5 December 2018

Boston Conservation Commission
City of Boston Environment Department
Boston City Hall, 1 City Hall Square, Room 709
Boston, MA 02201

Project 171860 – Draw Seven Park Path Extension, Boston, MA

To whom it may concern:

Please see the attached "Final Drainage System Improvements Report", prepared by C&C Consulting Engineers, dated February 2017, which was approved by the Boston Conservation Commission for the Shoreline Stabilization Project at the MBTA Charlestown Bus Facility (DEP File No. 006-1501). The route for the proposed Draw Seven Park Path Extension multi-use pathway was accommodated for in the Shoreline Stabilization Project documents with a proposed dedicated easement along the Mystic River and is referenced on page 1-1 of the attached stormwater report.

We are submitting the enclosed Notice of Intent (NOI) package for the construction of the proposed multi-use pathway within the above-referenced proposed easement. The drainage improvements associated with the proposed pathway consist of permeable pavement and perforated underdrains to promote recharge into planting soils in the shoreline embankment. The proposed pathway improvements will add de minimus impervious area to the site and maintain the routing of runoff flows proposed in the shoreline improvement project. We summarized the project's compliance with the MA DEP Stormwater Management Standards in Attachment G of the NOI package. It is our understanding that a comprehensive stormwater management report is not required due to the nature of the improvements and the limited modifications to the approved Shoreline Stabilization design.

We will happy to answer any follow-up questions in our meeting with the Commission.

Sincerely yours,

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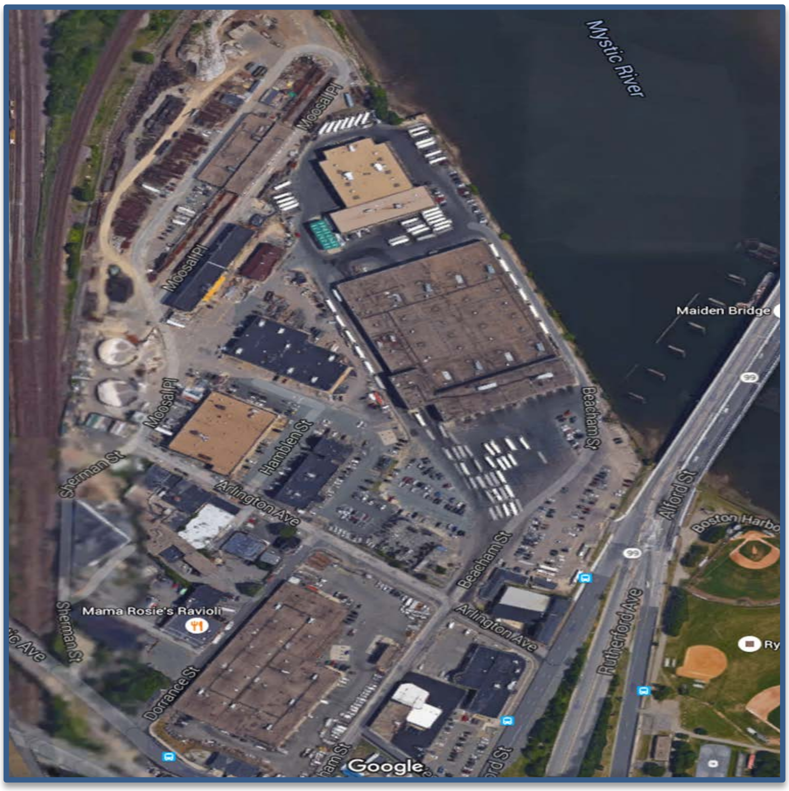
MBTA GEC Task 11 – MBTA Charlestown Bus Garage Shoreline Stabilization and Yard Improvements MBTA Contract No. Z92PS66

FINAL DRAINAGE SYSTEM IMPROVEMENTS REPORT

February 2017



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C&C
CONSULTING ENGINEERS, LLC

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1 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Massachusetts Bay Transportation Authority (MBTA) proposes the replacement of the existing sea wall and other site improvements/repairs at its Charlestown Bus Maintenance Facility and adjoining Engineering Rail Yard. As shown on Figure 1-1, the project site is on MBTA property generally located immediately north of Alford Street in the Charlestown neighborhood of Boston, west of the Mystic River, south of the MBTA Commuter Rail tracks to the north shore, and east of Arlington Street in the Boston, MA neighborhood of Charlestown and in the City of Somerville. The existing parcels of land cover a total of approximately 30 acres in both the cities of Boston and Somerville.

