0 | 1 |
| B-8(1) | 25.0 | 16.0 | 9.0 | 4 | 2 | 0 |

Notes
1. Refer to 60% Design Plans for the location of test borings.
2. Test borings B-6A, and B-8 were vacuum excavated to a depth of 6 feet below the existing ground surface.
3. Test borings B-4A, B-4B, and B-6 encountered obstructions and were terminated before reaching the planned total depth.

Details of the procedures used for conducting the field work and laboratory testing, and the factual results are summarized in the report found in Appendix 3*. Geotechnical Data Report (GDR), NBC Phase III CSO Program, Consolidation Conduits IIIA-4 and IIIA-5, McMillen Jacobs Associates, Burlington, Massachusetts*, dated 10 April 2020.

In addition to the new data being collected by BETA's Design Team, a geotechnical investigation program was completed for a planning-level geotechnical study of the Project (Stantec and Pare 2019). Data from that study were incorporated into the interpretation of the ground conditions in the Project area and were used to plan this geotechnical exploration program. Existing data relevant to the Project alignment is included in the GDR.

## 2.4 Test Pits

Test pits were completed in December 2020 to further identify existing utility locations within the project area and the subsurface conditions behind the retaining wall near the intersection of Jenks Way and Taft Street. Test pits associated with existing utility identification were completed with vacuum excavation excavation techniques to obtain information relative to the vertical elevation (both top and bottom) of the identified existing utility, consistent with a Quality Level "A" investigation as defined in ASCE 38-02 *Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data.*

Traditional test pits were completed to obtain information relative to the existing retaining wall. A mini excavator was utilized for this task with vacuum excavation assistance. The test pits associated with the retaining wall were completed to evaluate the existing wall limits and construction. BETA conducted a field assessment of the wall in February 2020 and test pits were recommended at that time.

A summary of the test pits, including the approximate station, the utility to be located (if applicable), and the purpose for each test pit, is presented in Table 2-2. Results of the test pits are incorporated into the design drawings.

TABLE 2-2 TEST PIT SUMMARY

| Test Pit Designation | Approximate Station | Utility | Purpose for Test Pit |
|---|---|---|---|
| TP-1 | 0+50 | Electric Duct Bank (24-5") | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed water main relocation. |
| TP-2 | 5+40 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed water main relocation. |
| TP-3 | 5+60 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed water main relocation. |
| TP-4 | 5+85 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed consolidation conduit to be installed by pipe jacking. |
| TP-5 | 6+30 | Electric Duct Bank / Water Main | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed consolidation conduit to be installed by pipe jacking. Confirm depth of water main at this location. Records indicate that the water main is unusually deep (~10' deep) in this area. |
| TP-6 | 6+95 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed consolidation conduit. |
| TP-7 | 7+05 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed consolidation conduit. |
| TP-8 | 9+80 | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed consolidation conduit to be installed by pipe jacking. Existing ductbank appears to be located beneath an existing telephone duct bank. |
| TP-9 | 1+50 (S) | Electric Duct Bank | Confirm depth (top and bottom) of duct bank in the vicinity of the proposed water main relocation. |
| TP-10 | 4+10 (S) | Electric Manhole | Confirm location and depth of electrical manhole closest to the proposed consolidation conduit to be installed by pipe jacking. |
| TP-11 | 0+10 (S) | None (Retaining Wall) | Evaluate construction of retaining wall and former building foundation near the Junction Chamber. |
| TP-12 | 2+60 | None (Retaining Wall) | Evaluate construction of retaining wall near OF-214 Diversion Structure. |
| TP-13 | 4+50 | Outfall | Evaluate subsurface conditions in the vicinity of OF-213 Diversion Structure. Prior attempts to obtain subsurface data by soil boring were unsuccessful due to obstruction(s). |

# 3.0 DESIGN CRITERIA

This section presents the overall Design Criteria for the project to achieve the desired program goals. In addition it provides a discussion relative to different construction methods that will be employed in the construction of the new OF-210/213 and 214 facilities considering geotechnical factors associated with the existing geologic conditions.

## 3.1 HYDRAULICS

A hydraulic analysis of localized level of service (LOS) has been assessed, by the Program Manager (Stantec), using the BPSA InfoWorks Integrated Catchment Model (ICM) software, calibrated through December 2017. Hydraulic grade lines (HGL) were developed for the 2-year design storm. The model estimates and the resulting hydraulic grade lines are the basis for the consolidation conduit design criteria.

Based on an evaluation of the design by the Program Manager, estimated peak flow rates for Contract IIIA-4 are greater than those presented in the Conceptual Design Technical Memorandum. The difference in the rates is a result of a change in the position of the project diversion structures, which allows more street drainage to enter the system, and a proposed plan to eliminate the OF-211 Diversion Structure and manage the wet weather flow in a different manner. The need for an alternate approach for OF-211 was driven by the number of conflicting underground utilities present in the vicinity of the proposed OF-211 diversion structure. These utilities include electric, telecommunication, gas and water. The size, number and configuration of these utilities did not allow for relocation to accommodate the new diversion structure.

The alternate approach considers elimination of the OF-211 Diversion Structure and modifications to the OF-211 Regulator. The regulator for OF-211 is downstream of the OF-210 regulator and consists of a brick weir within the OF-210 pipe. The proposed modifications include removal of the existing brick weir and repositioning it at the influent to the OF-211 pipe such that OF-210 will be the primary flow path. The height of the weir in front of OF-211 will be set to achieve the overall project goals of limiting the number of CSOs within the NBC system to four CSOs per year. Based on modeling results the height of the weir will be set near the crown of the OF-210 pipe.

A comparison between peak flow information presented in the Conceptual Design Technical Memorandum and from model information that considers the alternate configuration is presented in Table 4-1 below. Peak flow values representing the alternate configuration are listed in the table below the heading for ICM Results. ICM Results is included as Appendix 4.

Table 3-1 Design Peak Flow Information

| Location | Peak Hour Flow (MGD) | |
|---|---|---|
| | Conceptual Design | ICM Results |
| OF-210/211 | 39.9 | 52 |
| OF-210/211/213 | 54.5 | 64 |
| OF-214 | 82.1 | 91 |

The horizontal alignment and profile of the consolidation conduit were developed to achieve the specified hydraulic requirements. The Table below summarizes the design capacity and the required minimum slopes for the consolidation conduit as provided by the Program Manager. Peak hourly flow is presented as the peak hourly flow discharging from the structure.

Table 3-2 Consolidation Conduit Summary and Design Peak Flow

| Diversion Structure / Junction Chamber | | Peak Hourly Flow | Consolidation Conduit | | | | Overflow Pipe |
|---|---|---|---|---|---|---|---|
| | Weir Elevation | 2-year | Size | Min Slope | Capacity | Velocity | Size |
| | ft | (MGD) | (in) | ft/ft | MGD | FPS | (in) |
| OF-210 | 23 | 63.4 | 48 | .0047 | 63.8 | 7.9 | 48 |
| OF-213 | 10 | 83.2 | 54 | .0043 | 83.2 | 8.1 | 42 |
| OF-214 | 9.7 | 116.2 | 60 | .0048 | 116.2 | 9.2 | 54 (*) |
| OF-217 | 10.7 | 39 | 48 | .0018 | 39.5 | 4.9 | 42 |
| Junction Chamber | NA | 155.2 | 72 | .0032 | 155.7 | 8.5 | NA |

(*) OF-214 outfall upgraded from 30-inch to 54-inch

Consolidation Conduit sizes were presented in the "Phase III CSO Program, Conceptual Design for Consolidation Conduit and Regulator Modifications – Technical Memorandum". The sizes down stream of OF-213 and OF-214 have been modified based on predicted peak flows from hydraulic modeling conducted by the Program Manager. The hydraulic modeling reflects the current alignment presented in the 60% design drawings. Pipe sizes were determined based on the Manning Equation and Calculations are provided in Appendix 5. The minimum slope presented considers gravity flow without surcharging, thereby achieving the project goals The pipeline profile presented in the design documents takes into consideration minimum slopes, existing topography, and utility clearances and are adjusted accordingly.

Additional considerations incorporated into the design of the consolidation conduit system include:

- Manholes are designed with minimum 0.1-foot elevation difference between inlet and outlet pipes
- Manholes are spaced every 300 - 500 feet and at changes in alignment

Conduits and structures conveying the 2-year Peak hourly flow at a velocity of 10 fps or greater will require special design consideration for protection against displacement by erosion and impact. Manhole and pipe lining will be considerations for protection against scour and manhole anchoring will be considered for protection against displacement.

## 3.2 Geotechnical Considerations

This section presents an overview of the subsurface conditions in the Project area. This information is based on the subsurface investigation programs described above. Interpreted subsurface conditions and preliminary soil and rock engineering parameters will be provided in the Geotechnical Design Summary Report (GDSR).

### *3.2.1 Subsurface Conditions*

The subsurface materials in the Project area are anticipated to consist of the following geologic units from top downward (i.e., from youngest to oldest):

- Fill
- Glacial Deposits
- Bedrock

All geology units may not be encountered at all locations along the Project alignment.

The Fill consists of variable composition, uncontrolled man-made materials and other construction debris. The nature, quality, and thickness of the fill is expected to vary and includes granular soil with fragments of glass, brick, and concrete.

Glacial Deposits lie directly over the bedrock and is variable in nature due to the complex process of deposition either by retreating glaciers (glaciofluvial/outwash) or directly beneath the glacial ice (lodgment till). The Glacial Deposits consist of a medium dense to very dense, unsorted mix of sand and gravel and includes occurrences of cobbles, boulders and rock fragments from the underlying bedrock.

The bedrock consists of the Rhode Island Formation of the Narragansett Bay Group. The Rhode Island Formation consists of predominantly sandstone with lessor amounts of conglomerate sandstone and siltstone. Minor occurrences of mudstone, shale, and coal are also present along with discontinuous short intervals of the Wamsutta Formation at shallow depths which appear as dark red in color. The bedrock is generally described as strong, slightly weathered to fresh, sandstone to siltstone, laminated, with joints ranging from 20 degrees to 50 degrees from the horizontal. Quartz filled fractures are common. Evidence of faulting in the wider area is present but not expected along this Project alignment.

### *3.2.2 Preliminary Soil and Rock Engineering Properties*

Soil and rock engineering parameters will be determined based on the results of empirical correlations to standard penetration testing, laboratory index test results, and engineering judgment. The geotechnical design parameters needed by the Design Team to complete their work will be provided in the GDSR. The geotechnical data required by the contractor will be provided in the Geotechnical Data Report (GDR).

## 3.3 Trenchless Construction

The current plan is to install five (5) consolidation conduits along the Phase IIIA-4 alignment using trenchless construction methods. Trenchless methods result in less disruption and are cost effective beyond a certain depth of installation.

In selecting trenchless methods for this project, special considerations were focused on line and grade requirements, depth of installation, pipe size, installation lengths, presence of glacial soils and bedrock, groundwater table above pipe invert, ground cover, impacts to adjacent structures and managing surface disruptions.

The following trenchless methods were evaluated and considered for their technical feasibility on this project and a summary is provided in Table 4-3:

- Conventional Pipe Jacking
- Utility Tunneling

Table 3-3 Trenchless Summary for Consolidation Conduits IIIA-4

| Trenchless Crossing No. | Location | Trenchless Method | Nominal Diameter of Pipe (inches) | Approximate Length (ft) | Approximate Depth to Invert (ft) |
|---|---|---|---|---|---|
| TC-1a | Sta. 2+85 (S) to 3+11 (S) | Conventional Pipe Jacking | 48 | 27 | 18 |
| TC-1b | Sta. 3+11 (S) to 5+27 (S) | Conventional Pipe Jacking | 48 | 215 | 18 |
| TC-2 | JC to G&SS | Utility Tunneling | 72 | 53 | 32 |
| TC-3 | Sta. 5+31 to 6+36 | Conventional Pipe Jacking | 48 | 105 | 18 |
| TC-4 | Sta. 9+50 to 10+23 | Conventional Pipe Jacking | 48 | 72 | 15 |

### *3.3.1 Conventional Pipe Jacking*

Conventional Pipe jacking (PJ) consists of advancing pipe through the ground with thrust provided by hydraulic jacks and excavation of soil at the front of the pipe string either manually or mechanically. The process requires personnel entry into the pipe being jacked to operate excavation equipment. The excavation method can vary from a very basic process of hand excavation (such spades and shovels) to excavation using mechanical digging arms. Pipe jacking is typically limited to lengths less than 500-feet.

Regardless of the excavation method, it is usually accomplished inside of a shield attached to the leading section of pipe. The purpose of the shield is to provide a safe working environment for the workers and allow the bore to stay open during the excavation process for the pipe to be jacked into place. Pipe jacking is done with pipes 48-inches in diameter and larger which accommodates worker entry. Pipe jacking is typically used in soil types with low permeability and good stand-up time, or in soils that have been dewatered or otherwise pre-stabilized by ground improvement methods such as grouting.

Control of line and grade is maintained with the use of an optical or laser guidance system and shield jacks for steering corrections.

The process requires a simple, cyclic procedure for installing individual sections of pipe, then jacking the pipe forward by utilizing hydraulic jacks reacting against the back wall of the jacking pit. In unstable ground conditions, the face is excavated simultaneously with the jacking operation. In stable ground conditions, excavation may be advanced slightly ahead of the jacking process. The excavated spoil is removed through the inside of the pipe, typically with small carts, to the jacking pit. The typical components are shown below.

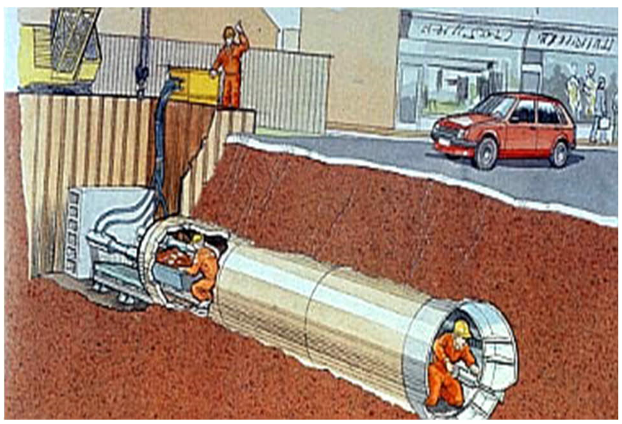


Figure 3-1: Conventional Pipe Jacking

The jacked pipe can either be a temporary casing or the product pipe. If the product pipe is jacked directly, it needs to be designed to handle the pipe jacking loads without damage. Directly jacking the product pipe is usually more economical than jacking a temporary casing pipe and installing the product pipe later due to the larger excavation size and annular backfill grouting requirement. It is recommended that direct jacking of the product pipe be considered for this project.

The friction force between the ground and the shield and pipe can be reduced by the injection of bentonite, or other lubricating fluid, into the annular space between the jacking pipe and the ground. If the shield and pipe annulus is sealed, the friction force can be reduced further by pressurizing the bentonite in the annulus to reduce the amount of closure due to unstable soils.

Face stabilization is used to minimize flowing ground behavior encountered below the groundwater table and raveling ground behavior above the groundwater table. Face stabilization for conventional pipe jacking typically consist of direct support of the face with breasting boards, doors, or sand shelves when needed. Obstructions are readily accessible due to the openness of the shield and mobility of the excavation tools. The need for face stabilization will be evaluated for the 60% design submission along with the benefits of soil modification techniques.

PJ requires that a jacking pit and receiving pit be excavated at either end of the casing to be installed. Staging area requirements at the jacking pit are relatively limited, with plant and equipment generally consisting of a small crane, front end loader, spoil storage area and stockpiled casing pipe segments. The jacking pit for PJ is generally at least 15-feet long and is generally governed by the length of pipe (casing) sections to be jacked. Receiving pits can be somewhat smaller and must be large enough to remove the PJ shield.

### *3.3.2 Utility Tunneling*

Utility tunneling (UT) is like conventional pipe jacking discussed above with the primary difference being the tunnel lining techniques. In all pipe jacking methods, the jacked pipe supports the ground during the excavation. In UT, ground supports consisting of prefabricated steel or concrete liner plates, or steel ribs and wood lagging systems are installed incrementally as the excavation advances. The lining is installed in the tunneling shield near the tunnel face as the soil is removed and the tunneling shield advances and forms a continuous support of the exposed soil. The typical components of utility tunneling are shown below.

Figure 3-2: Utility Tunneling Components

There are two basic lining system used for UT: two-pass and one-pass. A two-pass lining system is one in which an initial lining is placed as the tunnel is excavated and the final lining is placed later, typically after tunnel excavation is completed. For the ground conditions anticipated for this project, the most likely initial lining type would be steel ribs and lagging or steel liner plate. The final tunnel lining will consist of reinforced concrete pipe (RCP). A one-pass lining system is one in which the permanent lining is installed as the tunnel is excavated. The permanent lining typically consists of bolted and gasketed pre-cast concrete segments that are erected to form a ring within the tunneling shield. Use of one-pass lining systems is typically limited to tunnels 8 to 10 feet in diameter or larger.

The line and grade guidance systems to be used are like those for conventional pipe jacking. Steering control is accomplished during the soil excavation and shield advancing process. The tunneling shield is usually equipped with jacking cylinders at its rear portion, which propel the shield forward by jacking against the already erected liner sections as the face excavation proceeds. In addition to propelling the shield forward the jacks are used to steer the shield thereby enabling alignment change or correction if required.

### *3.3.3 Pipe Material*

Pipe Material for the Contract IIIA-4 consolidation conduit will be reinforced concrete pipe. Reinforced concrete pipe (RCP) is a durable, structurally sound pipe material and will be specified to be a watertight application. Class V RCP will be specified for open cut construction and the jacking pipe.

Concrete pipe is ideally suited for jacking as it can withstand the forces required to advance the pipe into position while providing a complete tunnel liner for protection of workers and equipment. The jacking pipe will be designed to be installed without a casing pipe, thereby eliminating the cost and additional time needed to first jack a casing pipe in place, and then install the carrier pipe.

RCP will meet the following standards:

- ASTM C-76 Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
- ASTM C443, Specification for Joints for Circular Concrete Culvert and Sewer Pipe, Using Rubber Gaskets.
- ASTM C497, Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
- ASTM C1628, Specification for flexible leak resistant joints for gravity flow sewer pipe using rubber gaskets when measurable or defined infiltration or exfiltration is a factor (joint spec)
- AASHTO M-170 Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.

The type of rubber gasketed joint type will be coordinated between the pipe jacking contractor and the pipe supplier. There is wide variation in joint dimensions and gasket cross section that are in conformity with ASTM C 443. The joint configuration presented below is primarily intended for use with pipe manufactured to meet the requirements of ASTM C-14 or ASTM C-76 and used with tongue and groove pipe.