The MBTA has hired a consulting engineering team headed by Simpson Gumpertz & Heger, Inc. (SGH) to prepare a 100% Design, following a Phase I Investigative Phase (15%) and 30% Design Phase. The SGH Team's scope of work addresses improvements and repairs needed in the Project Area identified on Figure 1-1 as the Bus Operations Area and the Engineering Rail Yard. The team proposes to install a new embankment and flood wall along the Mystic River from Alford Street in the south to the MBTA Commuter Rail bridge embankment to the north. This new embankment/flood wall will be constructed along the entire river front to protect the site from projected future sea level rise.

C&C Consulting Engineers, LLC, as subconsultant to SGH, is responsible for the design of drainage system and site improvements, along with the preparation of this Drainage System Improvements Report. Drainage improvements will be constructed to convey and treat as needed the projected stormwater runoff from the entire storm drainage system, with new outfalls constructed through the new embankments. Some of the outfalls discharge stormwater conveyed through the storm drainage system from areas beyond the Project Area. This area (approximately 13 acres) is identified on Figure 1-1 as the "Off-Site Drainage Area". When the Off-Site Drainage Area is combined with 16.4 acres in the Bus Operations and 4.5 acres in the Engineering Rail Yard, the total area drained through the nine outfalls is approximately 34 acres. A tenth existing outfall, located near the Alford Street Bridge in the MassDOT right-of-way, will be impacted by the proposed embankment and will be extended at the current pipe diameter and slope.

As another element of the project, the proposed embankment improvements will provide for construction of a new multi-use pathway along the riverfront of the site for the Massachusetts Department of Conservation and Recreation (DCR). This pathway will provide a critical (and heretofore missing) link between the existing DCR bike and pedestrian pathways in Somerville (underneath the MBTA Commuter Rail Bridge over the Mystic River) and in Boston (Alford Street).

Collectively, the shoreline stabilization, stormwater, and other improvements are referred to as the Charlestown Bus Facility – Shoreline Stabilization and Yard Improvements Project (the "Project").

Figure 1-1. Charlestown Bus Garage Locus Plan

1.2 Project Goals

The purpose of this drainage study is to evaluate and recommend practicable, cost effective solutions to repair and improve the current stormwater drainage system. Existing stormwater pipes, manholes, and catch basins that are damaged will be repaired or replaced, system improvements will be made as needed for the recommended site improvements, and current stormwater Best Management Practices (BMPs) will be evaluated and implemented in compliance with the Massachusetts Department of Environmental Protection's (MassDEP) current Stormwater Management Standards. In particular, as a "redevelopment project" as defined by Standard 7, the study seeks to demonstrate that the recommended improvements meet the applicable stormwater standards "to the maximum extent practical".

For example, all catch basins proposed to be replaced by the Project will be deep sump catch basins with hooded outlets to facilitate the capture of solids and road oils. This small change will immediately add an increase in stormwater treatment that does not exist today. Additional stormwater improvements under consideration include the use of proprietary separators for drainage systems in the Bus Operations area, as well as adding potential green space/ bioretention area, relocating materials handling and storage operations away from the river, and creating a 100-foot buffer zone in the Engineering Rail Yard area. These changes are among the alternative stormwater management improvements considered to improve the water quality of any stormwater that will be discharged from the Project site in the future.

1.3 Project Schedule

Approximately 36 months will be required to complete the final project design from 30% completion through bidding and construction, with an estimated construction completion date in March 2019. The project schedule is being driven by funding requirements from the US Department of Transportation Federal Transit Administration (FTA), who issued the MBTA a competitive resilience grant to fund a portion of the Project. The FTA has requested that the Project be completed as soon as possible. The MBTA is attempting to obtain permits by Spring of 2017, with construction anticipated to begin in Fall 2017.

2 EXISTING CONDITIONS

2.1 MBTA FACILITIES

The existing Project area is comprised of two areas - referred to as the Bus Operations area and the Engineering Rail Yard area, as shown previously on Figure 1-1. The Bus Operations area (also referred to as the project's Baseline area), consists of a large parking lot and access roadways, a Bus Storage and Service Building, and a Bus Inspection and Repair building. Buses are stored here in between routes, while waiting to be repaired, as well for regular washing, cleaning and refueling. This facility houses 231 of the MBTA's buses, making it the largest MBTA bus facility in its system, with buses passing through it all day. The routes operating out of this facility serve several communities in Boston as well as north of Boston.