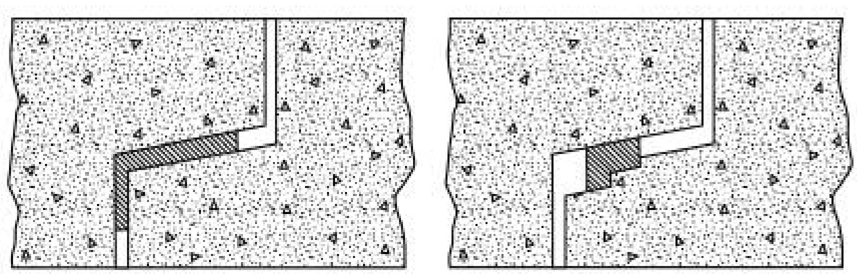


Figure 3-3: Basic Compression Type Rubber Gasket Joint

Steel bell and spigot rings with a groove on the spigot for an O-ring rubber gasket, is the preferred option for this application. Basically, a high-pressure joint designed for sewers where infiltration or exfiltration is a factor in the design. This type of joint is the least subject to damage during installation.

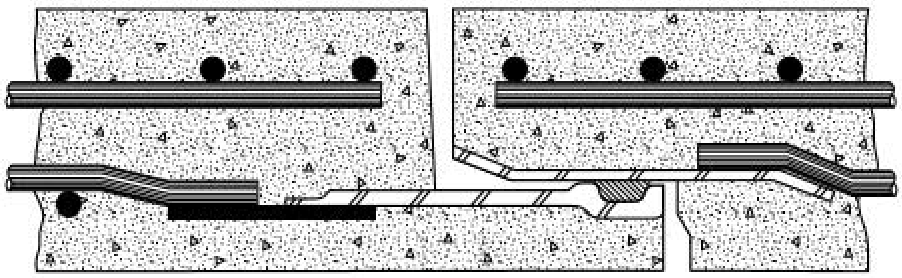


Figure 3-4: Steel End Ring Joint with Spigot Groove and O-Ring gasket

## 3.4 SHAFTS

Earth support systems for construction of the GSS, approach channel and Junction Chamber (JC) will be provided by a secant pile wall with piles drilled-into sound rock for water tightness. Depending on the rock quality at the base, permeation grouting may be required to create a plug to cut-off water inflows. Pumping from sumps within the excavation may be necessary to install the permanent structure. Secondary secant piles will be reinforced with steel beams allowing the wall to span vertically. Primary secant piles will be designed as lagging between the secondaries in accordance with ACI 318.

The excavation support system will be internally braced with steel struts and walers. Bracing levels should be kept to a minimum to maximize efficiency when constructing the GSS, approach channel and JC. The excavation support system is intended to act as a blind form for installing the GSS and JC, therefore, the design will need to consider installation tolerances to ensure complete build-out of the permanent structure as intended by design. Maximum installation tolerances of 1" within in-plan design location and 1% out-of-verticality are recommended to ensure contact between adjacent piles for water cut-off. Steel beams, struts and walers are to be designed in accordance with AISC 360 ASD.

Limit Equilibrium Method using appropriate apparent at-rest earth pressure diagrams derived from effective at-rest pressures based on soil parameters from the GDSR, will be used to design the excavation support system for strength. Lateral loads to be considered in the design include earth, groundwater and construction surcharge based on a vertical surface load of 600-psf. The design should also consider temperature effects where applicable. To limit surface settlement and protect adjacent structures, nonlinear analysis using beams on elastoplastic Winkler springs will be performed to check and limit lateral displacements to the larger of ½" and 0.0025H, where H is the depth of excavation.

Permeation grouting is to be performed in-advance of utility tunneling between the GSS and JC excavation support systems to improve strength and provide water cut-off. The utility tunneling will be excavated by hand methods and supported using steel liner plates spanning between steel ribs (the annulus between the support system and excavation will be contact grouted to ensure full support by the ground). It is anticipated the mined tunnel will require a diameter of 10-feet minimum to accommodate installation of the 72" RCP carrier pipe. The zone of improved ground will likely be 20-feet in diameter. A mixed face of both soil and bedrock is expected and will require removal by mechanical means.

Design and execution of secant pile shafts shall meet the above criteria and will be the responsibility of the Contractor.

### 3.5 Open-Cut

Temporary earth support for installation of cast-in-place diversion chambers, precast manholes and RCP consolidation conduits and outlet pipes, will be required and the methods selected along with their design and execution will be the responsibility of the Contractor.

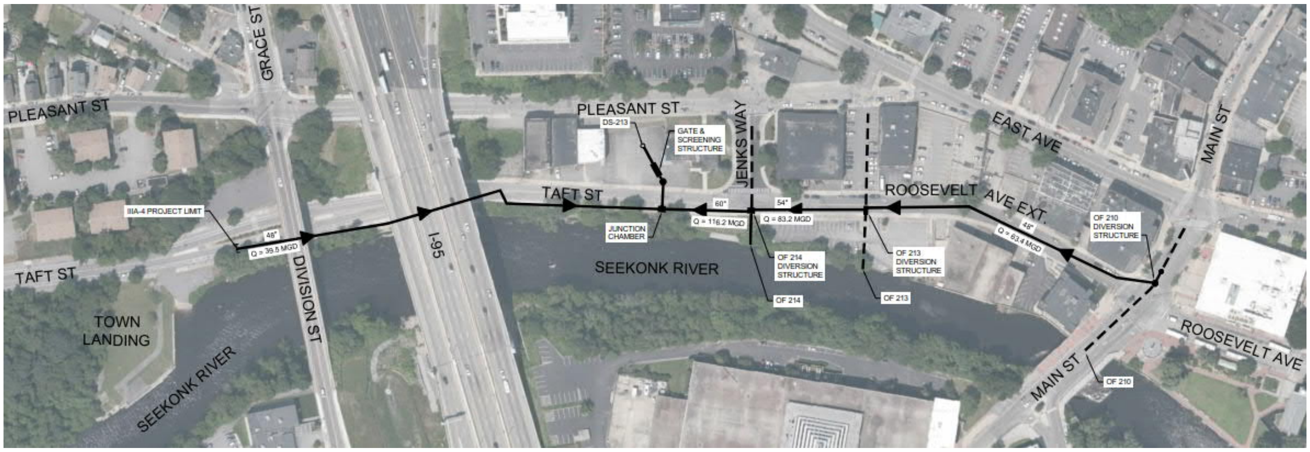
Active site de-watering will be necessary to install structures and consolidation conduit. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable limits as dictated by the utility owner. Specifications and contractor requirements have been developed but methods selected along with their design and execution will be the responsibility of the Contractor.

The excavation support systems should be designed to consider pile toe embedment, apparent earth pressures, maximum lateral earth pressures, and temperature effects. System should be designed to limit surface settlement and protect adjacent structures, and should be designed with sufficient space to accommodate installation of the permanent concrete structures and RCP carrier pipe. The excavation width for the consolidation conduit and outlet pipe should be 3-feet wider than the outside diameter of the RCP carrier pipe. The excavation width for precast manholes should be 3-feet wider than the manhole base diameter.

## 4.0 Consolidation Conduit

The OF-210/213/214 consolidation conduits will extend between Main Street, at the intersection with Roosevelt Avenue Extension, to the new tunnel drop shaft, DS-213. The new drop shaft is to be located in the parking lot of the former Masonic Temple property, south of Jenk's Way, and is to be constructed as part of the Tunnel Contract. The scope of this project also includes construction of a portion of the OF-217 consolidation conduit that extends between the Masonic Temple property to just south of the Division Street Bridge on Taft Street.

Flow will be diverted from the CSO pipes, OF-210,213 and 214, to the consolidation conduit with the construction of diversion structures over each location. The OF-210 consolidation conduit will flow into the OF-213 consolidation conduit and then into the OF-214 consolidation conduit where it will combine with flow from the OF-217 consolidation conduit, within a junction chamber. Flow will then exit the junction chamber into a 72-inch consolidation conduit and flow to the gate and screening structure prior to discharge to DS-213. A figure depicting a general layout of the consolidation conduit is presented below.




## 4.1 Gate and Screening Structure to Junction Chamber

The consolidation conduit between the Gate and Screening Structure (GSS) and the Junction Chamber (JC) receives flow from OF-210, OF-213, OF-214 from the north and OF-217 from the south. The 72-inch diameter consolidation conduit is approximately 60-feet long, is designed to convey a peak flow of approximately 155 MGD, and has a slope of 0.0056 ft/ft. The consolidation conduit runs east to west perpendicular to Taft Street, just south of Jenk's Way, to a 12-foot diameter alignment manhole and then to the GSS location, both located within Parcel 53-551. The Parcel was formerly the location of the Jenks Masonic Lodge. The identified location for Tunnel Drop Shaft 213 (to be designed and constructed by others) is also located within Parcel 53-551.

### *4.1.1 Construction Considerations*

<u>Site and Subsurface Conditions</u>

Several other alternative locations and configurations for Drop Shaft 213, GSS and JC were reviewed in the early design stages. One of the original configurations (presented in the Conceptual Design Report) considered having the Drop Shaft 213 and GSS located on Jenks' Way. This configuration and location combined with the associated consolidation conduit alignments required significant disruption of the existing underground communications and electric infrastructure. As a result, this option was discounted. Drop shaft locations were also considered to be in the vicinity of the City's Town Landing property (along Taft Street, south of the Division Street bridge), as well as several different configurations on the former Masonic Lodge property. The location presented on the 60% design drawings have been reviewed by the NBC and Stantec.

The horizontal and vertical alignment for the junction chamber, consolidation conduit between the junction chamber and GSS was developed with Computational Fluid Dynamic (CFD) modeling prepared by Stantec. The consolidation conduit exiting the junction chamber is positioned perpendicular to Taft Street with the downstream end located at a 12 -foot diameter manhole to provide an alignment adjustment prior to entry into the GSS that allows a direct flow path through the GSS. The vertical alignment for the consolidation conduit was set such that the crown matches the crown of the 48-inch pipe conveying flow from OF-217. The approximate depth is between 32 and 34-feet below existing grade.

Encountered subsurface conditions along the alignment are anticipated to be soil and bedrock. At the GSS, bedrock is anticipated and consists of strong, gray Sandstone. Towards the JC, bedrock appears to drop below the invert of the 72-inch diameter pipe to Glacial Deposits that consist of very dense, coarse to fine gravel with varying amounts of sand and silt are anticipated above top of bedrock along the alignment. Observed groundwater levels range from about 10 to 20-feet below the existing ground surface, sloping downward towards the JC and the River.

Based on review of the 1884 historical plan information, waterfront buildings once occupied the area between the Division Street Bridge and Jenk's Way on the east side of Taft Street. The information predates construction of Jenk's Way, Roosevelt Avenue Extension and Interstate Rte. 95. There are currently no existing buildings in this area however it is uncertain if remnants of old foundations still exist. During the advancement of Test Boring B-4, concrete was encountered at approximately 8-feet below ground surface. The test boring was relocated twice due to concrete being encountered. Utility information was reviewed but there was no evidence of utilities in the area. It appears the test boring is in the general footprint of a former building. The driller was able to advance the boring through the concrete and achieve the required depth. No further investigation for the presence of a foundation has been completed. The approximate locations of the building footprints have been outlined on the design drawings and will be further identified for removal during construction.

Utility Relocation and Coordination

The consolidation conduit will cross beneath a duct-bank with twenty-four (24), 5-inch conduits, a primary component of the City's electrical infrastructure. The duct-bank is reportedly unreinforced concrete with the interior conduits being either fiber conduit (Orangeburg pipe) or cast-iron pipe. The consolidation conduit is anticipated to be approximately 10 to 15-feet below the duct-bank. National Grid has reviewed the 30-percent design and have requested that coordination continue as the design advances, and their requirements and protective measures will be incorporated into the design.

The consolidation conduit also crosses a 12-inch diameter steel gas main identified by National Grid as being abandoned. BETA continues to coordinate this crossing with National Grid who has indicated that, if necessary, the abandoned gas main may be removed as part of the NBC's construction contract. Requirements for removal and abandonment of gas main has been provided by National Grid.

The consolidation conduit also crosses a communications duct-bank containing four (4) 4-inch conduits which are reportedly empty. Inquiries were made with Verizon, as to whether the duct-bank may be removed, but the inquiry remains unanswered. At this time, removal of the duct bank is not required.

The consolidation conduit also crosses an 8-inch cast iron water main within the footprint of the Junction Chamber. BETA coordinated with the Pawtucket Water Supply Board (PWSB) and proposed to temporarily bypass the water main during construction to maintain water service. Upon completion of the consolidation conduit and diversion structure construction a new water main would then be installed as part of the NBC contract. PWSB reviewed and took no exception to the proposed water main relocation plans. The plans are included with the 60% design submission.

Protection of Adjacent Structures

The stone retaining wall adjacent to the Seekonk River will require continuous monitoring and protection during construction of the Junction Chamber (JC), Diversion Structure 214, and connecting segments of the consolidation conduit. It is anticipated that some wall damage may occur due to the depth of the utility and associated construction vibrations, however it will be important to maintain stability during construction. The Contractor will be directed to employ methods to fortify the wall prior to construction and complete construction utilizing techniques to manage loading, and vibrations experienced by the wall.

### 4.1.2 RECOMMENDED INSTALLATION METHODS

Open-cut and trenchless construction techniques were considered for the installation of the consolidation conduit between the GSS and JC with trenchless techniques being selected as the preferred installation method. Constructability challenges uniquely identified for conventional open-cut construction include the unknown condition of the existing underground electric utilities, the ability to adequately support the unreinforced concrete duct-banks, and the required excavation support given the anticipated depth of construction. Groundwater management is a constructability challenge for both open-cut and trenchless techniques.

Trenchless construction of the consolidation conduit mitigates potential impacts to the existing electrical utilities. Trenchless installation will be conducted from the temporary excavations prepared for the GSS and JC structures.

Two trenchless construction techniques were considered – pipe jacking and utility tunneling: both with spoils removal by hand mining. Utility tunneling is recommended given the relatively short reach (approximately 70-feet), ability to excavate mixed soil and bedrock conditions, and the versatility of conducting mining operations from within the JC and GSS excavations. Ground improvement methods, such as jet grouting, is proposed to manage groundwater along this relatively short reach. The modified ground would enable mining operations being conducted in stable conditions. It is anticipated that the ground improvements will occur following the construction of the excavation support systems for the GSS and JC. Ground improvement would take place from the ground surface. If deemed necessary supplemented improvements could be conducted from within the face of the tunnel.

Excavation support for the construction of the GSS, approach channel and JC will consist of a secant pile wall system socketed into bedrock to create an effective groundwater cut-off. Additional management of groundwater within the excavation shafts will consist of localized sumps. Further discussion regarding structure construction is included in Section 6.

## 4.2 JUNCTION CHAMBER TO PROJECT LIMITS (SOUTH)

The consolidation conduit between the Junction Chamber and the southern-most limits of Contract IIIA-4, will receive flow from OF-217. The Contract IIIA-4 portion of the consolidation conduit, extending south of the Junction Chamber along Taft Street, is approximately 800 linear feet, and runs beneath the

Interstate Rte. 95 bridge and the Division Street bridge. This 48-inch diameter consolidation conduit is designed to convey a peak flow of approximately 39 MGD and has a minimum slope of 0.0018 ft/ft.

Following similar design criteria, the consolidation conduit extending upstream between the Contract IIIA-4 limits and OF-217 will be constructed under a separate construction phase, Contract IIIA-5. This segment of the consolidation conduit system will consist of constructing approximately 1,900 linear feet of 48-inch diameter pipe and the OF-217 Diversion Structure itself, as well as other appurtenant work directly associated with OF-217.

#### *4.2.1 Construction Considerations*

Site and Subsurface Conditions

The horizontal alignment of the consolidation conduit is being maintained on the eastern side of the roadway as it exits the Junction Chamber to the south. This is due to the amount of underground utility infrastructure that currently exists on the western side of the roadway. The initial 300-foot segment of the pipeline follows a fairly, narrow corridor between the roadway (Taft Street) and the Seekonk River. In the area the ground slopes to the immediate east towards an existing retaining wall and the Seekonk River. Vertically, this wall is approximately 7-10 feet in height. From the wall's toe the ground continues to slope eastly to the River, which is then channeled by a secondary wall. Reference is made to the adjacent photograph. An existing guard rail runs along the eastern edge of the roadway (Taft Street) and a chain-link fence is positioned on the top of the existing retaining wall. At its closest point the pipe is positioned approximately 13-feet west of the retaining wall. As noted above, this conduit alignment although not considered ideal in relation to the wall, was selected to avoid disrupting significant underground infrastructure that exists within Taft Street. This infrastructure, which provides critical service to the City of Pawtucket, includes electrical duct-banks (including twenty-four (24), 5-inch conduits identified in Section 5.1.1) that are positioned more or less in the center of the roadway, and underground communications facilities positioned on the western side of the roadway.

View of retaining wall - facing south, with the Seekonk River to the left and Taft Street to the right

Continuing to the south the conduit alignment then shifts to the southbound travel lane (western side of the road) as the pipeline approaches the I-95 bridge. This shift was warranted to avoid encountering reinforced concrete foundation supports that were left remaining underground from the old I-95 Bridge, which has since been replaced. The extent and composition of these foundations, specifically reinforcement, are unknown. Although both partial and complete removal of the former foundations were considered, this approach was rejected primarily due to the extent of excavation support and dewatering that would be required, the close proximity and potential impacts upon an existing electrical vault located in the immediate vicinity, the environmental concerns and permitting restrictions that may be necessary for working within the Seekonk River, the unknown elements of the structures, and the related costs for attempting such a removal.

The footprint of the former buildings referenced in Section 5.1.1 occupies space within the proposed pipe alignment. As stated, the approximate locations of the building footprints have been outlined on the plan and will need to be identified and more specifically delineated for removal during construction.

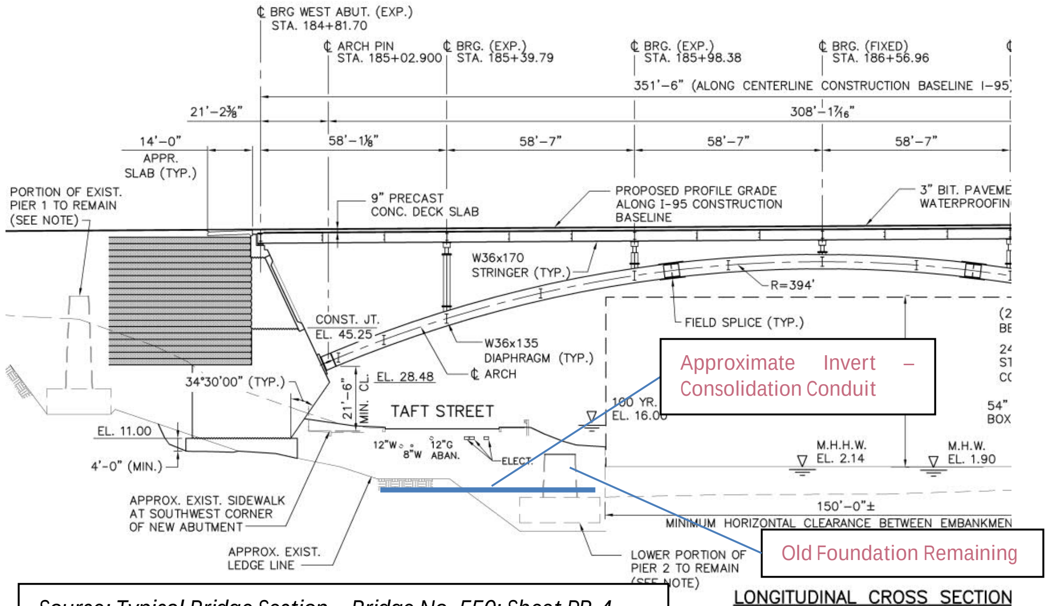
Station 3+11(S) to Station 5+33(S):

Station 3+11(S) to Station 5+33(S) extends beneath the I-95 bridge, Pawtucket Bridge No. 550. In preparation of the design for this section, the following information was reviewed:

- RIDOT design plans for Bridge No. 550, prepared by Commonwealth Engineers, dated 2010. Plan review included demolition plans, boring log information and new bridge foundation information.
- Coordination with National Grid and structure field investigations
- Survey information for existing drainage infrastructure

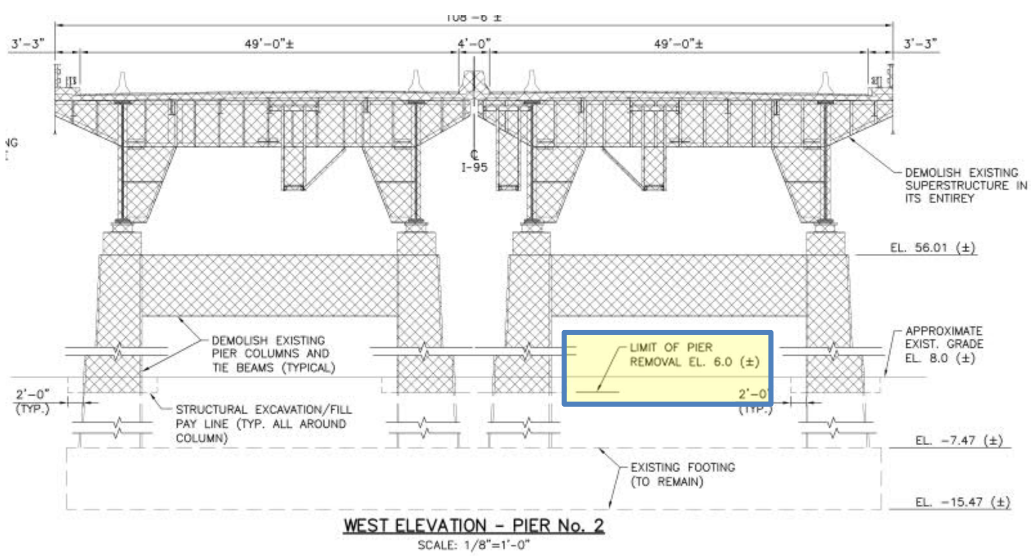
View of southbound lane of Taft Street beneath Route 95 Bridge looking towards the Division Street Bridge

The horizontal alignment was selected with the goal of limiting potential rock removal, avoiding disturbance to adjacent bridge foundation and, as discussed earlier, avoiding the need to remove any existing/former bridge foundation materials that may be remaining from bridge demolition work. The bedrock profile is anticipated to rise towards the western side of Taft Street and therefore the eastern side of the roadway was favored. Height clearances beneath the bridge on Taft street range between 22 and 35 feet.




*Source: Typical Bridge Section – Bridge No. 550: Sheet PB-4*

Relative to the former bridge foundation, it appears the foundation footing and two support piers, cut off at or about Elevation 6.0, remain within the ground. An alignment was evaluated that conflicted with the northern pier, at approximate Station 3+60(S). The following construction challenges were determined to pose significant risk and cost for the project.




*Source: Demolition Plan Sheet 2 – Bridge No. 550: Sheet G-26*

- Ability to install excavation support and provide an adequate groundwater/river cutoff to allow removal of the pier and installation of the consolidation conduit. The remaining bridge footing (Top Elevation -7), although below the invert of the pipe, limits the ability to extend the excavation support to a depth required to successfully cutoff groundwater penetration.
- The significant efforts associated with such pier removal, based on the size and configuration of pier and the unknown elements of the internal reinforcement.

The conduit alignment then transitions back to the northbound travel lane as the pipeline progresses along Taft Street to the south. One major controlling factor for this alignment is the location of the pipeline relative to the Division Street Bridge. The existing bridge consist of stone arches over each of the travel lanes. The intent of the alignment is to cross beneath the Division Street Bridge within the center of the northbound lane, both to maximize the vertical clearance between the bridge and the roadway for conventional trench installation and to maximize the distance away from the adjacent bridge piers.


View of Taft Street southbound towards Division Street Bridge from beneath I-95 Bridge

The vertical alignment for the consolidation conduit along this route was set to maintain two (2) existing drainage pipes (24-inch RCP and 30-inch RCP) that cross perpendicular to Taft Street flowing towards the River. Both are located directly beneath the I-95 Bridge. The vertical depth provides approximately two (2) feet of separation between the bottom of the utilities to the top of the consolidation conduit. The overall depth of the consolidation conduit varies between 15-feet and 20-feet below existing grade.

Subsurface conditions along the alignment are anticipated to consist of Fill or Glacial Deposits. The Fill consists of dense sand, gravel, and stone, with fragments of rock and brick. The Glacial Deposits consist of dense to very dense, coarse to fine gravel with varying amounts of sand and silt. Bedrock may be encountered along the vertical alignment in the area of the existing I-95 Bridge and is expected to consist of strong, gray, Sandstone, Siltstone, and Conglomerate. The groundwater level is anticipated to be located above the proposed consolidation sewer crown.

<u>Excavation Support and Dewatering</u>

Excavation support to accommodate construction of the 48-inch diameter RCP consolidation conduit in open cut sections, and for MH217-1 to MH217-3, will be considered contractor means and methods and will be selected and designed by the Contractor.

Active site dewatering will be necessary to install the RCP pipe. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable tolerances as dictated by the utility owner. Specifications and contractor requirements will be included in the Contract documents.

Selection of excavation support systems will also be important in protecting the adjacent retaining wall, south of the junction chamber. An excavation support system that considers soldier pile and lagging would enable the contractor to drill in piles thereby reducing vibrations that may be associated with other techniques such as sheet piling or slide rail systems. The ability to drill for the installation of soldier piles will also improve the potential to pass by anticipated boulders, cobbles and chunks of concrete anticipated in the area fill material.

Utility Relocation and Coordination

Active utility conflicts requiring management for the proposed alignment are limited to the water main, street lighting, and relatively shallow drain lines. As stated in Section 5.1.1, BETA coordinated with the PWSB regarding temporary water bypass during construction and relocation of the water main upon completion of the consolidation conduit and diversion structure construction. The water main requiring bypass and relocation within this consolidation conduit segment includes the water main located crossing within the footprint of the Junction Chamber and the water main running north and parallel to the consolidation conduit to approximately MH217-3 (approximately 320 feet).

Disruption of street lighting and associated electrical conduit is also anticipated to accommodate the work. Coordination with the City is required to define provisions for temporary lighting as well as replacement lighting. During the consolidation conduit installation shallow drain lines will require management by removing and replacing as necessary. Temporary pipe connections are anticipated to maintain stormwater flow until the final pipe repairs can be completed after installation of the consolidation conduit. The contractor will be required to coordinate this work with the construction phasing and concurrent coordination with the City as required.

Utility conflicts for inactive utilities within the proposed alignment include removal of an abandoned gas main section (approximately 20-foot section north in the vicinity of MH 217-3) and a section of reportedly empty communications duct bank in the vicinity of the proposed pipe jacking pit at Station 3+11(S). Inquiries were made with Verizon, as to whether the duct may be removed, but the inquiry remains unanswered.

As part of a continuing coordination effort, BETA has met with National Grid specifically regarding an existing electric vault and electric duct banks located on Taft Street directly beneath the I-95 Bridge. One alignment option evaluated included the consolidation conduit being installed underneath the vault by trenchless construction methods. National Grid indicated that the existing structure is believed to be of brick construction with a concrete floor (base thickness unknown). National Grid expressed concern regarding methods for supporting the structure during this type of installation. They also identified a recent issue whereby a manhole structure was damaged due to a sewer leak, requiring extensive repairs to their structure and removal/reinstallation of electrical infrastructure to repair the sewer. Based on these concerns and National Grid's recent experience, they objected to the consolidation conduit being installed directly beneath their vault. The alignment has been shifted to avoid being beneath the structure, but crossing beneath the electric duct banks is unavoidable, therefore further coordination is required.

Protection of Adjacent Structures

Several structures adjacent to the consolidation conduit must be managed and/or protected during pipeline construction. These structures include:

- the retaining wall along the east side of Taft Street between Jenk's Way and the I-95 Bridge
- the existing electrical infrastructure, including a major electrical duct bank
- existing ground conditions and known obstructions beneath the I-95 Bridge

- horizontal and vertical clearance for construction beneath the Division Street Bridge

Test Pits completed in the vicinity of the retaining wall found wall construction to be a dry loosely laid fieldstone masonry structure with random mortared joints throughout and a mortared fieldstone face. The wall stem has a top-of-wall width of approximately 16" and a relatively steep batter on the back face. Fill material behind the wall consists of a well-graded sandy gravel with cobbles and boulders. The wall is assumed to have no concrete footing. The wall is considered substandard when evaluated and compared to current AASHTO design standards. The wall also exhibits signs of fatigue with several large random cracks.

Depending on proximity, installation of the consolidation conduit may increase loading and vibrations to the wall and thereby reduce the wall's effectiveness in resisting overturning and sliding. The Contractor will be required to protect the wall and the method will be left to the Contractor but may include practices such as the following:

Table 4-1: Retaining Wall Protection Methods

| Documentation | Fortify Wall | Limit Load | Limit Vibration |
|---|---|---|---|
| Preconstruction Survey | Ground Improvements behind wall | SOE Design Criteria: Design bracing systems to eliminate lateral pressure on retaining wall | Define Vibration Limits |
| Instrumentation for continuous Monitoring during construction | Repoint wall and repair cracks | SOE Design Criteria: Design Piles to support vertical traffic and construction load and require contractor to work from decking supported by piles | Drill piles (Protect wall and utility / and pass through obstructions) |
| Post Construction Survey | | | Identify Contractor limitations (i.e. no closer than 10 feet) |
| | | | Chip out obstructions within trench limits |

Electrical infrastructure within the area of the proposed alignment includes the primary duct-bank consisting of twenty-four (24), 5-inch conduits within Taft Street from the Junction Chamber to the electric vault at approximately Station 4+10 (S). The duct-bank between the Junction Chamber and MH217-1 is located at a distance sufficiently away so as not to be impacted by parallel trench construction with appropriate excavation support. The consolidation conduit crosses the duct-bank between manholes MH 217-2 and MH 217-3. The duct-bank is reportedly unreinforced concrete with the internal; conduits being either fiber conduit (Orangeburg pipe) or cast-iron pipe. To protect the duct-bank in this area, trenchless construction techniques are proposed. Pipe jacking is being considered for installation of this pipe section.

The consolidation conduit crosses the same duct-bank and is aligned adjacent to the previously identified electric vault between MH217-3 and Station 4+10(S), which is approximately 100-feet. To protect and support the duct-bank in this area, the installation of the consolidation conduit shall be completed with pipe jacking techniques. Additional protection measures near the electric vault may be required, as mutually coordinated with National Grid.

Conventional pipe jacking will require a jacking pit at Station 5+33(S) and a receiving pit at Station 3+11 (S). Direct jacking of the 48-inch diameter RCP pipe will be conducted. A protective shield ahead of the reinforced concrete pipe would be used to provide additional face stability during soil excavation. With this method, obstructions can be manually removed from the tunnel face if any are encountered.

#### *4.2.2 Recommended Installation Methods*

Multiple construction methods are proposed at various sections of this consolidation segment. These include the following:

Station 0+00(S) to Station 2+85(S):
The horizontal alignment between Station 0+00(S) to Station 2+85(S) begins along the eastern edge of the Taft Street within the northbound travel lane. Both Open-cut construction techniques are proposed for the installation of the consolidation conduit.

Station 2+85(S) to Station 3+11(S):
The horizontal alignment between Station 2+85(S) to Station 3+11(S) begins along the eastern edge of the Taft Street within the northbound travel lane. Open-cut and trenchless construction techniques were considered for the installation of the consolidation conduit. Constructability challenges uniquely identified for conventional open-cut construction include the unknown condition of the existing electric utilities and the unknown ability to adequately support the unreinforced concrete duct-bank. Therefore, trenchless construction of the consolidation conduit mitigates potential impacts to the existing electrical utilities.

Two trenchless construction techniques were considered – pipe jacking and utility tunneling, both with spoils removal by hand mining. Utility tunneling would normally be recommended given the short distance. However, the consolidation conduit between Station 3+14 (S) and Station 6+00 (S) is proposed to be installed utilizing the pipe jacking method (see discussion below). Since both segments are comprised of the same pipe size and material and share a common pit at Station 3+14(S), installation of this segment utilizing pipe jacking is recommended.

Station 3+11(S) to Station 5+33(S):
The horizontal alignment between Station 3+11(S) to Station 5+33(S) begins near the center of the roadway and crosses into the northbound travel lane as the alignment proceeds south. To protect the existing electrical infrastructure (duct-bank and vault), the recommended means of installation is utilizing the pipe jacking method. Since overhead access is limited by the overhead I-95 Bridge, jacking pits are proposed on either side of the above Bridge.

Station 5+33(S) to Station 8+07(S):

The horizontal alignment between Station 5+33(S) to Station 8+07(S) begins along the eastern edge of the Taft Street northbound travel lane. Open-cut and trenchless construction techniques were considered for the installation of the consolidation conduit. This segment of the alignment is not impacted by existing utilities to the same extent as previously discussed segments. With an average excavation depth of 15-feet, open-cut installation is recommended as the most cost-effective means for completing the pipe installation in this area.

## 4.3 Junction Chamber to OF-214 Diversion Structure

The consolidation conduit between the Junction Chamber and OF-214 Diversion Structure receives flow from the OF-210 Diversion Structure, the OF-213 Diversion Structure, and the OF-214 Diversion Structure all from the north. The 60-inch diameter consolidation conduit is approximately 150-feet in length, is designed to convey a peak flow of approximately 91 MGD and has a slope of 0.0048 ft/ft. The consolidation conduit runs south-to-north, parallel to Taft Street along the eastern side of the right-of-way, to the intersection with Jenk's Way, which is the location of the OF-214 Diversion Structure. The OF-214 Diversion Structure is located off the road just to the east of Taft Street, adjacent to a stone masonry retaining wall.

### *4.3.1 Construction Considerations*

Site and Subsurface Conditions

The horizontal alignment is maintained on the eastern side of the roadway to avoid electrical duct-banks positioned more in the center of the roadway and underground communications infrastructure existing on the western side of the roadway further upstream. Available space for the OF-214 Diversion Structure was also a factor. The OF-214 pipe system is located and aligned with the center median strip of Jenk's Way and then it crosses Taft Street as it continues towards the Seekonk River at which place it discharges.

The vertical alignment for the consolidation conduit was set to avoid conflicting with existing electrical duct-banks located upstream. The invert depths range from 18 to 23-feet.

Subsurface conditions along the alignment are anticipated to consist of Fill and Glacial Deposits. The Fill consists of dense sand and gravel with fragments of concrete. The potential exists for remnants of old building foundations to be encountered within the Fill. The Glacial Deposits consist of dense, coarse gravel and sand. The groundwater level is anticipated to be located above the proposed consolidation sewer crown.

Excavation Support and Dewatering

Excavation support to accommodate construction of the 60-inch diameter RCP consolidation conduit will be required and the methods selected along with their design and execution will be the responsibility of the Contractor.

Active site de-watering will be necessary to install the RCP pipe. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable limits as dictated by the utility owner. Specifications and contractor requirements have been developed but methods selected along with their design and execution will be the responsibility of the Contractor.

Utility Relocation and Coordination

Active utility conflicts requiring management for the proposed alignment are limited to the water main, street lighting, and shallow storm drains. As stated in Section 5.1.1, BETA coordinated with the PWSB regarding temporary water bypass during construction and relocation of the water main upon completion of the consolidation conduit and diversion structure construction. The water main requiring bypass and relocation within this consolidation conduit segment (approximately 160 feet).

Disruption of street lighting and associated electrical conduit is anticipated to accommodate the work. Coordination with the City is required to define provisions for temporary lighting as well as replacement lighting. Shallow storm drains require management during the construction by removing and replacing as needed during the consolidation conduit installation. Temporary pipe connections are anticipated to maintain stormwater flow until the final pipe repairs can be completed after installation of the consolidation conduit.

Protection of Adjacent Structures

There is an existing retaining wall located to the east of the consolidation conduit. Details of the wall construction are not available. The stone wall was constructed above the river wall and appears to have been built to support earth fill associated with the construction of Jenk's Way and Roosevelt Avenue Ext. to the north. The condition of the wall is variable and has been repaired at least once at the base of the wall near its tallest point. The repaired concrete was observed in the field, south of OF-214. Repair plans prepared by Fuss and O'Neil were also obtained from the City.

View of retaining wall from across the river

Vibrations associated with construction of the pipeline may have impacts to the wall. Due to the proximity of the OF-214 Diversion Structure and the required upgrades to OF-214 a portion of the wall is being identified to be removed and replaced. The wall along the pipe alignment is part of the same wall system that will be encountered for the construction of Consolidation Conduit between Station 0+00(S) and 2+85(S) and the same protection measures (Table 4-1) are identified.

### *4.3.2 Recommended Installation Methods*

The location of Drop Shaft 213, GSS, Junction Chamber and OF-214 Diversion Structure dictated the location of the consolidation conduit. No other alternatives were reviewed. The relatively short run of pipe, the lack of utility conflicts, and the proposed structure installations made open-cut construction techniques a logical choice for this construction.