The Engineering Rail Yard area has a Rail Bending Building and is also used for miscellaneous storage of rail; track components, such as wooden crossties, grade crossings, and switchpoints; and other bulk materials such as ballast and salt storage. The Engineering Rail Yard is also the temporary location for storing construction debris, such as used crossties and excavated materials. The MBTA regularly issues contracts for the proper removal and disposal of the construction debris.

The site drainage characteristics for these two areas are quite different, mainly the result of their two distinct functions. The Bus Operations area is entirely covered with impervious surfaces (building roofs and paved bus roadways and parking surfaces), except for small grass strips along the southern and eastern edge of the site. The Engineering Rail Yard, on the other hand, has only one main building, a few smaller storage sheds, and a paved access roadway that makes a loop around the Rail Bending Building. A small paved area from the roadway to the materials handling and transfer pad facilitates the movement of loading equipment and tractor trailers transporting materials. The remainder of the yard is largely unpaved and covered with compacted ballast stone, which provides a permeable working surface for equipment and trucks moving around the yard and for storage of the rail materials cited previously.

2.2 EXISTING DRAINAGE SYSTEMS

There are currently ten (10) separate existing outfalls that will be affected by the proposed construction, which have been labeled Outfalls "A" through "H" and "X". These outfalls and their respective drainage areas are shown on Figure 2-1.

Seven of these outfalls, A, B, C, C1, D, E, and F, provide drainage of surface runoff from the MBTA's Bus Operations area. Although Outfall F is located in the Engineering Rail Yard area adjacent to Outfalls G and H, the stormwater runoff comes largely from the roof of the Bus Inspection and Repair Building, as well as the small area immediately north of the inspection building. System G collects stormwater runoff from a portion of the Engineering Rail Yard and discharges it through the MBTA's eighth Outfall G.