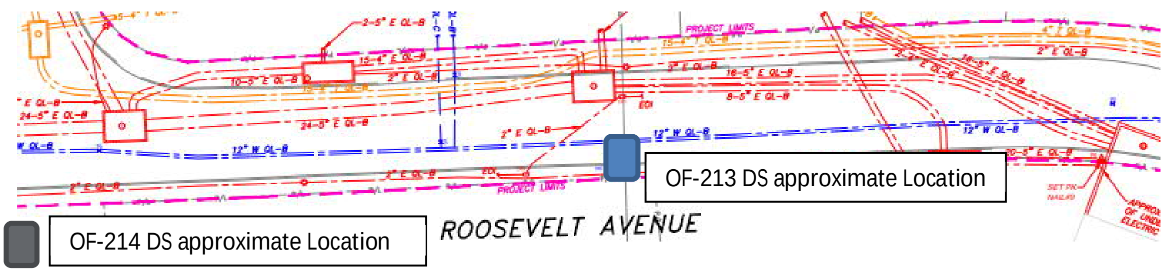
## 4.4 OF-214 Diversion Structure to OF-213 Diversion Structure

The consolidation conduit between OF-214 Diversion Structure and OF-213 Diversion Structure receives flow from OF-210 Diversion Structure and OF-213 Diversion Structure. The 54-inch consolidation conduit is approximately 203 feet long, is designed to convey a peak flow of approximately 64 MGD and has a slope of 0.004 ft/ft. The consolidation conduit runs south-to-north, parallel to Roosevelt Avenue Ext. along the eastern side of the road and partially within the limits of the curb line and sidewalk to the OF-213 Diversion Structure. The OF-213 Diversion Structure is located within the northbound travel lane and extends off road to the east side of the right-of way. OF-213 is located immediately south of the entrance to a private parking lot area.

### *4.4.1 Construction Considerations*

<u>Site and Subsurface Conditions</u>

The horizontal alignment is maintained on the eastern side of the northbound travel lane to avoid electrical duct-banks positioned in the center of the roadway and underground communications infrastructure on the western side of the roadway. Below is a portion of utility research completed by BSI Engineering for the Project. The picture depicts the utilities between OF-214 Diversion Structure and OF213 Diversion Structure.




The vertical alignment for the consolidation conduit was set to allow upstream crossing of electrical duct banks. The consolidation conduit depth ranges between 18 and 22 feet within this stretch.

Subsurface conditions along the alignment are anticipated to consist of Fill and Glacial Deposits. The Fill consists of dense sand and gravel with fragments of glass. The Glacial Deposits consist of dense, coarse to fine, gravel and sand. The groundwater level is anticipated to be located above the proposed consolidation sewer crown.

<u>Excavation Support and Dewatering</u>

Excavation support to accommodate construction of the 54-inch RCP consolidation conduit, and for MH214-1, will be left to the Contractor but due to the proximity to existing utilities and a retaining wall the contractor will be required to reduce vibrations and provide support for equipment. An excavation support system that considers soldier pile and lagging would enable the contractor to drill in piles thereby reducing vibrations that may be associated with other techniques such as sheet piling or slide rail systems. The ability to drill for the installation of soldier piles will also improve the potential to pass by anticipated boulders, cobbles and chunks of concrete anticipated in the area fill material.

Active site de-watering will be necessary to install the RCP pipe. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable criteria as dictated by the utility owner.

The field stone masonry retaining wall protecting the parking lot is expected to be a gravity wall with similar construction to that identified during a test pit completed for the southern portion of the wall. Wall construction is described as a dry loosely laid fieldstone masonry structure with random mortared joints throughout and a mortared fieldstone face. The wall stem has a top-of-wall width of approximately 16" and a relatively steep batter on the back face of approximately 3V:1H. Fill material behind the wall consists of a well-graded sandy gravel with cobbles and boulders. The wall is assumed to have no concrete footing. The wall is considered substandard when evaluated and compared to current AASHTO design standards. The wall also exhibits signs of fatigue with several large random cracks.

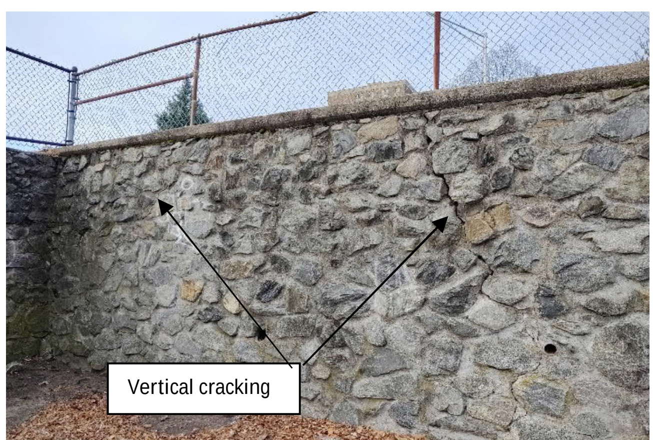
Utility Relocation and Coordination

Active utility conflicts requiring management for the proposed alignment are limited to the water main, street lighting, and shallow storm drains. As stated in Section 5.1.1, BETA coordinated with the PWSB regarding temporary water bypass during construction and relocation of the water main upon completion of the consolidation conduit and diversion structure construction. The water main requiring bypass and relocation within this consolidation conduit segment (approximately 160-feet).

Disruption of street lighting and associated electrical conduit is anticipated to accommodate the work. Coordination with the City is required to define provisions for temporary lighting as well as replacement lighting. Shallow storm drains require management during the construction by removing and replacing as needed during the consolidation conduit installation. Temporary pipe connections are anticipated to maintain stormwater flow until the final pipe repairs can be completed after installation of the consolidation conduit. The Contractor will be required to coordinate these efforts with the City.

Protection of Adjacent Structures

Construction within the eastern right-of-way will impact the curb line, concrete sidewalk and likely the existing retaining wall for the parking lot area (Parcel 584). The existing retaining wall has existing vertical cracking, and vibrations resulting from construction activities will likely cause further damage to the wall. The Contractor will be required to protect the wall and the method will be left to the contractor but may include practices such as those presented in Table 4-1. In addition the lower level parking area may allow the contractor to support the face of the wall during construction with a Raker system.

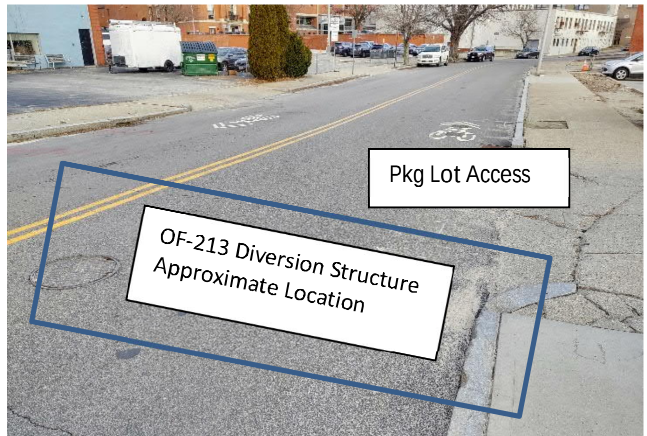



View of Parcel 584 Retaining Wall

Review of property deed information and a property line boundary survey will be required to determine ownership of the retaining wall.

Stakeholder Impacts (Parking)

As the work progresses to the north toward the OF-213 Diversion Structure, construction activities will obstruct access to the Parcel 584 parking lot. The OF-213 Diversion Structure is located immediately south of a shared entrance for the 584 Parcel parking area and the abutting National Grid Property Parking area to the north. Based on review of tax assessor parcel mapping, the entrance appears to be owned by National Grid. There is opportunity to create a temporary entrance to the National Grid property parking area further to the north. The temporary access would require removal of curbing and sidewalk panels. A similar shared access agreement would need to be reached between the two parties for continued access to the parcel 584 parking area during times when construction obstructs the entrance. The property Owner will need to be made aware of times when the lot is obstructed.




View of Roosevelt Ave Ext Looking North

### *4.4.2 Recommended Installation Methods*

This section of consolidation conduit will be installed with open cut methods. Utility congestion in the center and southbound travel lane of the roadway directed the design alignment to the eastern edge of the northbound lane. City plans to construct a bike path within this alignment also favored this position considering restoration improvements are currently planned for the area.

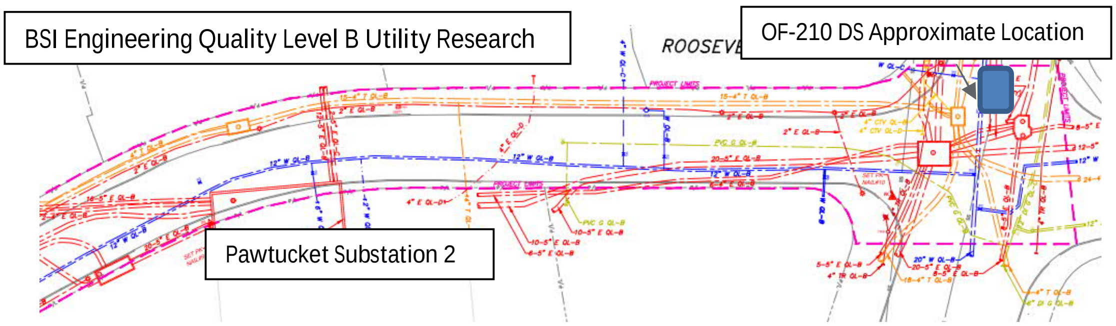
## 4.5 OF-213 Diversion Structure to OF-210 Diversion Structure

The consolidation conduit between OF-213 diversion structure and OF-210 diversion structure receives flow from OF-210 Diversion Structure. The 48-inch consolidation conduit is approximately 560 feet long, is designed to convey a peak flow of approximately 53 MGD and has a slope that ranges between .005 and0.008 ft/ft. The consolidation conduit runs south to north, within Roosevelt Avenue Ext. and transitions from the east side to the western side of the road as the project progresses toward Main Street at the OF-210 Diversion Structure. The OF-210 Diversion Structure is located within the west bound lane of the intersection of Roosevelt Avenue Ext. and Main Street.

### *4.5.1 Construction Considerations*

Site and Subsurface Conditions

Upstream of OF-213 Diversion Structure, the horizontal alignment is maintained on the eastern side of the northbound lane to avoid electrical duct banks positioned in the center of the roadway and underground communications infrastructure on the western side of the road. The underground electrical distribution system within the project limits originates from a substation located north of OF-213 Diversion Structure referred to as Pawtucket Substation No. 2. Approximately 165 feet north of the OF-213 Diversion Structure, a portion of the Substation No. 2 facility extends underground into the northbound lane of the roadway. Multiple duct banks extend from the south side of this structure. The location of the electrical infrastructure requires the consolidation conduit to cross the duct banks and extend into the southbound travel lane. Below is a portion of utility research completed by BSI Engineering for the project. The picture depicts underground utilities, except for the drain and sewer, between OF-213 Diversion Structure and OF-210 Diversion Structure.




The alignment then extends to the north crossing the water main along its path. Open-cut construction is the proposed installation method north of the pipe jack segment and south of the intersection with Main Street. There is significant utility congestion within Main Street and includes electric, communication, gas, water, drain, sewer and gas. The utility congestion is depicted above in the referenced BSI utility research.

The vertical alignment for the consolidation conduit was set to allow crossing of electrical duct banks emanating from the Pawtucket Substation No. 2 and the existing electrical duct banks within the Main Street intersection. The consolidation conduit depth ranges between 12 and 18 feet within this stretch. Subsurface conditions along the alignment are anticipated to consist of Fill and Glacial Deposits. The Fill consists of loose to very dense sand and gravel with silt. The Glacial Deposits consist of dense, coarse to fine, gravel and sand and may include fragments of fractured rock. The groundwater level is anticipated to be located above the proposed consolidation sewer crown.

<u>Excavation Support and Dewatering</u>

Excavation support to accommodate construction of the 48-inch diameter RCP consolidation conduit by open-cut methods, and for jacking pits at MH213-1 and MH213-4, will be required and the methods selected along with their design and execution will be the responsibility of the Contractor.

Active site de-watering will be necessary to install the RCP pipe. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable limits as dictated by the utility owner. Specifications and contractor requirements have been developed but methods selected along with their design and execution will be the responsibility of the Contractor.

Utility Relocation and Coordination

Active utility conflicts requiring management for the proposed alignment are limited to the water main, street lighting, and shallow storm drains. As stated in Section 5.1.1, BETA coordinated with the PWSB regarding temporary water bypass during construction and relocation of the water main upon completion of the consolidation conduit and diversion structure construction. The water main requiring bypass and relocation within this consolidation conduit segment (approximately 160-feet).

Disruption of street lighting and associated electrical conduit is anticipated to accommodate the work. Coordination with the City is required to define provisions for temporary lighting as well as replacement lighting. Shallow storm drains require management during the construction by removing and replacing as needed during the consolidation conduit installation. Temporary pipe connections are anticipated to maintain stormwater flow until the final pipe repairs can be completed after installation of the consolidation conduit. The contractor will be required to coordinate this work with the construction phasing and coordination with the City will be required.

Protection of Adjacent Structures

The structures potentially impacted by consolidation conduit construction consist of the electrical duct-banks and the underground vault at the previously identified electric substation and a telecommunications vault within the Main Street intersection. Protection of these structures is provided by the chosen construction method in these areas discussed below.

Stakeholder Impacts (Public Transportation, Parking)

As noted above, construction of consolidation conduit north of OF-213 Diversion Structure will temporarily obstruct the parking facilities for Parcel 584 and National Grid. In addition, temporary access interruptions will be experienced for street parking on the west side of the road, and access to parking facilities for 200 Main Street, on the west side of the roadway.

Construction within Main Street will impact vehicular traffic as well as public transportation. Close coordination with the City, RIPTA and safety departments will be required for planning this construction. Coordination completed with RIPTA in relation to the relocation of their hub is included in Section 2.1.6.

### *4.5.2 Recommended Installation Methods*

Station 4+96 to Station 6+87:

The horizontal alignment between Station 4+96 (OF-213 Diversion Structure) to Station 6+87 (MH213-3) will require a combination of open cut and trenchless construction. The initial 40 foot stretch begins along the eastern edge of the Roosevelt Avenue Extension northbound travel lane. The relatively short run of pipe, the lack of utility conflicts, made open-cut construction techniques a logical choice for this construction. Trenchless construction methods could be considered in this area if the Parcel 584 parking lot access issue becomes problematic, but other more cost-effective options for managing access to the site appear available.

As the horizontal alignment extends to the north, it crosses the previously identified duct-banks originating from the Pawtucket Substation No. 2. The duct-banks have similar properties to those referenced above and the ability to support these facilities is uncertain when considering open-cut construction techniques. For that reason, trenchless construction in the form of pipe jacking is proposed to cross the electric utilities.

Station 6+87 to Station 8+05:
The horizontal alignment between Station 6+87 (MH213-3) to Station 8+05 (MH213-2) is maintained in the center of Roosevelt Avenue Extension as it approaches MH 213-2. The lack of utility conflicts and the proposed structure installations made open-cut construction techniques a logical choice for this construction.

Station 8+05 to Station 9+88: The horizontal alignment between Station 8+05 (MH213-2) to Station 9+88 (MH213-1)begins in the center of of Roosevelt Avenue Ext. and migrates into the southbound travel lane on the approach to Manhole 213-1. The lack of utility conflicts and the proposed structure installations made open-cut construction techniques a logical choice for this construction.

Station 9+88 to Station 10+59: The horizontal alignment between Station 9+88 (MH213-1) to Station 10+59 (OF-210 Diversion Structure) begins along the western edge of the Roosevelt Avenue Ext. Open-cut and trenchless construction techniques were considered for the installation of the consolidation conduit. Due to the presence of numerous underground utilities, open-cut installation methods were discounted. The consolidation conduit requires installation utilizing trenchless construction and pipe jacking with hand mining was determined to be an appropriate method.

# 5.0 STRUCTURES

## 5.1 GATE AND SCREENING STRUCTURE

The consolidation conduits, discussed in Chapter 5, convey wet weather flow from upstream diversion structures to the Gate and Screening Structure (GSS) prior to discharging combined sewerage into the storage tunnel via the approach channel. Combined sewage flows contain debris and floatables and the GSS serves to reduce the volume of these materials from discharging to the Tunnel. Peak flow through the GSS is estimated to be 155 MGD.

### *5.1.1 SITING*

Siting for the GSS as presented in the Conceptual Design was within Jenk's Way and its right-of-way, along with Drop Shaft 213. The control "head" house was to be located within the grassed area east of Roosevelt Ave. Extension. Drop Shaft 213 was also located within Jenks Way. During the development of the 30-percent design, further review of the location revealed that significant utility relocation would be required for the construction of the GSS and DS-213 facilities at this proposed location. Utilities included water, electric and communications and it was determined that alternate locations for the GSS and Drop Shaft 213 (DS-213) facilities should be evaluated.

The decision to seek alternate siting locations is also a result of the actual location of OF-214. During the advancement of program soil borings, OF-214 which was originally thought to be extending southeasterly from Jenk's Way beneath the Masonic Temple Property, was actually located running directly east just north of the traffic median within Jenks Way as a 30-inch diameter reinforced concrete pipe. Therefore, the current alignment of OF-214 makes it difficult to locate a diversion structure and route the discharge to the GSS location as originally proposed.

Alternate sites were identified and reviewed with Stantec and the NBC. Alternate sites reviewed included:

- Option A – Town Landing, two (2) configurations
- Option B – Masonic Temple Parcel, multiple configurations
- Option C – Parking lot, parcel 53-584
- Option D – City Property, grassed area south of Parcel 53-584

Figures depicting a layout of Drop Shaft 213 and the GSS at each location are included in Appendix 6. Based on review of the alternatives, the selected location of the GSS is Option B, with the GSS located in the center along the eastern boundary of the Masonic Temple property with the control "head" house at ground level above the GSS. Advantages of this location include:

- Minimal siting impacts associated with existing utilities
- Maintains use of the site for future redevelopment
- Sites the GSS away from areas sensitive to construction impacts on Masonic Temple Property (retaining wall on western side of parking area, southern residential buildings)
- Available opportunity to make a real estate transaction,
- Avoids impacts to future City development plans
- Provides consideration for the location of OF-214 Diversion structure,
- Allows beneficial siting for the upstream junction chamber that combines flow from the OF-210,211, 213, and 214 conduits with the OF-217 consolidation conduit.

View of Masonic Temple Property Looking South West

It is noted that the structure depicted on the righthand side of the photograph has been demolished as part of the Tunnel contract that includes construction of Drop Shaft 213.

### *5.1.2 Structure Description*

The GSS is a cast-in-place concrete structure with slide gates positioned at the influent and effluent of the GSS to provide isolation for the tunnel. Two gates are proposed for redundancy, and the slide gates will be equipped with hydraulic actuators. Flow will be conveyed to the GSS via a 72-inch diameter consolidation conduit exiting from an upstream alignment manhole that receives flow from the upstream Junction Chamber. Flow will enter the GSS near the bottom of the structure and will pass through a debris screen and exit the structure to the approach channel for Drop Shaft 213.

The structure will require entry for inspection and maintenance. Access hatches are provided at grade to allow for observation of the interior structure, and access to a ladder for entry, if required. No lighting, ventilation equipment, or stairs and landings are proposed. The NBC will need to mobilize temporary lighting, ventilation equipment, air monitoring, and personal safety equipment required for a permit-required confined space entry.