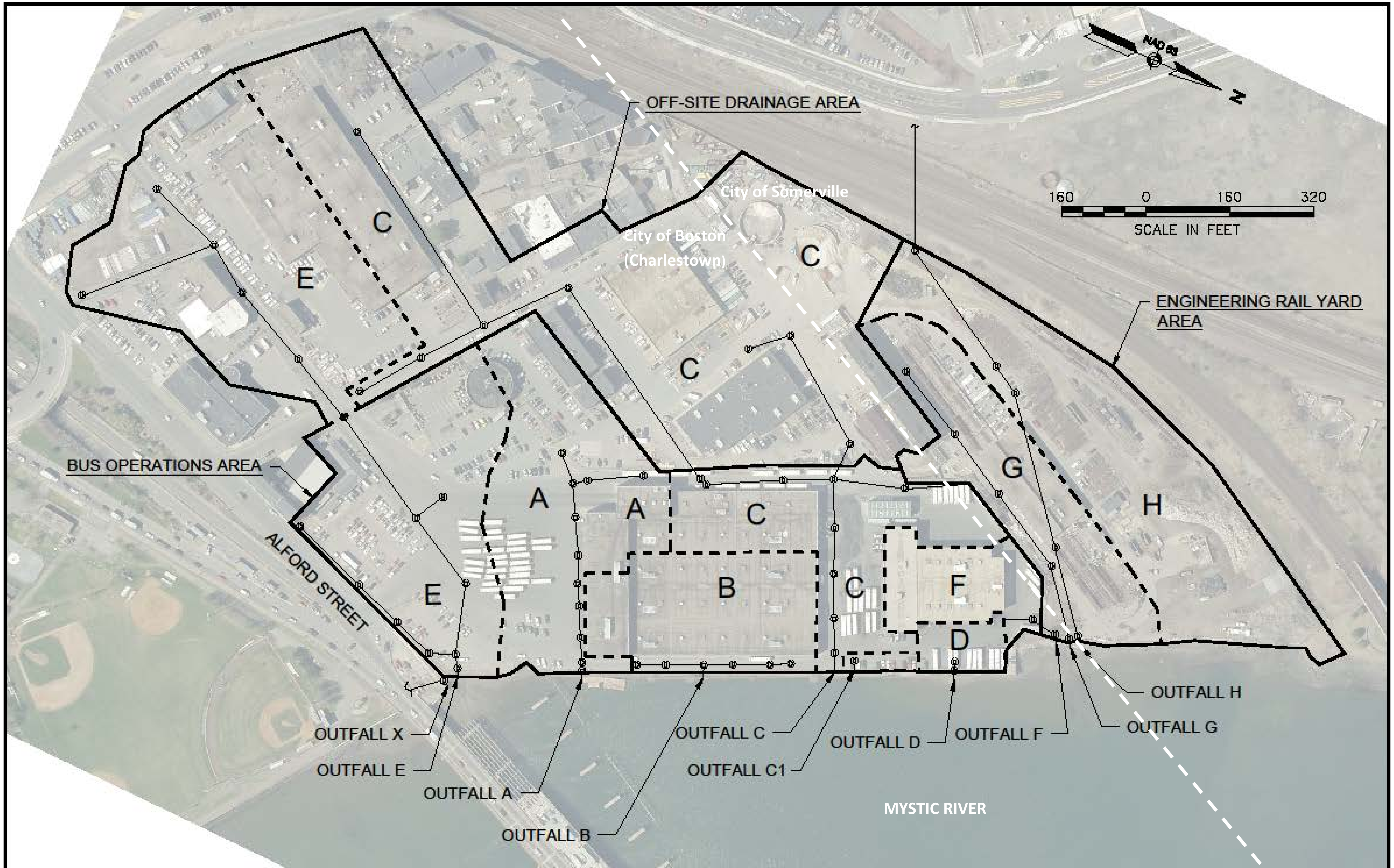

Figure 2-1 Existing Drainage Areas

Outfall C discharges stormwater runoff collected from the offsite drainage area through pipes located in a City of Boston easement through MBTA property. As stated in the August 24, 1977 agreement between the City of Boston and MBTA when the Outfall C drainage system was modified, "The surface drain, . . ., shall become the property of the City of Boston . . . It [*MBTA]* further grants to the City of Boston the right to enter in and upon said private land between Arlington Street and the Mystic River for the purpose of maintaining said surface drain."[1]

The other two outfalls, Outfalls H (ninth) and X (tenth), collect stormwater from outside the MBTA project site. Outfall H is located in the Engineering Rail Yard area, but is actually owned by the City of Somerville, which has an easement across the MBTA property. No stormwater drainage from MBTA property is discharged through Outfall H. Outfall X is located within an adjacent retaining wall connected to the southern abutment of the Alford Street Bridge. This Outfall X discharges stormwater runoff collected from Alford Street (Route 99) and is within the MassDOT roadway right-of-way.

The following sections describe each of the existing ten drainage systems:

2.2.1 Existing Drainage System A

System A consists of 11 manholes with reinforced concrete pipe (RCP) pipe diameters ranging from 15 inches to 30 inches. The current outfall is a 30-inch diameter, asphalt-coated, corrugated metal pipe (ACCMP). Because of severe corrosion in the outfall pipe from tide gate manhole TMH A1 to the Mystic River, a large area of soil around TMH A1 was washed away by the changing tides. As a result, the last two sections of 30-inch ACCMP were replaced in March 2016. The work removed TMH A1 entirely and installed 30-inch PVC replacement pipe with an inline rubber check valve inside the pipe to keep the rising tide out while allowing stormwater to discharge when the Mystic River levels are below the pipe.

Figure 2-2 shows the location of System A drain lines and the associated catch basins, which runs across the entire length of the southern end of the Bus Storage and Service Building. Due to both its location and pipe size, this length of 30-inch diameter pipeline from DMH A8 to DMH A2 is considered critical to the continued safe operation of the buses. As a result, during the Phase I investigations, a closed circuit televised (CCTV) inspection of the pipeline was performed. The results of the CCTV work are summarized and presented in a separate technical memorandum.

2.2.2 Existing Drainage System B

System B picks up stormwater runoff in the "Tube-out" exit roadway and consists of 6 manholes with pipe diameters ranging in size from 15 inches to 24 inches RCP in the roadway. The existing outfall pipe was a 30-inch diameter ACCMP, which had collapsed entirely due to corrosion from the tide gate manhole TMH B1 to the Mystic River. The collapsed pipe allowed the surrounding soil to be washed into the river by the changing tides. Soil had also eroded in the area between DMH B2 and TMH B1 and threatened the safe operation of buses using the Tube exit roadway. These two sections of ACCMP from DMH B2 to the river were also replaced.

[1] Record of Deed #8983 179, "Know All Men by These Presents", executed by R. R. Kiley, MBTA Chairman, August 24, 1977.

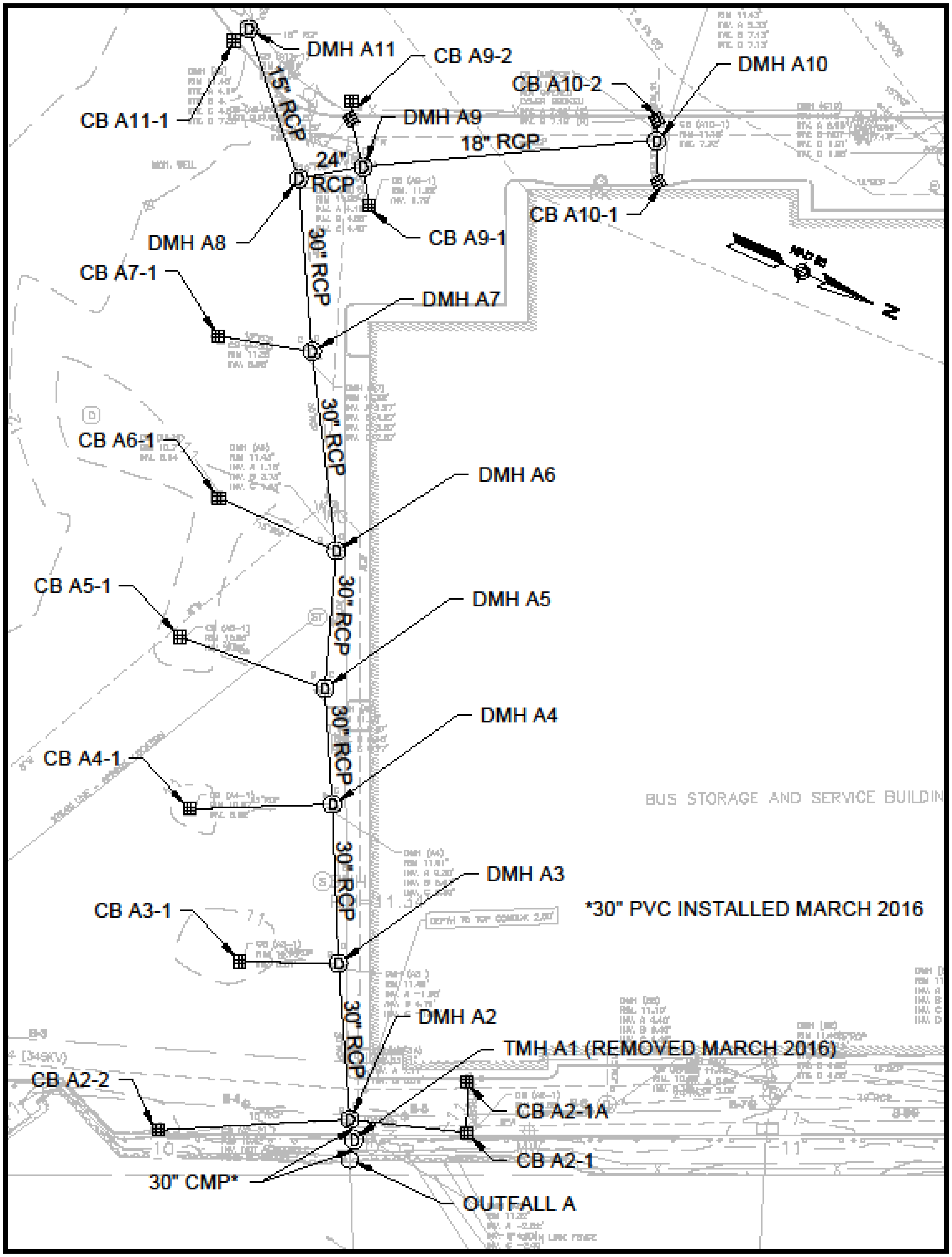

Figure 2-2. Existing Drainage System A

However, TMH B1 remained and two sections of 30-inch PVC pipe replaced the collapsed sections of pipe, with an inline rubber check valve installed in the last section of pipe.