Mechanical equipment located in the structure is limited to the gates and the hydraulic cylinder for the operator. Removeable concrete panels at grade are provided to allow removal of the gates when required.

The structure has interior plan dimensions of 10-feet by 26-feet and is approximately 33-feet deep. It is anticipated that the excavation will extend below the bedrock surface. Rock removal is required for the installation of the structure, the influent consolidation conduit, and the effluent approach channel to Drop Shaft 213.

### *5.1.3 Subsurface Conditions*

The GSS will require excavation of soil and bedrock. Fill underlain by Glacial Deposits with thicknesses of approximately 10-feet and 8-feet, respectively, are expected to be encountered above the bedrock. Approximately 18-feet of bedrock will be excavated. The Fill consists of medium dense, coarse to fine sand with trace amounts of silt and gravel and contains fragments of brick and glass. The Glacial Deposits consist of very dense, coarse to fine gravel with varying amounts of sand and silt. The Bedrock consists of strong, gray Sandstone. Groundwater levels are anticipated to be about 10-feet below the existing ground surface.

### *5.1.4 Excavation Support and Dewatering*

Excavation support to accommodate construction of GSS will be provided by a secant pile wall with piles drilled-into sound bedrock for water tightness. Design of secant pile systems is discussed in Section 4.4. The excavation support footprint will be extended and squared-off to the north to provide adequate room for tunnel mining operations. Depending on the rock quality at the base, permeation grouting may be required to create a plug to cut-off water inflows. Locked-in groundwater will need to be removed from within the excavation limits by use of localized sumps as excavation proceeds. This ensures maintenance of a suitable subgrade to work from. Secondary secant piles will be reinforced with steel beams allowing the wall to span vertically. Primary secant piles will be designed as lagging between the secondaries in accordance with ACI 318.

### 5.1.5 STRUCTURAL

The GSS will be of cast-in-place reinforced concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Analysis will be performed using three-dimensional finite element method (3D FEM).

Minimum 28-day compressive strength for concrete design will be 5,000 psi. Reinforcement shall conform to ASTM A615, is to be hot dipped galvanized per ASTM A1094, and placed to achieve a minimum clear cover of 3-inch for any concrete cast against earth or rock, and 2-inch clear cover elsewhere. The structure exterior is to be waterproofed with a bentonite geotextile. PVC water stops will be provided at all construction joints located below design groundwater elevation.

The GSS will also be designed to resist uplift from buoyancy due to high groundwater by providing a 6-inch extension of the base keyed into the secant pile wall system. Skin friction from adjacent earth will not be permitted in participating in the resistance to uplift. A minimum factor-of-safety of 1.15 shall be achieved to demonstrate adequate uplift resistance when considering the design groundwater elevation.

### 5.1.6 MECHANICAL

Screening will be provided with a stainless steel trash rack with a 3-inch apparent opening size (AOS). No mechanical equipment is proposed for the trash rack. The screen extends the full width of the structure and is supported from the walls and floor of the structure.

A slide gate is positioned upstream and downstream of the screen. The gates are six (6) feet by six (6) feet and are constructed of Type 316 stainless steel. The gates are fastened to interior concrete walls and cover the openings that allow passage of flow through the screen and exiting the structure. The gates are equipped with hydraulic actuators.

The hydraulic actuators provide for automatic operation of the gates. The gates have linear actuators suitable for open / close operation, as no provisions are planned for gate modulation. Under normal conditions, the gates are maintained in the open position and fully close on command. The gates are equipped with operators that provide for closure upon power fail (i.e. fail-safe). Power failure closure is provided with an “Accumulator”, a pre-charged nitrogen cannister that is called to actuate through the control panel’s programmable logic controller (PLC) that is equipped with an uninterruptible power supply (UPS). Redundancy for the motor driven system is a manual hand pump located within the controls unit. The hand driven pump can also be operated with a power hand drill.

A split hydraulic actuator system is proposed for this application and most of the equipment and control panels located in the proposed Head House adjacent to the GSS. Equipment located in the structure is limited to a hydraulic cylinder that is positioned near the top of the structure. The cylinder equals the height of the required gate travel and has hydraulic lines entering and exiting the cylinder. The cylinder, hydraulic tubing, and connectors are all Type 316 stainless steel. Frost protection of the hydraulic lines are not required.

A position indicator is provided and located on top of the hydraulic cylinder. The position indicator provides a 4-20 mA signal back to the PLC. The position indicator is accessible from grade through a hatch provided at grade level and the position indicator requires a quarter turn for removal. The operator needs to be able to put a wrench on the indicator to loosen the connection.

### *5.1.7 BUILDING (HEAD HOUSE)*

The head house, positioned above the GSS, is a precast concrete utility building with plan dimensions of twelve (12) feet by twenty (20) feet maximum. The structure is equipped with lighting, and passive ventilation. The structure houses the hydraulic motor and equipment for the gate operator. Each unit is 30-inches in diameter and has a control panel. The panels maintained in the building include:

- Gate Control Panel (2 @ 30” by 30” by 12”)
- Lighting Panel (20”by 30”by 8”)
- SCADA control panel (30” by 36” by 12”)
- Intrusion Detection Panel (12” by 12” by 6”)
- Approach Channel Flow Meter

### *5.1.8 ELECTRICAL AND INSTRUMENTATION*

Electrical (Power)Electrical service shall consist of a new 120V/208 Volt, 3-phase, 4-wire, 100 Amp electrical service for the new GSS. The service shall be buried and concrete-encased with the service feeder conduit from a National Grid underground 120/208 Volt transformer located in a vault to a utility meter located on the side of the proposed head house..

On-site electrical service shall consist of a new 120/208 Volt, 3-phae, 4-wire, 100 Amp main panelboard (MPB) with a 100 Amp main circuit breaker, surge protection device, and branch circuit breakers. A power monitoring relay shall be connected into the MPB bus and will provide Loss of Power and Undervoltage alarms to the SCADA system. Branch circuits from the MPB include 120V circuits for the two (2) wall-mounted receptacles, the exhaust fan and associated louver dampers, the intrusion detection control panel, and the SCADA control panel, and 240V circuits for the slide gate operator hydraulic unit and the electric unit heater.

Lighting

Interior and exterior lighting shall be provided for the control building (head house). Interior lighting within the control building shall consist of two (2) vapor tight polycarbonate housing LED light fixtures with a wall light switch control. Exterior lighting shall consist of one (1) LED wall pack light fixture with integral photocell at the control building’s entrance with a wall switch. Emergency building lighting shall consist of a wall-mounted emergency battery lighting unit and a remote dual-head emergency light at the building entrance.

No lighting within the GSS is proposed.

Building Intrusion

The building intrusion detection system for the GSS control building shall consist of a control panel, keypad, non-contact magnetic switch, and a heat detector. The magnetic switch shall be mounted on the entrance door to indicate intrusion and shall be hard-wired back to the control panel. The heat detector shall be mounted on the building's ceiling to indicate a fire condition and shall be hardwired back to the control panel. The keypad to arm/disarm the system shall be mounted next the entrance door and shall be hard-wired back to the control panel. The control panel shall have intrusion alarm and fire alarm dry contacts that shall be hard-wired to the SCADA system control panel.

Instrumentation and Control

A SCADA RTU Control Panel capable of system I/O control and monitoring shall be provided and mounted in the GSS control building. The panel shall include a new Allen-Bradley Compact logix PLC with discrete and analog input/output control and shall have a door-mounted 10-inch color touch screen operator interface terminal (OIT). All controls and monitoring features shall be provided locally at the OIT and will be capable of being transmitted to NBC's master SCADA system via a telemetry connection that is to be provided under separate contract. The control panel shall be a 30" W x 36"H NEMA 12 wall mounted enclosure with a door mounted OIT and shall house the PLC and radio communications equipment. The control panel shall be connected to a building-mounted radio antenna for the communications link to the remote I/O control panel at the OF-217 Diversion Structure. A list of hard-wired signals to the PLC I/O modules is provided as Table 6-1.

The GSS control building also shall be equipped with a building wall-mounted temperature transmitter and a power monitor relay that shall be hard-wired back to the SCADA control panel PLC I/O modules.

Combustible gas monitoring system will not be provided for the Diversion Structures and GSS sub-structure as it is not required per NFPA 820 – 2016 Table 4.2.2 Row 15. Additionally, oxygen and toxic gas monitoring system will not be provided for the Diversion Structures or the GSS sub-structure since the structures do not require frequent entry, and when entry is required confined space procedures shall provide monitoring for personnel protection.

Table 5-1 PLC I/O Modules

| Diversion Structures / Approach Channel | Gate and Screening Structure (GSS) |
|---|---|
| Diversion Structure OF-210 Level | Gate & Screen Structure Level |
| Diversion Structure OF-210 High Level Alarm | Gate & Screen Structure High Level Alarm |
| Diversion Structure OF-213 Level | Gate #1 Position |
| Diversion Structure OF-213 High Level Alarm | Gate #1 Opened |
| Diversion Structure OF-214 Level | Gate #1 Closed |
| Diversion Structure OF-214 High Level Alarm | Gate #1 Open Command |
| Diversion Structure OF-217 Level | Gate #1 Close Command |
| Diversion Structure OF-217 High Level Alarm | Gate #2 Position |
| Diversion Structure OF-217 Electrical Enclosure Temperature | Gate #2 Opened |
| Diversion Structure OF-217 Electrical Enclosure Intrusion | Gate #2 Closed |
| Diversion Structure OF-217 Electrical Enclosure Loss of Power | Gate #2 Open Command |

| | |
|---|---|
| Diversion Structure OF-217<br>Electrical Enclosure Power Undervoltage | Gate #2 Close Command |
| Approach Channel - Flow | Hydraulic Power Unit High Pressure Alarm |
| | Hydraulic Power Unit Low Pressure Alarm |
| | Hydraulic Power Unit High Temperature Alarm |
| | Hydraulic Power Unit High Tank Level Alarm |
| | Hydraulic Power Unit Low Tank Level Alarm |
| | Hydraulic Power Unit Tank Leak Alarm |
| | Building Temperature |
| | Building Intrusion |
| | Building Fire |
| | Building Loss of Power |
| | Building Power Undervoltage |
| | |

## 5.2 Approach Channel

Located downstream of the GSS, the approach channel is positioned extending south of the GSS along the eastern boundary of the Masonic Temple property. The Approach Channel receives flow from the GSS and conveys it to Drop Shaft 213.

### *5.2.1 Structure Description*

A six-foot by six-foot channel shall be constructed between the Drop Shaft 213 vortex structure and the GSS. The approach channel will be cast-in-place concrete. The connection to the Vortex Structure will need to be closely coordinated with the Program Manager (Stantec) and the Drop Shaft 213 design/construction.

### *5.2.2 Subsurface Conditions*

The Approach Channel will require excavation of soil and bedrock. Fill underlain by Glacial Deposits with thicknesses of approximately 10-feet and 8-feet, respectively, are expected to be encountered above the bedrock. The Fill consists of medium dense, coarse to fine sand with trace amounts of silt and gravel and contains fragments of brick and glass. The Glacial Deposits consist of very dense, coarse to fine gravel with varying amounts of sand and silt. The Bedrock consists of strong, gray Sandstone. Groundwater levels are anticipated to be about 10-feet below the existing ground surface.

### *5.2.3 Excavation Support and Dewatering*

Excavation support to accommodate construction of the Approach Channel will be an extension of the watertight support system being used to construct the GSS. The excavation support system will be internally braced with steel struts and walers and arranged to accommodate and not interfere with the channel placement. The excavation width should be at least 3-feet wider than the outer width of the Approach Channel.

#### 5.2.4 Structural

The Approach Channel will be of cast-in-place reinforced concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Analysis will be performed using 3D FEM.

Minimum 28-day compressive strength for concrete design will be 5,000 psi. Reinforcement is to be hot dipped galvanized per ASTM A1094, and placed to achieve a minimum clear cover of 3-inch for any concrete cast against earth or rock, and 2-inch clear cover elsewhere. PVC water stops will be provided at all construction joints located below design groundwater elevation. The southern end of the approach channel will be designed and detailed to accommodate a connection with the vortex structure expected to be in-place.

#### 5.2.5 Level/Flow Instrumentation

Instrumentation will consist of a non-contact Doppler laser sensor providing velocity measurements at multiple points below the water surface with a non-contact ultrasonic level sensor, like the Teledyne ISCO TieNet 360 LaserFlow Ex. The sensor shall be bracket mounted from the top of the approach tunnel. A retrieval arm shall be provided for installation and removal of the sensor without entrance into the Channel.

An output signal from the sensor shall be hardwired via an intrinsically safe barrier to the flowmeter located in the GSS's control building. The flow meter shall be like the Teledyne ISCO Signature Flowmeter. A flow output signal from the flowmeter shall be hard wired back to the SCADA control panel PLC I/O modules.

### 5.3 Junction Chamber

Located upstream of the GSS, the Junction Chamber is positioned within the northbound travel lane of Roosevelt Avenue Ext./Taft Street and extends east of the roadway on City-owned property. The Junction Chamber receives flow from consolidation conduits from the north (OF-210, OF-213, and OF-214) and from the south (OF-217). The Junction Chamber combines the flow and discharges to a 72-inch consolidation conduit which conveys flow to the GSS.

#### 5.3.1 Structure Description

Upstream consolidation conduits to the north range in size between 48-inch and 60-inch diameter, and the consolidation conduit from the south is 48-inch diameter. The 60-inch conduit from the north conveys an estimated peak flow of 91 MGD and enters the Junction Chamber at Elevation.28. The 48-inch conduit from the south discharges an estimated 39 MGD into the Junction Chamber and enters the structure approximately 180-degrees from the north discharge, at Elevation -3.9. The 72-inch discharge pipe exits to the west with its invert set such that the pipe crown is near the invert of the 48-inch pipe conveying flow from OF-217. The 72-inch pipe is approximately 28-feet deep, the vertical alignment selected to reduce hydraulic impedances, as flow from OF-217 and flow from OF-210,213, and 214 converge and discharge to the 72-inch pipe. Computation fluid dynamic (CFD) modeling was completed by Stantec to demonstrate that the proposed alignment, and the resulting hydraulic conditions, does not restrict flow. The CFD model, included in Appendix 4, incorporated influent consolidation conduits to the junction chamber, the junction chamber, and the consolidation conduit between the GSS and the junction chamber. The CFD model was completed in preparation of the 60% Design submission.

The CFD model resulted in a reduction in the size of the Junction Chamber dimensions and removal of a proposed dividing wall intended to reduce turbulence. The proposed structure has plan dimensions of 10-feet by 12-feet.

### *5.3.2 Construction Considerations*

The Junction Chamber is located between the electric duct-bank described in Section 5.1.1 to the west and a stone retaining wall to the east. Drawings for the wall are not available however based on observation the wall is constructed of stone masonry. Test pitting in the area revealed the existing wall to be comprised of field stone bonded together with mortar. The batter of the wall against the earth backfill is estimated to be 1 foot horizontal to 3 feet vertical (1H:3V).

View of Retaining Wall - Facing South

Due to the proximity of the junction chamber to the retaining wall, protection of the wall will be required as described in Table 4-1

Due to the depth of the structure, construction will require support of excavation and dewatering systems.

### *5.3.3 Subsurface Conditions*

The Junction Chamber will require excavation of soil and possibly a limited amount of bedrock. Fill underlain by Glacial Deposits with thicknesses of approximately 20-feet and 10-feet, respectively, are expected to be encountered above the bedrock. A few feet of bedrock may need to be excavated at the planned invert. The Fill consists of dense, coarse to fine sand with varying amounts of silt and gravel and contains fragments of brick and glass. Concrete obstructions from remnant foundations should be expected from about 8 feet to 11-feet below the existing grade. The Glacial Deposits consist of very hard silt and dense sand to coarse to fine gravel with varying amounts of sand and silt. The Bedrock consists of strong, purple Siltstone. The groundwater level is anticipated to be about 10-feet below the existing ground surface.

### *5.3.4 Excavation Support and Dewatering*

Excavation support to accommodate construction of Junction Chamber will be provided by a secant pile wall with piles drilled-into sound rock for water tightness, as discussed in Section 3.4.

### *5.3.5 Structural*

The Junction Chamber will be of cast-in-place reinforced concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Analysis will be performed using 3D FEM.

Minimum 28-day compressive strength for concrete design will be 5,000 psi. Reinforcement is to be in accordance with ASTM A615,hot dipped galvanized per ASTM A1094, and placed to achieve a minimum clear cover of 3-inch for any concrete cast against earth or rock, and 2-inch clear cover elsewhere. The structure exterior is to be waterproofed with a bentonite geotextile. PVC water stops will be provided at all construction joints located below design groundwater elevation.

The Junction Chamber will resist uplift by providing a 6-inch extension of the base keyed into the secant pile wall system. Skin friction from adjacent earth will not be permitted in participating in the resistance to uplift. A minimum factor-of-safety of 1.15 shall be achieved to demonstrate adequate uplift resistance when considering the design groundwater elevation.

## 5.4 OF-214 Diversion Structure

Located upstream of the Junction Chamber, and to the north, the OF-214 Diversion Structure serves to divert wet weather CSO flow from OF-214 to the downstream facilities and ultimately to the Tunnel via DS-213. OF-214 Diversion Structure is located east of Roosevelt Avenue Extension in the grassed area owned by the City directly across from Jenk's Way. There is an existing retaining wall to the north and to the east of the structure.

View of City property at location the of OF-214 Diversion Structure - Looking North

### *5.4.1 Structure Description*

The diversion structure will consist of two separate structures. The primary structure has plan dimensions of 11 feet by 14 feet and will be constructed over the existing OF-214 outfall pipe and incorporates the consolidation conduit from the north and the south. The secondary structure has plan dimensions of 8 feet by 8.5 feet and incorporates a flap gate for the upsized overflow pipe to protect against flood waters from entering the system.

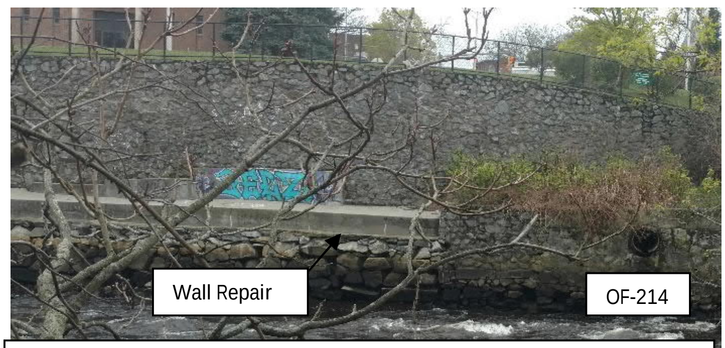
The consolidation conduit enters the primary structure as a 54-inch pipe and exits the structure as a 60-inch pipe to the south. The crown of the consolidation conduit is set at the invert of the existing 30-inch CSO pipe that enters the structure from the west. The overflow for the structure is provided by a 60-inch pipe that exits to the east towards the secondary structure and then towards the river. The invert of the overflow pipe is set at the invert of the existing OF-214 discharge pipe and is approximately 8-feet higher than the 60-inch discharge pipe on the south side of the structure.