Figure 2-3 shows the layout of System B, including catch basins and roof drain connections from the Bus Storage and Service Building. One of the catch basins, CB B6-2, has settled and is covered over by a steel plate in the roadway. Because of the critical location of System B in the Tube area and near the river, the entire length of drain line below the roadway was also inspected using CCTV during the 30% Design phase, with the results summarized along with System A in a separate technical memorandum.

2.2.3 Existing Drainage System C

As previously described, System C is owned and maintained by the City of Boston through its Boston Water and Sewer Commission (BWSC). As a result, as shown previously on Figure 2-1, System C has the largest drainage area of the nine storm drainage systems discharging at the Charlestown Bus Garage and Engineering Rail Yard properties. System C has one tide gate manhole (TMH C1), 8 drain manholes (DMH C2 – C6, C8 – C10), and 9 catch basins connected within the Project Area. These structures are shown on Figure 2-4, along with drain manholes DMH C7 and C15 and two arrows indicating additional System C drainage flows originating outside the Project Area. Pipe diameters range from 18 inches to 48 inches RCP, with the current outfall pipe being a 48-inch diameter ACCMP.

The 1977 record drawings for System C[2] show the relocated drain line as 48-inch diameter from DMH C5 to TMH C1 across the north end of the Bus Storage and Maintenance Building. These pipe sizes, as depicted in Figure 2-4, were confirmed by direct field measurements made by C&C's subcontractor, EST Associates, using properly equipped and confined space trained crews.

Some of the pipe inverts had been partially filled with concrete, one by at least 6 inches, when the manholes were constructed. Using the information gathered, pipe invert elevations were adjusted accordingly.

Because the section of drain line from DMH C5 to TMH C1 consists of deep, large diameter pipes in a location critical to MBTA bus operations, C&C recommended as part of its Phase 1 Investigation work that this length of pipe be televised during 30% Design phase to determine the present condition of the pipes and structures. This work was performed and both the reinforced concrete pipe and manhole structures were found to be in good condition. The results of these CCTV inspections are also contained in the technical memorandum previously mentioned for Systems A and B. Since the last pipe segment from TMH C1 to the river consists of 48-inch ACCMP scheduled for replacement, this section was not televised.

[2] Joseph W. Mullany, Jr, PE (seal on plan), "Private Land Between Arlington Ave. and Mystic River, Charlestown", Prepared by DeLeuw Cather & Co., Record Plan #Z04-30, 3/31/97

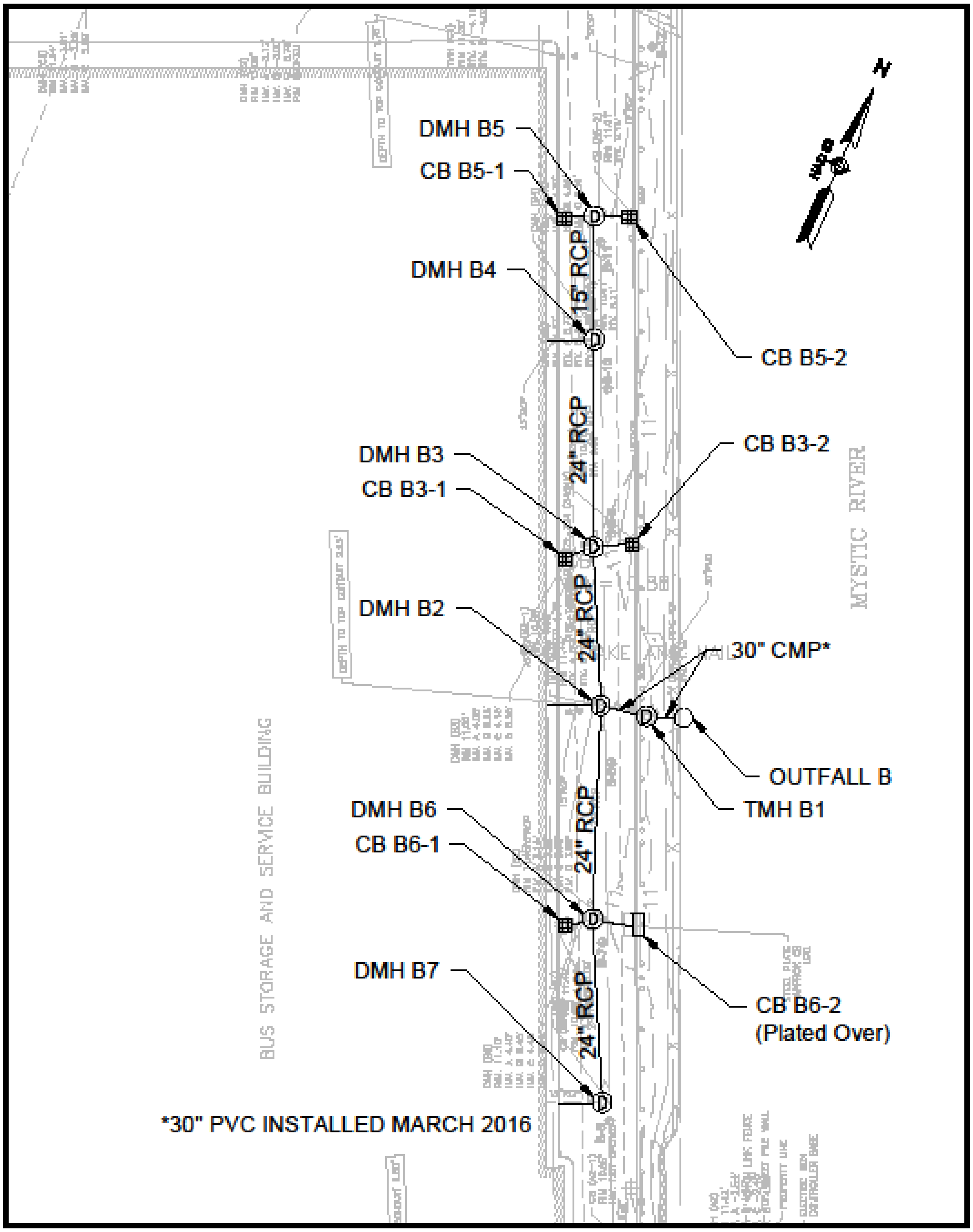

Figure 2-3. Existing Drainage System B

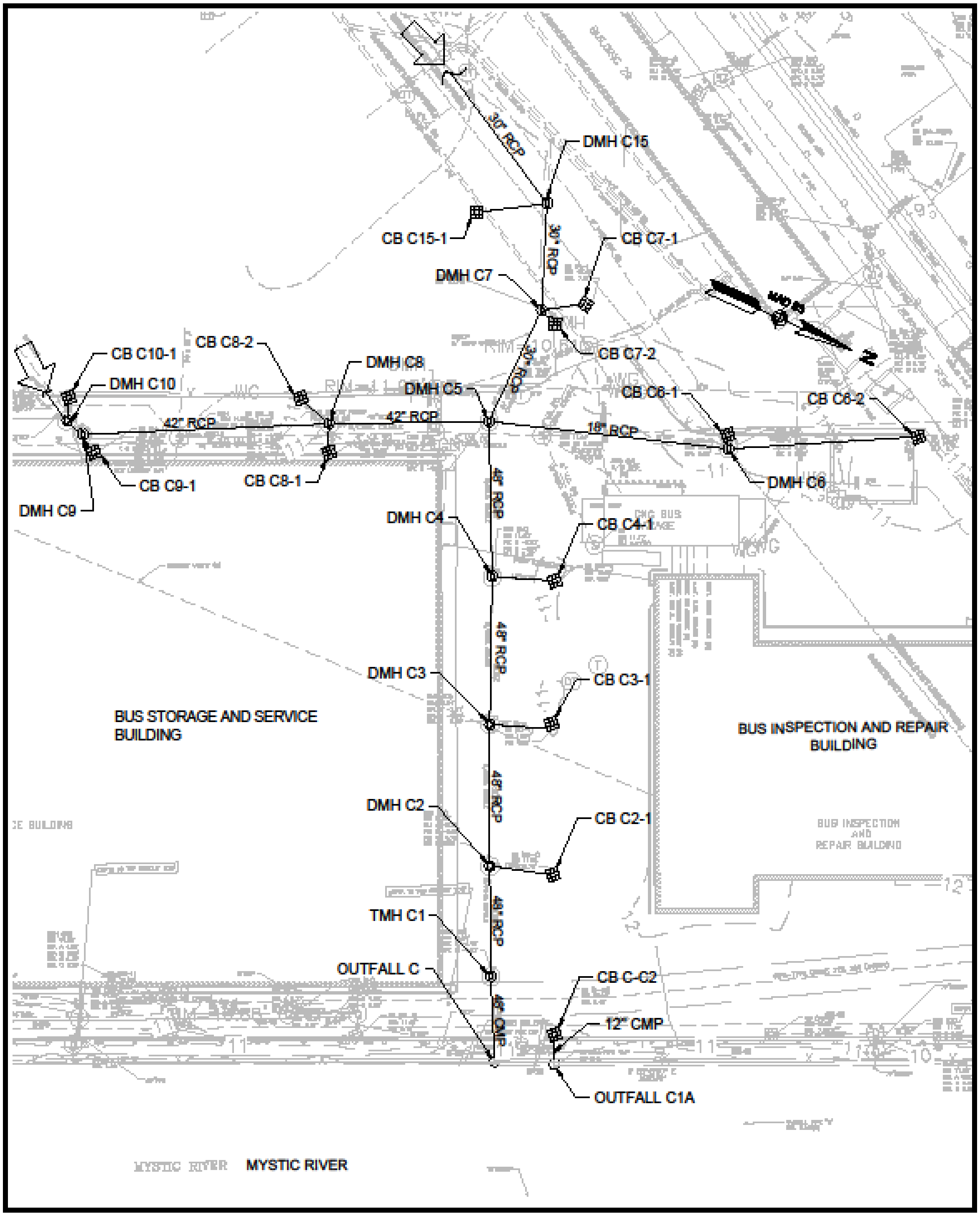

Figure 2-4. Existing Drainage System C

2.2.3.1 Subsystem C1A.

As shown on the previous Figure 2-4, there is one catch basin in the overall System C drainage area that discharges directly to the Mystic River. Catch basin CB C-C2 drains a small area through a 12-inch diameter ACCMP to Outfall C1A. In the 1977 record drawing referenced above, this catch basin CB C-C2 is shown as being connected to the 48-inch line through a drain manhole, which was located along the curb line and immediately upstream of the tide gate manhole. Neither the tide gate manhole nor the catch basin was built as shown.

In the proposed System C drainage improvements, catch basin CB C-C2 and its small drainage area will be connected to the System C outfall, eliminating Outfall C1A.

2.2.4 Existing Drainage System D

System D consists of two manholes, drain manhole DMH D2 and tide gate manhole TMH D1, connected to each other and to Outfall D by a total of approximately twelve feet of 15-inch diameter ACCMP. This small drainage system has only two catch basins, each connected to DMH D2 by approximately 70 feet of 15 inches RCP.

Figure 2-5 shows the entire System D drainage system.

2.2.5 Existing Drainage System E

System E, the second largest drainage system at the Alford Street site, consists of 11 manholes located on the MBTA Bus Operations site with pipe diameters ranging from 18 inches to 36 inches. As shown on Figure 2-1 and on Figure 2-6, an additional area outside the main MBTA entrance gate on Arlington Street is connected to System E.