When the flow level reaches the invert of the overflow pipe, flow will continue to discharge to the upgraded outfall pipe. Relief of the consolidation conduit is necessary to avoid surcharge and flooding when the tunnel is full and the gate at DS-213 closes. The elevation differential between upstream flow from OF-217 and DS-213 results in surcharge of the conduit when the gate is closed. The OF-214 Diversion Structure is near the low point in the OF-217 consolidation conduit. Increased capacity is therefore required through the OF-214 overflow pipe, necessitating an upsize from 30-inch to 60-inch. The upsizing of the conduit provides adequate relief to the consolidation conduits when the tunnel gate closes during the two-year design storm event. The elevation of the overflow pipe is below the FEMA 100-year flood elevation. To limit the ability of flood waters to enter the into the system, provisions for a flap gate for the overflow pipe are incorporated into the design of the secondary structure.

### 5.4.2 CONSTRUCTION CONSIDERATIONS

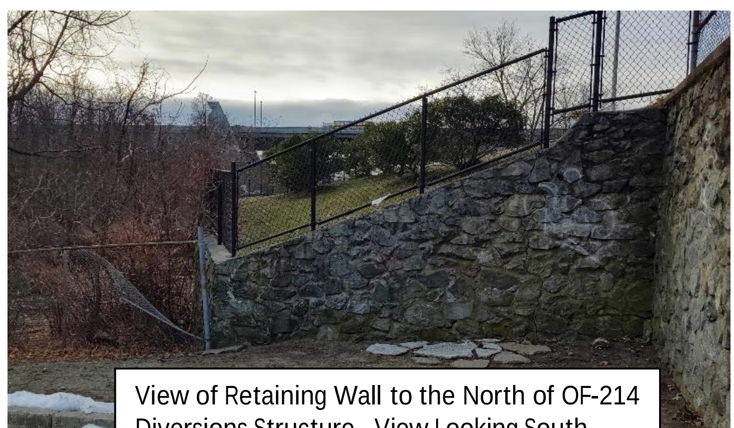
Retaining Wall

There is an existing retaining wall located to the north and east of the OF-214 Diversion Structure. Details of the wall construction are not available. The stone wall was constructed above the river wall and appears to have been built to support earth fill associated with the construction of Jenk's Way and Roosevelt Avenue Ext. to the north. The condition of the wall is variable and has been repaired at least once at the base of the wall near its tallest point. The repaired concrete was observed in the field, south of OF-214. Repair plans prepared by Fuss and O'Neil were also obtained from the City.




View of retaining wall looking west from across the river

The wall to the north is also displaying signs of disrepair, with vertical cracking observed on the face of the wall.



View of Retaining Wall to the North of OF-214 Diversions Structure - View Looking South

Providing adequate space for support of excavation systems and vibrations associated with construction are anticipated to have negative impacts to the wall. Due to the required upgrades to OF-214, a portion of the wall is being identified to be removed and replaced. The remaining sections of the wall will require protection and the means in which that is completed will be left to the contractor, but methods of protection may include those outlined in Table 4-1.

Flow Management

The goal of the flow management scheme is to continue to manage flow through existing pipes and facilities until much of the construction is complete, at which time short system interruptions need to occur with careful planning and a clear understanding of the weather conditions. Flow management includes construction sequencing, employed construction methods, and temporary dams and pipe connections. The flow management considerations presented assume that the downstream tunnel improvements are complete and ready to receive flow. The downstream improvements include the tunnel, pump stations, drop shafts, GSS, junction chamber and associated appurtenances required for operation of the CSO control system. Goal is to manage flow by gravity and avoid having to utilize pumping equipment to convey flow past the work. Further coordination is required with the Tunnel project to determine when it is feasible to convey flow to the tunnel. The inability to convey flow to the tunnel may impact when the diversion weir construction is completed.

It is anticipated that the consolidation conduit and associated diversions structures will be installed from the downstream end and proceed upstream, with the lower elevation sections completed first (i.e. the section south toward the bridges).

Flow management will be critical in the construction of the diversion structures. The cast-in-place structures will be installed around the existing combined sewer outfall pipes, and the outfalls will need to be maintained in service until the structures and connecting consolidation conduit are near complete. OF-214 presents a unique challenge in this regard as the outfall pipe requires replacement.

Managing flow will be considered contractor means and methods. Proposed sequence of construction for OF-214 Diversion Structure is as follows:

- Secure the site
- Excavate and remove retaining wall
- Install excavation support and dewatering systems
- Excavate to expose existing outfall pipe to the discharge
- Disassemble wall at the discharge and fully expose the existing outfall pipe
- Review weather conditions and schedule upgrade of sewer pipe for a dry period
- Install upgraded combined sewer overflow pipe and extend to middle of diversion structure
- Connect existing outfall pipe to new outfall pipe with a temporary sleeve connection and secure.
- Reconstruct wall around the new outfall pipe at the discharge and continue to backfill around new pipe, including construction of a portion of the secondary retaining wall. Continue backfill to the diversion structure,
- Provide support for the existing pipe and install form work and reinforcing for the diversion structure. (potential to fabricate removable temporary section of pipe)
- Pour the base and walls for diversion structure
- Construct invert in the diversion structure for the consolidation conduit
- Install connecting consolidation conduit pipe
- Block consolidation conduit pipe sections
- Review weather conditions and schedule weir wall installation
- Remove temporary outfall pipe from the structure and form and install weir wall
- Remove plugs from consolidation conduit
- Construct concrete ceiling and bring structure to grade
- Backfill around structure

### 5.4.3 *Subsurface Conditions*

The OF-214 Diversion Structure will require excavation of soil. Fill underlain by Glacial Deposits with thicknesses of approximately 19-feet and 7-feet, respectively, are expected to be encountered. The Fill consists of dense, coarse to fine sand and coarse gravel to stiff silt. The Glacial Deposits consist of dense, coarse sand and gravel. The groundwater level is anticipated to be about 10-feet below the existing ground surface.

### 5.4.4 *Excavation Support and Dewatering*

Excavation support to accommodate construction of DS-214 will be required and the methods selected along with their design and execution will be the responsibility of the Contractor.

Active site de-watering will be necessary to install the structure. Permeation grouting may be necessary to improve ground conditions, to reduce permeability in certain areas, and to protect the sections of the wall to remain. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable limits as dictated by the utility owner. Specifications and contractor requirements have been developed but methods selected along with their design and execution will be the responsibility of the Contractor.

### 5.4.5 *Structural*

DS-214 will be of cast-in-place reinforced concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Analysis will be performed using 3D FEM.

Minimum 28-day compressive strength for concrete design will be 5,000 psi. Reinforcement is to be in accordance with ASTM A615, hot dipped galvanized per ASTM A1094, and placed to achieve a minimum clear cover of 3-inch for any concrete cast against earth or rock, and 2-inch clear cover elsewhere. The structure exterior is to be waterproofed with a bentonite geotextile. PVC water stops will be provided at all construction joints located below design groundwater elevation.

DS-214 is designed to resist uplift solely based on self-weight of the permanent structure and overburden on the roof. Skin friction from adjacent earth will not be permitted in participating in the resistance to uplift. A minimum factor-of-safety of 1.15 shall be achieved to demonstrate adequate uplift resistance when considering the design groundwater elevation.

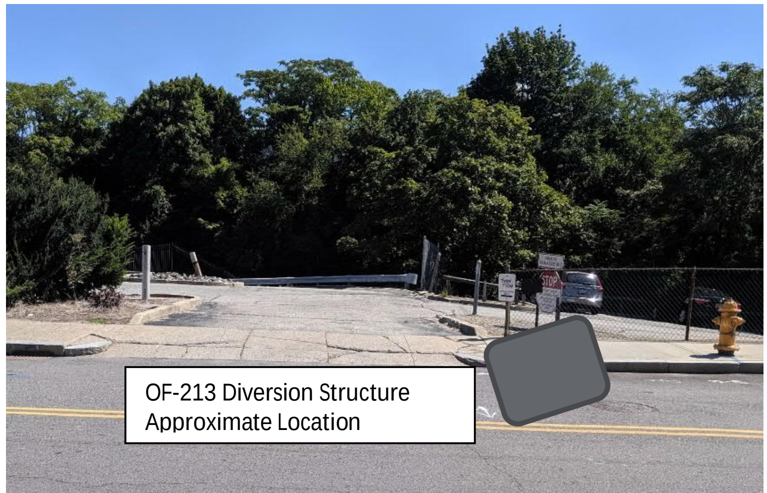
### 5.4.6 *Level Instrumentation*

Level instrumentation for the OF-214 Diversion Structure consists of a non-contact radar transmitter like the VEGAPLUS 66 shall be bracket mounted from the top of the diversion structure. An intrinsically safe output signal from the transmitter shall be hard-wired back to the SCADA control panel PLC I/O modules. A high-level float switch shall be suspended from a bracket mounted to the top of the diversion structure. The output contact from the float switch shall be hard-wired back to the SCADA control panel PLC I/O modules via an intrinsically safe barrier. Control and signaling wire running longer than 1,000-feet shall utilize #14-gauge wire. All other wire runs shall utilize #16-gauge wire.

## 5.5 OF-213 Diversion Structure

Located upstream of the OF-214 Diversion Structure, the OF-213 Diversion Structure serves to divert wet weather CSO flow from OF-213 to the downstream facilities and ultimately to the Tunnel via DS-213. OF-213 Diversion Structure is located east of Roosevelt Avenue Extension immediately south of the parking lot entrance for the Pawtucket Substation no. 2.

Like OF-214, the OF-213 Diversion Structure incorporates the consolidation conduit as it enters the structure from the north and exists the structure to the south.




View of Driveway Entrance to Pawtucket Substation No. 2 - Looking East

### 5.5.1 Structure Description

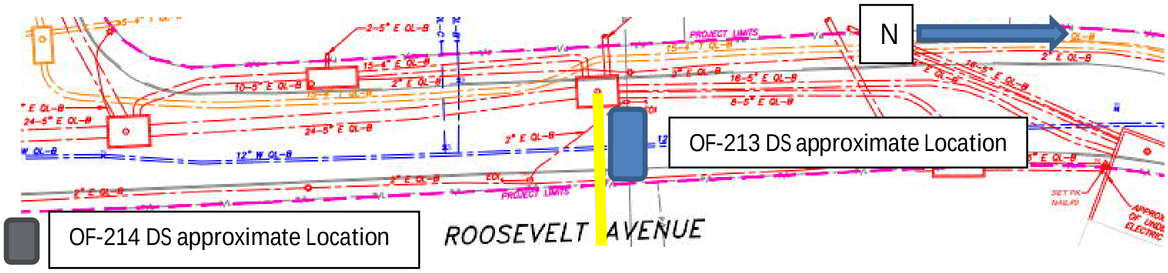
The cast-in-place concrete diversion structure will be constructed over the existing OF-213 outfall pipe and will incorporate the consolidation conduit from the north. The consolidation conduit will enter the structure as a 48-inch diameter pipe and exit the structure as a 54-inch pipe. The crown of the consolidation conduit is set at the crown elevation of the OF-213 30-inch diameter pipe entering the structure from the west. A weir shall be constructed parallel to the consolidation conduit on the east side of the structure to direct flow to the 48-inch diameter discharge pipe on the south side of the structure.

Flow that overtops the diversion weir will continue to discharge to the existing outfall pipe. Relief of the consolidation conduit is necessary to avoid surcharge and flooding when the tunnel is full and the gate at DS-213 closes. The elevation differential between upstream flow from OF-217 and DS-213 results in surcharge of the conduit when the gate is closed.

The structure has a rectangular shape and plan dimensions of 8-feet by 18-feet. The depth of the structure is approximately 20-feet.

### 5.5.2 Construction Considerations

The horizontal alignment for the consolidation conduit is maintained on the eastern side of the northbound lane to avoid electrical duct banks positioned in the center of the roadway and underground communications infrastructure on the western side of the road. Below is a portion of utility research completed by BSI Engineering for the project. The picture depicts the utilities between OF-214 DS and OF213 DS.




Utility conflicts for the OF-213 Diversion Structure as presented include water main and street lighting. The water main is recommended for relocation for approximately 1,000 linear feet of the Contract IIIA-4 project. The disruption to the water system will include a hydrant in this location. An empty duct bank extending to the east is depicted in yellow on the above figure. National Grid has provided authorization to cut and abandon the empty duct to the limits required for construction of the diversion structure. Shallow storm drains will need to be managed during the construction by methods including construction of temporary drainage pipe and structures, temporary isolation of structures and rerouting of flow. It is anticipated that temporary pipe connections will be made to manage flow, until the final connections can be made.


Construction of OF-213 Diversion Structure will obstruct access to the National Grid parking area and the Parcel 584, parking lot. The 584 Parcel parking area shares the entrance with the National Grid Property Parking area to the north. There is opportunity to create a temporary entrance to the National Grid property parking area further to the north. The temporary access requires removal of curbing and sidewalk panels. A similar shared access agreement is required between the two parties for continued access to the Parcel 584 parking area during times when construction obstructs the entrance. Coordination with the Property Owner is required during construction to advise of times when the lot is obstructed, typically associated with retaining wall demolition and/or reconstruction.

Flow Management

Like the OF-214 Diversion Structure construction, the goal of the flow management scheme is to continue to manage flow through existing pipes and facilities until much of the construction is complete. Goal is to manage flow by gravity and avoid having to utilize pumping equipment to convey flow past the work. Further coordination is required with the Tunnel project to determine when it is feasible to convey flow to the tunnel. The inability to convey flow to the tunnel may impact when the diversion weir construction is completed.

The cast-in-place concrete structures will be installed around the existing combined sewer outfall pipes, and the outfalls will need to be maintained in service until the structures and connecting consolidation conduit are complete.

Managing flow is considered contractor means and methods. Proposed sequence of construction for OF-213 Diversion Structure is as follows:

- Secure the site
- The bypass water system has been in place since the start of construction
- Install excavation support and dewatering systems, make penetrations for existing drainage and reconnect
- Excavate to expose existing outfall pipe within the structure limits
- Provide support for the existing pipe and install form work and reinforcing for the diversion structure. (existing pipe is to maintained intact and able to pass flow throughout the construction, or potential to cut out existing pipe and fabricate removeable temporary section of pipe)
- Pour the base and walls for diversion structure
- Construct invert in the diversion structure for the consolidation conduit
- Install connecting consolidation conduit pipe
- Block consolidation conduit pipe sections
- Review weather conditions and schedule weir wall installation
- Remove temporary outfall pipe from the structure and form and install weir wall
- Remove plugs from consolidation conduit
- Construct concrete ceiling and bring structure to grade
- Backfill around structure

### *5.5.3 Subsurface Conditions*

The OF-213 Diversion Structure will require excavation of soil. Fill underlain by Glacial Deposits with thicknesses of approximately 14-feet and 6-feet, respectively, are expected to be encountered. The Fill consists of dense, coarse to fine sand and gravel with fragments of wood. The Glacial Deposits consist of dense, medium to fine sand with some gravel. The groundwater level is anticipated to be about 6-feet below the existing ground surface.

### *5.5.4 Excavation Support and Dewatering*

Excavation support to accommodate construction of DS-214 will be required and the methods selected along with their design and execution will be the responsibility of the Contractor. Active site de-watering will be necessary to install OF-213 Diversion Structure. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas.

### *5.5.5 Structural*

OF-213 Diversion Structure will be of cast-in-place reinforced concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Analysis will be performed using 3D FEM.

Minimum 28-day compressive strength for concrete design will be 5,000 psi. Reinforcement is to be in accordance with ASTM A615, hot dipped galvanized per ASTM A1094, and placed to achieve a minimum clear cover of 3-inch for any concrete cast against earth or rock, and 2-inch clear cover elsewhere. The structure exterior is to be waterproofed with a bentonite geotextile. PVC water stops will be provided at all construction joints located below design groundwater elevation.

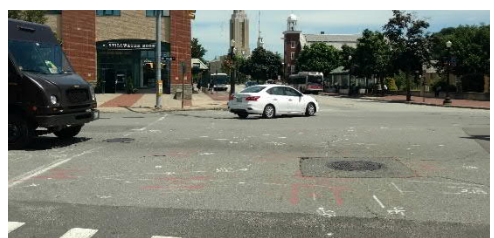
OF-213 Diversion Structure is designed to resist uplift solely based on self-weight of the permanent structure and overburden on the roof. Skin friction from adjacent earth will not be permitted in participating in the resistance to uplift. A minimum factor-of-safety of 1.15 shall be achieved to demonstrate adequate uplift resistance when considering the design groundwater elevation.

### *5.5.6 Level Instrumentation*

Level instrumentation for the OF-213 Diversion Structure consists of a non-contact radar transmitter like the VEGAPLUS 66 shall be bracket mounted from the top of the diversion structure. An intrinsically safe output signal from the transmitter shall be hard-wired back to the SCADA control panel PLC I/O modules. A high-level float switch shall be suspended from a bracket mounted to the top of the diversion structure. The output contact from the float switch shall be hard-wired back to the SCADA control panel PLC I/O modules via an intrinsically safe barrier. Control and signaling wire running longer than 1,000-feet shall utilize #14-gauge wire, while all other wire runs shall utilize #16-gauge wire.

## 5.6 OF-210 Diversion Structure

Located upstream of the OF-213 Diversion Structure, the OF-210 Diversion Structure serves to divert wet weather CSO flow from OF-210 to the downstream facilities and ultimately to the Tunnel via DS-213. OF-210 Diversion Structure is located north of Roosevelt Avenue Extension within the westbound travel lane of Main Street.



View of Main Street Looking North

### *5.6.1 Structure Description*

The OF-210 diversion structure is proposed to be a precast concrete 10-foot diameter manhole to be constructed within the alignment of the existing OF-210 outfall pipe. To accommodate construction of the consolidation conduit and crossing of existing utilities, the required depth of the consolidation conduit exiting OF-210 diversion structure is about 8-feet below the existing OF-210 discharge pipe. To reduce the height of the required drop in the OF-210 diversion structure and improve hydraulic conditions, an upstream manhole to OF-210 diversion structure is proposed. A portion of the drop will be accommodated in the upstream manhole and the remainder will be accounted for in the diversion structure.

A connection to the existing outfall pipe, down-stream of the diversion structure is provided; however, relief of the consolidation conduit from system surcharging is not anticipated at this location based on hydraulic modeling.

The original design concept considered diversion structures for both OF-210 and OF-211, one structure located on each outfall pipe. Due to the utility congestion, it was determined unfeasible to install a diversion structure over OF-211. OF-211 begins downstream of the OF-210 regulator structure at Main Street and Pleasant Street. A weir exists within the OF-210 pipe and directs flow to the OF-211 pipe. It appears that the OF-211 pipe system was installed to provide hydraulic relief to OF-210.

BETA requested assistance from Stantec's hydraulic modeling group to review a condition where the OF-211 pipe was isolated from OF-210, and the OF-210 weir was removed from the pipe. OF-211 would remain and function solely to convey storm drainage. Model results estimate that the OF-210 system can manage flow for the two-year design storm event without overflowing, eliminating the need for a separate diversion structure for OF-211.

Based on this information, the proposed approach for OF-211 is to eliminate the connection with the OF-210 pipe.

### *5.6.2 Construction Considerations*

As discussed in the prior chapter, pipe jacking is proposed for the consolidation conduit approaching Main Street due to the utility congestion. Duct-banks have similar properties to those referenced above and the ability to support these facilities is uncertain when considering open-cut construction techniques.

The picture depicts underground utilities, except for drain and sewer, in the vicinity of the OF-210 Diversion Structure.

BSI Engineering Quality Level B Utility Research

Installation of the OF-210 Diversion Structure will require temporary shutdown of the existing 20-inch diameter cast iron water main. Installation of an insertion valve, west of the work on Main Street, will be required to isolate and remove the water main section within the OF-210 DS excavation. It is anticipated that the water main will be replaced in the same location as the removed section upon construction of the OF-210 DS.

<u>Flow Management</u>

Like the OF-213 Diversion Structure construction, the flow management scheme aims to manage flow through existing pipes and facilities until much of the construction is complete. Goal is to manage flow by gravity and avoid having to utilize pumping equipment to convey flow past the work. Further coordination is required with the Tunnel project to determine when it is feasible to convey flow to the tunnel. The inability to convey flow to the tunnel may impact when the diversion weir construction is completed.

The pre-cast concrete structure is within the alignment of the existing combined sewer outfall pipe and the outfall will need to be maintained in service until the structures and connecting consolidation conduit are complete.

Managing flow is considered contractor means and methods. Proposed sequence of construction for OF-210 Diversion Structure is as follows:

- Secure the site
- Install water insertion valve and restrain pipe to the west on Main Street to allow isolation of the 20-inch water main in the vicinity of the work
- Install excavation support and dewatering systems
- Excavate to expose existing outfall pipe within the structure limits
- Provide support for the existing pipe (existing pipe is to maintained intact and able to pass flow throughout the construction, or potential to cut out existing pipe and fabricate removeable temporary section of pipe)
- Install connecting consolidation conduit pipe (Pipe Jacking)
- install precast diversion structures and connect pipe
- Construct invert in the diversion structure for the consolidation conduit
- Block consolidation conduit pipe section
- Backfill around structure

#### *5.6.3 Subsurface Conditions*

The OF-210 Diversion Structure will require excavation of soil. Fill underlain by Glacial Deposits with thicknesses of approximately 8-feet and 5-feet, respectively, are expected to be encountered. The Fill consists of medium dense, sand with some silt and little gravel. The Glacial Deposits consist of loose sand to very dense, coarse to fine gravel. The groundwater level is anticipated to be about 6 feet below the existing ground surface.

#### *5.6.4 Excavation Support and Dewatering*

Excavation support to accommodate construction of OF-210 Diversion Structure will be required and the methods selected along with their design and execution will be the responsibility of the Contractor.

Active site de-watering will be necessary to install the structure. Permeation grouting may be necessary to improve ground conditions to reduce permeability in certain areas. Utilities not being relocated prior to excavation, will be supported in-place keeping deflections to within allowable limits as dictated by the utility owner. Specifications and contractor requirements have been developed but methods selected along with their design and execution will be the responsibility of the Contractor.

### *5.6.5 Structural*

OF-210 Diversion Structure will be Precast concrete designed in accordance with ACI-350 for strength and durability considering moderate exposure to sulfate containing solutions, both on the interior and exterior, and freeze-thaw where applicable. Loads considered in design will include earth, groundwater, surcharge, earthquake and AASHTO HL-93 truck loading. Exterior of precast chamber to be coated with bitumen modified waterproofing membrane.

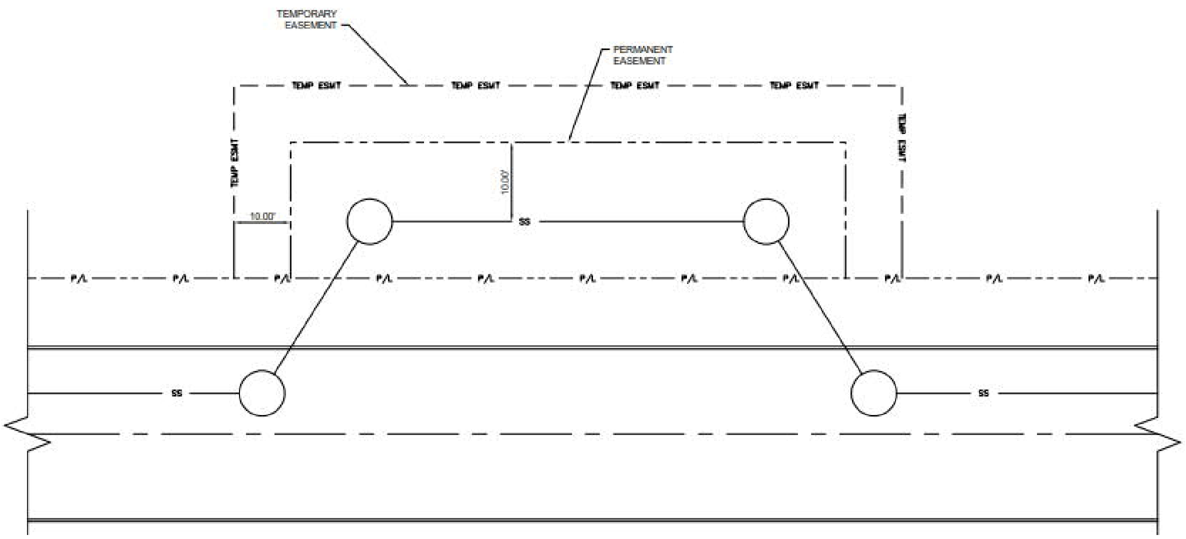
OF-21 Diversion Structure will also be designed to resist uplift either solely based on self-weight of the permanent structure and overburden on the roof, or alternatively by a combination of self-weight of the permanent structure and engaging adjacent overburden by employing an extended base of 6-inches or more. Skin friction from adjacent earth will not be permitted in participating in the resistance to uplift. A minimum factor-of-safety of 1.15 shall be achieved to demonstrate adequate uplift resistance when considering the design groundwater elevation. Contractor is responsible for design of OF-210 following the criteria provided.

### *5.6.6 Level Instrumentation*

Level instrumentation for the OF-210 Diversion Structure consists of a non-contact radar transmitter like the VEGAPLUS 66 shall be bracket mounted from the top of the diversion structure. An intrinsically safe output signal from the transmitter shall be hard-wired back to the SCADA control panel PLC I/O modules. A high-level float switch shall be suspended from a bracket mounted to the top of the diversion structure. The output contact from the float switch shall be hard-wired back to the SCADA control panel PLC I/O modules via an intrinsically safe barrier. Control and signaling wire running longer than 1,000 feet shall utilize #14-gauge wire while all other wire runs shall utilize #16-gauge wire.

# 6.0 Easements

The proposed improvements were positioned, to the extent practical, within the public Right-of-Way. There are locations, however, where the alignment extends onto private property to avoid existing infrastructure that would be costly to relocate, or the relocation of that utility would in-turn need to extend onto private property. Permanent and temporary easements will be required in locations where the contractor's activities are required to extend onto private property for the construction of the improvements. Permanent easements will be required where permanent works extend onto private property. Measured by the square foot, the easement will cover the area occupied by the infrastructure as well as an agreed upon off-set area that will be utilized for future maintenance or access. Temporary easements generally cover areas of private property that will likely be disturbed by contractor activity during the construction of the permanent works. Easement plans for the project are provided in Appendix 7. A schematic of a general easement scenario is provided below.




It is noted that staging and equipment storage areas, required by the contractor, are not addressed here. It is assumed these areas will be arranged by the Contractor independently and they will form a separate Agreement with the property owner.

## 6.1 CITY OF PAWTUCKET

The consolidation conduit, manholes, diversions structures and Junction Chamber will all lie within City streets and the respective rights-of-way. Diversion Structure OF-214, the Junction Chamber and the connecting consolidation conduit are proposed to be within the grassed park area, directly east of Jenk's Way. In addition to the location of the utilities, the construction disturbance associated with installation will expand the limits of disruption for these areas, particularly as it relates to construction in the vicinity of the existing retaining walls.

Based on review of the Pawtucket parcel mapping, the parcel is not defined and has been assumed to be owned by the City of Pawtucket, like a right-of-way. The City has not been approached about utilization of this area for the consolidation conduit, however some form of agreement may be required.

The consolidation conduit, south of the Interstate Rte. 95 Bridge and west of Taft Street, extends onto a parcel identified as property owned by the City. It appears that an easement will be required for this location as well.

| Parcel | Property Owner | Temporary Easement Area (SF) | Permanent Easement Area (SF) |
|---|---|---|---|
| 53-704 | City of Pawtucket | 5,851 | 3,708 |

## 6.2 National Grid

A permanent and temporary construction easement area will be required on Parcel 583 owned by National Grid. A temporary easement at this location will allow parking access to Parcel 53-0584, while an adjacent permanent easement will allow for the installation of the excavation support system for the OF-213 Diversion Structure, which is being constructed in the immediate vicinity of their parking lot entrance.

View of National Grid Parking Entrance – OF-213 DS is adjacent and south of entrance

| Parcel | Property Owner | Temporary Easement Area (SF) | Permanent Easement Area (SF) |
|---|---|---|---|
| 53-0583 | NARRAGANSETT ELECTRIC CO | 2,050 | 103 |

## 6.3 One Fifty Main Inc.& WB&Q LLC.

The consolidation conduit alignment between OF-214 and OF-213 resides partially within the curb line and sidewalk on the east side of Roosevelt Avenue Ext. The work will run parallel to Parcel 584 owned by One Fifty Main Inc. & WB & Q LLC. The Parcel contains a parking area that is bounded on the south and west sides by a variable height retaining wall on the back side of the sidewalk on Roosevelt Avenue Ext. Since a property survey has not been conducted as of this time it is not clear whether the City owns the wall or if it is owned by the property owner.

Due to its proximity to the work it is likely that the wall will experience some damage during the construction of the consolidation conduit and the OF-214 Diversion Structure. The wall repair work will require access and occupancy of the site therefore a temporary easement will be required.

View of Parcel 584 Retaining Wall – Looking south

| Parcel | Property Owner | Temporary Easement Area (SF) | Permanent Easement Area (SF) |
|---|---|---|---|
| 53-0584 | ONE FIFTY MAIN INC & WB & Q LLC | 10,780 | 197 |

## 6.4 State of RI and Providence Plantations

The consolidation conduit, beneath the I-95 Bridge, extends onto property owned by the State of Rhode Island, west of Taft Street.

| Parcel | Property Owner | Temporary Easement Area (SF) | Permanent Easement Area (SF) |
|---|---|---|---|
| 54-703 | State of RI and Providence Plantations | 4,046 | 3,079 |

# 7.0 ENVIRONMENTAL CONDITIONS

Performed In conjunction with the subsurface investigation work, BETA conducted an Environmental Investigation program within the Project area. The purpose of the Environmental Investigation program was to identify areas and potential areas of soil and/or groundwater contamination that may be encountered during construction activities. The program sought to identify potential contamination through research of historical information and databases, site reconnaissance, and soil and groundwater sampling and analysis.

The Environmental Investigation was performed in accordance with the "NBC Phase III CSO Program Consolidation Conduits Phase IIIA-4 and IIIA-5, Subsurface Investigation Work Plan", by McMillen Jacobs Associates, revised July 1, 2019. A summary of findings is presented in the "NBC Phase III Consolidation Conduits IIIA-4 and IIIA-5, Environmental Technical Memorandum", by BETA Group, Inc., dated March 30, 2020. The following summarizes the environmental conditions in the project area, conclusions, and recommendations.

Historic research identified several properties along the proposed project route with known releases and the potential to impact the property. The project runs along one of these, Town Landing, which is an active remediation site with the Rhode Island Department of Environmental Management (RIDEM) and through an area where RIDOT implemented a Remedial Action Work Plan for the construction of the I-95 bridge. The following summarizes info for these two properties:

- BETA reviewed a "Site Investigation Report/Targeted Brownfields Assessment" prepared by Fuss & O'Neill for the Town Landing property. This report included laboratory data from four soil borings near the proposed layout on the Town Landing property. The data indicated concentrations of lead and polynuclear aromatic hydrocarbons (PAHs) in soil.
- BETA reviewed a letter from RIDEM approving a Remedial Action Work plan for Pawtucket Bridge #550 and reports relating to the project including an August 2009 "Site Investigation Report" for the RIDOT Pawtucket Bridge #550 Replacement and Improvements project prepared by Wright-Pierce, Inc. This report included results from two soil borings (WP-7 and WP-8) that were advanced in Taft Street under the Route 95 bridge and just north of Division Street. Laboratory analysis of a soil sample from WP-7 (5 to 7 feet below grade) identified arsenic, lead, chrysene, and benzo(a)pyrene above RIDEM's RDEC. Laboratory analysis of a second soil sample from WP-7 (9 to 10 feet below grade) identified chrysene above RIDEM's RDEC. Laboratory analysis of a soil sample from WP-8 (10 to 12 feet below grade) identified arsenic above RIDEM's RDEC. Sampling of groundwater from a well installed in boring WP-7 did not identify contaminants above RIDEM's GB groundwater criteria.

A Remedial Action Work Plan prepared by Wright Pierce, Inc. indicated that an ELUR would likely be filed for the Taft Street bridge abutment area; however, a copy of the ELUR was not in RIDEM's file. Mr. Jeff Crawford of RIDEM indicated that the ELUR had not yet been filed for this area. BETA was provided with a draft of the ELUR and Post Remediation Soil Management Plan (SMP). Based on the information reviewed, it is likely that contaminated soil will be encountered during excavation work in this area. Furthermore, even though the ELUR has not been filed, work in this area should adhere to the provisions of the ELUR and SMP.

In August and September 2019 and February 2020, BETA oversaw the advancement of six (6) soil borings with installation of monitoring wells in two of these borings.

BETA submitted soil samples from each split spoon collected during the first ten feet of borings B-4, B-5, B-6, B-6A, B-7, and B-8 to ESS Laboratory (ESS) of Cranston, Rhode Island for analysis of thirteen priority pollutant metals (PP-13) by EPA Method 6010B, total petroleum hydrocarbons (TPH) by EPA Method 8100M, volatile organic compounds (VOCs) by EPA Method 8260B, semi-volatile organic compounds (SVOCs) by EPA Method 8270D, and polychlorinated biphenyls (PCBs) by EPA Method 8082A.
The laboratory identified thirty-one (31) detections of eleven compounds from four of the six borings that exceeded RIDEM's Residential Direct Exposure Criteria (RDEC). The results of each sample analysis are included in the Environmental Technical Memorandum, Appendix 8.

The Technical Memorandum (TM) contains summaries and a table detailing the results of the soil laboratory analysis. The following table summarizes the maximum detected concentrations for each of the eleven compounds that had exceedances of the RIDEM standards. This table also includes the limits for acceptance as Alternative Daily Cover at the Rhode Island Resource Recovery Corporation's (RIRRC's) landfill in Johnston, Rhode Island.

| | Maximum Concentration | RIDEM RDEC | RIDEM ICDEC | RIRRC Alternative Daily Cover |
|---|---|---|---|---|
| Semi-Volatile Organic Compounds, mg/kg | | | | |
| Benzo(a)anthracene | 2.29 | 0.9 | 7.8 | NE |
| Benzo(a)pyrene | 1.98 | 0.4 | 0.8 | 4 |
| Benzo(b)fluoranthene | 1.49 | 0.9 | 7.8 | NE |
| Benzo(g,h,i)perylene | 1.11 | 0.8 | 10,000 | NE |
| Benzo(k)fluoranthene | 2.07 | 0.9 | 78 | NE |
| Chrysene | 2.04 | 0.4 | 780 | NE |
| Dibenzo(a,h)Anthracene | 0.51 | 0.4 | 0.8 | NE |
| Indeno(1,2,3-cd)Pyrene | 1.1 | 0.9 | 7.8 | NE |
| Total SVOCs | 25.3 | NE | NE | 100.0 |
| Total Petroleum Hydrocarbons, mg/kg | | | | |
| TPH | 1,850 | 500 | 2,500 | 2,500 |
| Total Metals, mg/kg | | | | |
| Arsenic (*) | 52.5 | 7 | 7 | 19 |
| Lead | 153 | 150 | 500 | 2,000 |
| Toxicity Characteristic Leaching Procedure Metals, mg/L | | | | |
| Lead | 0.054 | 5 (EPA) | | <5 |

(*) The arsenic concentration presented is from boring B-7 at a depth of 6-10 feet.

Based on a review of the results, the arsenic concentration from test boring B-7 is the only contaminant that exceeds the RIRRC's Alternative Daily Cover limit. Soil from this area may require an alternate disposal option. Results of soil analyses from the other test borings are below the RIRRC Alternate Daily Cover Criteria. The next highest concentration of arsenic was 16.8 mg/kg.
BETA collected groundwater samples from the two wells and submitted them to ESS for analysis of the PP-13 metals by EPA Method 6010B, TPH by EPA Method 8100M, VOCs by EPA Method 8260B, SVOCs by EPA Method 8270D, and PCBs by EPA Method 8082A.

The TM contains summaries and a table detailing the results of the groundwater laboratory analysis. The following table summarizes the results. This table also includes the limits for discharge to the NBC's Bucklin Point system.

<table>
<tr><td>Sample Designation</td><td>MW-4</td><td>MW-7</td><td rowspan="2">RIDEM GB Objective</td><td rowspan="2">NBC BPWWTF Local Limits (*)</td></tr>
<tr><td>Sample Date</td><td>03/12/2020</td><td>03/12/2020</td></tr>
<tr><td colspan="4">Volatile Organic Compounds, micrograms per liter (µg/L)</td><td rowspan="7">2,130<br>(Total Toxic Organics)</td></tr>
<tr><td>Chloroform</td><td>ND</td><td>2.1</td><td>NE</td></tr>
<tr><td>Trichloroethene</td><td>ND</td><td>1.6</td><td>540</td></tr>
<tr><td colspan="4">Semi-volatile Organic Compounds, µg/L</td></tr>
<tr><td>Benzo(b)fluoranthene</td><td>0.5</td><td>ND</td><td>NE</td></tr>
<tr><td colspan="4">Polychlorinated Biphenyls (PCBs), µg/L</td></tr>
<tr><td>PCBs</td><td>ND</td><td>ND</td><td>NE</td></tr>
<tr><td colspan="5">Total Petroleum Hydrocarbons (TPH), µg/L</td></tr>
<tr><td>TPH</td><td>ND</td><td>ND</td><td>NE</td><td>125,000</td></tr>
<tr><td colspan="5">Total Metals, µg/L</td></tr>
<tr><td>Antimony</td><td>ND</td><td>ND</td><td>NE</td><td>NE</td></tr>
<tr><td>Arsenic</td><td>3</td><td>2.7</td><td>NE</td><td>200</td></tr>
<tr><td>Beryllium</td><td>ND</td><td>ND</td><td>NE</td><td>NE</td></tr>
<tr><td>Cadmium</td><td>ND</td><td>ND</td><td>NE</td><td>110</td></tr>
<tr><td>Chromium</td><td>10.1</td><td>ND</td><td>NE</td><td>2,770</td></tr>
<tr><td>Copper</td><td>13.4</td><td>14.2</td><td>NE</td><td>1,200</td></tr>
<tr><td>Lead</td><td>ND</td><td>17.5</td><td>NE</td><td>690</td></tr>
<tr><td>Mercury</td><td>ND</td><td>ND</td><td>NE</td><td>60</td></tr>
<tr><td>Nickel</td><td>ND</td><td>ND</td><td>NE</td><td>1,620</td></tr>
<tr><td>Selenium</td><td>ND</td><td>ND</td><td>NE</td><td>400</td></tr>
<tr><td>Silver</td><td>ND</td><td>ND</td><td>NE</td><td>400</td></tr>
<tr><td>Thallium</td><td>ND</td><td>ND</td><td>NE</td><td>NE</td></tr>
<tr><td>Zinc</td><td>ND</td><td>27.9</td><td>NE</td><td>1,670</td></tr>
</table>

(*) Bucklin Point Wastewater Treatment Facility

Based on the investigatory activities conducted in support of the NBC Phase III CSO Consolidation Conduits IIIA-4 project, BETA makes the following conclusions:

- Contaminated soil and groundwater may be encountered during work on the Town Landing and RIDOT I-95 properties.
- Laboratory analysis of soil samples identified concentrations of lead, arsenic, TPH, and SVOCs above the applicable RIDEM RDEC in four of the six boring locations along Taft Street and Roosevelt Avenue Extension (B-4, B-5, B-7, and B-8).
- In addition, benzo(a)pyrene was identified in concentrations in excess of the applicable RIDEM Industrial/Commercial Direct Exposure Criteria (ICDEC) (0.8 mg/kg) in samples B-5 4-6 ft (1.98 mg/kg) and B-7 6-10 ft (1.70 mg/kg). Arsenic was identified in concentrations in excess of the applicable RIDEM ICDEC (7 mg/kg) in samples B-4 6-10 ft (7.69 mg/kg), B-7 2-4 ft (9.20 mg/kg), B-7 4-6 ft (8.15 mg/kg), B-7 6-10 ft (52.5 mg/kg), B-8 0-2 ft (9.94 mg/kg), B-8 4-6 ft (16.8 mg/kg), and B-8 6-10 ft (12.4 mg/kg).
- The arsenic concentration from test boring B-7 is the only contaminant that exceeds the RIRRC's Alternative Daily Cover limit. Soil from this area may require an alternate disposal option.
- Laboratory analysis of groundwater samples did not identify exceedances of RIDEM's GB groundwater objectives.

Instructions for the contractor to manage his operations and address contaminated soil and dewatering effluent will be provided in the Contract documents. BETA makes the following recommendations for the project:

- Even though the ELUR has not been filed for the I-95 area, work in this area should adhere to the provisions of the ELUR and SMP which include:
    - Notification to RIDEM prior to initiating work
    - Appropriate work health and safety provisions
    - Reuse of soil is allowed
    - Dust suppression during excavation
    - Excess soil to be placed on and covered with 10 mil poly sheeting
    - Equipment decontamination, and
    - Restoration of areas to their original conditions.
- The identified soil concentrations in the samples from B-4, B-5, B-7 and B-8 should be reported to RIDEM. It is likely that RIDEM will require a Short-Term Response Action Plan (STRAP) to address the contamination that will be encountered during the project.
- Contractors will need to develop Health and Safety Plans and Soil Management Plans that address contaminants identified in the soil samples analyzed for this project;
- Soil management will consist of excavation of impacted soil, stockpiling at locations to be determined, backfilling with excavated soil to the extent possible, and backfilling with documented clean fill if needed. Disposal of soil will be at approved facilities based on the results of stockpile sampling.
- Groundwater dewatering will require treatment prior to discharge to the NBC system. The contractor will be required to design a treatment system to meet NBC's Bucklin Point Wastewater Treatment Facility Local Limits. Treatment systems may include settling tanks, bag filtration, and

carbon treatment. Effluent sampling will include twelve metals, VOCs, SVOCs, PCBs, TPH, total suspended solids, and pH.

# 8.0 RISK MANAGEMENT

As is the case with every project, risk is an ever present and inherent part of the design and construction industry. To determine how risk may affect a project, risks must be identified, then evaluated for their likelihood of a particular risk event occurring and the anticipated impact to the project cost and project schedule should said event take place. A risk management strategy and associated approach must be identified for each risk and the residual risk likelihood and impacts to cost and schedule, post-risk management, must be assessed.

BETA has identified several risks related to the overall Project and have cataloged them in a Risk Register. The Risk Register categorizes these risks into several different categories, specifically Safety, Planning & Permitting, Procurement, Design, Construction, Environmental, Stakeholder Engagement, Financial, Land Acquisition/Easements/Right of Entry, and Operations & Maintenance. The likelihood of each risk is assessed, ranging from “Rare” (1% chance of occurring) to “Probable” (70% chance of occurring) and assigned a corresponding likelihood score ranging from 1 to 5, with 1 being the least likely to occur of occurrence and 5 being the most likely to occur. Cost and schedule impacts associated with risk event are assessed, ranging from “Very Low” (<$100k for cost, <15 days for schedule) to ”Very High” (>$2.5M for cost, >90 days for schedule). Cost and schedule are each assigned a corresponding score based on the identified impact ranging from 1 to 100, with 1 representing the lowest impact to cost or schedule and 100 representing the highest impact.

The Cost Risk Level and Schedule Risk Level are calculated for each risk based on the risk’s likelihood score and cost and schedule scores.

$$\text{Cost Risk Level} = \text{Likelihood Score} \times \text{Cost Score}$$

$$\text{Schedule Risk Level} = \text{Likelihood Score} \times \text{Schedule Score}$$

The Cost Risk Level and Schedule Risk Level are used to evaluate the risks across all the various risk categories to identify which risks pose the highest threat to the project.

For each risk, a strategy is identified as to how the risk would be managed if such an event occurred, as well as an approach defined to better clarify some of the mechanisms of risk transfer and proposed measures for risk mitigation. The risk strategies employed for this project include:

- Transfer – Transferring a risk involves assigning the risk to another party usually through contractual terms or through insuring against a particular risk or threat.
- Avoid – Avoiding a risk event involves not performing the activity for which the risk affects or advancing an alternative that eliminates the risk.
- Mitigate – Mitigating a risk involves specifying measures to reduce the likelihood and/or consequence of a risk occurrence.
- Accept – Accepting the consequences and associated impacts shoud a risk event occur

The risk status is also identified. Many of the risks are simply identified as potential risks. Other risks have already occurred on the project. They are active and currently being mitigated, accepted, transferred, or avoided. Risks that did not occur over the life of the project are identified as "Expired". Risks that have occurred and the strategy is complete are considered closed. Currently, many risks have simply been identified with a risk strategy to be implemented at a later date. However, some identified risks have occurred and the risk management strategies actively implemented.

Ideally, the implementation of a risk management strategy will reduce the risk level from its pre-managed identified risk levels, either by reducing the likelihood that the risk event will occur or by reducing the cost and/or schedule impact to the project. However, most risks will have a residual risk component after risk management strategies are implemented. Likelihood of occurrence, cost impacts, and schedule impacts for each risk are reevaluated after chosen risk strategies are implemented and scored in the same manner as when the risks were intitially identified. Corresponding Cost Risk Levels and Schedule Risk Levels are calculated in the same manner as when the risks were initially identified. Based on the resulting Levels, one can again compare risks across the various risk categories to identify which risks pose the highes threat to the project and may require further investigation.

Currently, forty (40) risks have been identified and included in the risk register. Four of these risks are confirmed as "Active" and two risks have "Expired". A summary of the risks identified are summarized below.

The highest risks with respect to cost impacts (post-mitigation) are presented below:

| Risk | Status | Cost Risk Level | Risk Mgmt Strategy |
|---|---|---|---|
| Presence of bedrock identified | Active | 250 | Accept |
| Pedestrian accident due to construction activities | Identified | 160 | Transfer |
| Existing utility information is inaccurate | Active | 150 | Mitigate |
| Electrical vault beneath I-95 bridge damaged | Identified | 150 | Avoid |

The highest risks with respect to schedule impacts (post-mitigation) are presented below:

| Risk | Status | Schedule Risk Level | Risk Mgmt Strategy |
|---|---|---|---|
| Stakeholder-requested scope changes | Active | 400 | Accept |
| Presence of bedrock identified | Active | 250 | Accept |
| OF-214 - Stone Retaining Wall impacted by structure construction | Identified | 250 | Accept |
| Insufficient groundwater management for utility tunnel between GSS and Junction Chamber | Identified | 200 | Transfer |

The Risk Register and associated basis documentation is provided as *Appendix 9.*

# 9.0 TRAFFIC MANAGEMENT

Maintenance of vehicular, bicycle, pedestrian traffic around the work zone and construction activities is critical to the public safety with respect to the project. BETA has prepared a traffic management plan based on currently proposed construction locations and activities. Vehicular traffic management shall consist of shoulder and lane closures, lane shifts, and temporary road closures and detours. Temporary road closures shall only be utilized when a minimum one 11-foot travel lane cannot be maintained for either one-way or alternating one-way traffic. In addition, temporary road closures shall allow local traffic to access abutting properties as indicated on the traffic management plans. Pedestrian and bicycle traffic management shall consist of sidewalk and bicycle route detours and diversions.

## 9.1 VEHICULAR

The proposed work will impact vehicular traffic along Taft Street and Roosevelt Avenue that includes lane shifts, lane and shoulder closures, and roadway closures. The initial analysis of work along Taft Street/Roosevelt Avenue identified in the Tech Memo did not include a full road closure along the segment between Tidewater Street and Main Street. It was anticipated based upon trench and construction zone requirements that at a minimum one 11-foot travel lane could be maintained for either one-way or alternating one-way traffic as necessary.

Further development of the design and consideration of the required support equipment for the work has reduced the potential to maintain a lane of travel to accommodate traffic (vehicular/bicycle/pedestrian) within the work zone. BETA has developed separate detour plans, if temporary road closure is necessary, for two segments along the westerly side of the Blackstone River including Taft Street (TTC Plan 1) and Roosevelt Avenue (TTC Plan 2). The vehicle traffic detour is based on closure by segment along Taft Street and Roosevelt Avenue and are as follows; Detour Plan 1 consist of closure to through traffic along the section of Taft Street between Spencer Street and Jenks Way with the detour route via Pleasant Street; Detour Plan 2 consist of closure to through traffic along the section of Roosevelt Avenue between Jenks Way and Main Street with the detour route via Pleasant Street/East Avenue; and Detour Plan 3 consist of closure of the Main Street eastbound lanes at the intersection with Roosevelt Avenue while allowing westbound through traffic at the intersection. Detour for the closure of the Main Street eastbound traffic at the intersection with Roosevelt Avenue will be routed to the north via High Street, Exchange Street, and Roosevelt Avenue. In addition, it is anticipated that daily access to abutting properties will be impacted and as a result, a provision is included to ensure the Contractor's responsibility of notifying abutters 48 hours in advance of the start of any work that may require temporary daily interference with or closure of site access. In addition, further review of the proposed work at and/or in the vicinity of access points to abutting properties will be completed to determine the impacts to parking lots. Parking mitigation plan, where necessary, will be provided as the design progresses.

The initial traffic analysis included with the Conceptual Design Report considered the complete closure of Jenks Way due to expected impacts associated with the location of structures, GSS, and drop shaft installations proposed within the roadway proper. The current design relocated these structures out of the roadway into an adjacent property owned by the NBC, eliminating the need for short- and long-term closure of Jenks Way.

Preliminary detour plans and typical temporary traffic control plans in accordance with The Manual on Uniform Traffic Control Devices (MUTCD), latest edition, have been prepared and are included in the design submission. Additional details and provisions will be provided as the design progresses.

### 9.2 Pedestrians

Sidewalks are provided on both sides of Taft Street and Roosevelt Avenue within the construction zone limits. It is anticipated that sidewalks will be closed to pedestrians daily as needed in short segments along both Taft Street and Roosevelt Avenue requiring detours. Typical Sidewalk Detour and Diversion details are provided in the current submission and will be implemented by the Contractor on a day-by-day basis dependent upon construction activities. Sidewalk closures requiring crossings will be provided at an existing marked crosswalk. Pedestrians will be provided accessible routes in accordance with provided contract specifications that are compliant with the American with Disabilities Act (ADA) guidelines.

### 9.3 Bicyclist

Taft Street/Roosevelt Avenue within the project area provides for an on-street bike route as part of a shared vehicular/bicycle lane. The bike route between Main Street and I-95 is delineated by lane markings ("sharrows") which transition to separate dedicated bike lanes in each direction to the south of I-95 extending south to Tower Street.

During construction where separate bike lanes are temporarily closed due to narrowing in the construction zone, but vehicle travel lanes are maintained, bicycles will be permitted to operate in a "shared lane" with vehicles through the work area similar to existing conditions north of I-95. In addition, if a bicycle detour is required as a result of roadway closure, bicycles will be directed to use the vehicle detour and operate as a vehicle through the detour route. Applicable MUTCD details with signage for direction of bicycle users will be provided in the TTC plans.

## 10.0 Opinion of Probable Construction Cost and Schedule

An Opinion of Probable Construction Costs (OPCC) has been prepared for the 60% design and is included as Appendix 10. The OPCC is a Class 3 Cost Estimate prepared in accordance with the Association for the Advancement of Cost Engineering (AACE) International Recommended Practice 18R-97.

The Engineers' Opinion of Probable Capital Costs for infrastructure are initially developed as part of the planning process. As the project progresses, it is critical that these costs are updated and refined at each stage of the planning and design process to accurately reflect items that may impact them. Items that could impact cost include, but are not limited to:

- Changes in bidding climate and tariffs.
- Design changes resulting from planned property development.
- Owner-driven decisions and changes.

The 60% Design level OPCC includes a 20% design contingency to cover undeveloped parts of the project and bidding variability. Cost elements that are known to require further development include water main improvements, and wall protection, reconstruction, and repair. During final design, a reduced contingency will be carried, as more design details will be addressed. The final design contingency is primarily for variability in the bidding climate, project changes before bidding, and change orders due to unforeseen conditions.

A summary of the costs presented at each design level OPCC is summarized in the Table below.

| | DCR | | 30% Design | | 60% Design | |
|---|---|---|---|---|---|---|
| Opinion of Probable Construction Cost (OPCC)* | $8,400,000 | | $19,500,000 | | $18,100,000 | |
| AACE Class | 5 | | 4 | | 3 | |
| Accuracy Range | (-50%) | 100% | (-30%) | +50% | (-20%) | +30% |
| OPCC Range | $4,200,000 | $16,800,000 | $13,650,000 | $29,250,000 | $14,480,000 | $23,530,000 |

The OPCC for the project decreased from $19.5 M at the 30% Design level to $18.1 M at the 60% Design level, a decrease of approximately $1.4 M. In comparing the OPCCs from the 30% Design and the 60% Design, the change in project costs are largely attributed to management of the retaining wall. At the 30% design stage the design called for removal and replacement of the retaining wall at an estimated cost of $1.4M. Management of the existing retaining wall was reevaluated following reconfiguration of the alignment of the consolidation conduit and reduction in the size of the Junction Chamber. The plan for protection of the existing retaining wall is presented in Table 4-1.

Refer to Appendix 11 for the Opinion of Probable Construction Schedule. Information relative to the Tunnel project schedule was not a consideration in the schedule presented. It is anticipated that the construction schedule will be coordinated with the tunnel construction, and Drop Shaft 213 specifically, as the design progresses to 90%. The schedule provided is linear with generally one operation occurring at a time and limited overlap of activities. There are opportunities to compress the schedule and as the design progresses, we will evaluate the benefits of a second operation that would advance construction on the north side of the junction chamber at the same time construction operations are active on the south side of the junction chamber. The primary impacts generated by the second operation will be associated with traffic. The feasibility of a traffic detour that extends the full length of the project will be evaluated. In addition, the potential impacts associated with interruptions to the water utility will also be evaluated.

# 11.0 References

Stantec

- "Phase III CSO Program, Conceptual Design for Consolidation Conduits and Regulator Modifications - Technical Memorandum, January 25, 2019" for the Narragansett Bay Commission, prepared by Stantec

RIDOT

- "RI Department of Transportation, Plans, Profiles and Sections of Proposed Bridge Replacement, Pawtucket Bridge No. 550, I-95 Over the Seekonk River, Volume 3 Bridge Plans, RI Contract No. 2010-CB-004, FA Project Nos. BRO-0550(003), IM-0550(004), IMG-0550(005), Length =0.9 miles, Commonwealth Engineers and Consultants, Inc. Providence RI, April 2010"
- "RI Department of Public Works, Division of Roads and Bridges, Plan, Profile and Sections of Proposed State Highway, Division St. Project, Contract Three, RIFA Project NO. I-01(11) Length 0723 Miles, Contract Number 5753, April 1957"
- "Construction Stage Soil Management Plan for the Pawtucket River Bridge #550 Replacement and Improvements, For Commonwealth Engineers and Consultants, Inc., DEM Case #2009-13, August 2009" by Wright Pierce
- Site investigation Report of the Phase II and III ESA Work Associated with Pawtucket Bridge #550 Replacement and Improvements for Commonwealth Engineers and Consultants, Inc., DEM Case #2009-13, Volume 1 and Volume 2, August 2009" by Wright Pierce
- Remedial Action Work Plan for the Pawtucket Bridge #550 Replacement and Improvements for Commonwealth Engineers and Consultants, Inc., DEM Case #2009-13, October 2009, Revised December 2009" by Wright Pierce

City of Pawtucket

- City of Pawtucket, Seekonk/Blackstone River Wall Repair Project, June 10, 2011, prepared for: City of Pawtucket, Prepared by: Fuss and O'Neill Inc.