There are 10 catch basins connected to the 11 manholes located within the project area, including CB E11-1 on Arlington Street, which is connected to DMH E11 located at the site entrance. Drain manholes DMH E-12 and DMH E-13 as well as CB E12-1, shown on Figure 2-6, are located in the Offsite Drainage Area and not included in the project.

Also shown on Figure 2-6, two of the manholes, drain manhole DMH E2 and tide gate manhole TMH E1, were connected to each other and to Outfall E by approximately eight feet of 36-inch diameter ACCMP. These two 4-foot long sections of ACCMP had collapsed entirely, with the soil around TMH E1 washed into the Mystic River by the rising and falling tides, exposing the upper 10-12 feet of manhole structure. Also, the tide gate in TMH E1 was also gone. These two sections of ACCMP were replaced by one length of 30-inch diameter PVC pipe as part of the Task 1 - Immediate Repairs work -cited previously. TMH E1 was also removed and an inline rubber check valve installed inside the 30-inch PVC pipe.

2.2.6 Existing Drainage System F

System F consists of two manholes, drain manhole DMH F2 and tide gate manhole TMH D1, connected by a 24-inch diameter RCP. System F has only 2 catch basins draining a small paved area, but the entire roof of the Bus Inspection and Repair Building discharges through a 12-inch diameter RCP connected to DMH F2. A 24-inch diameter RCP connects DMH F2 to TMH F1, while approximately 15 feet of a 24-inch diameter ACCMP connects TMH F1 to a concrete Outfall F headwall. Figure 2-7 shows the layout of System F.

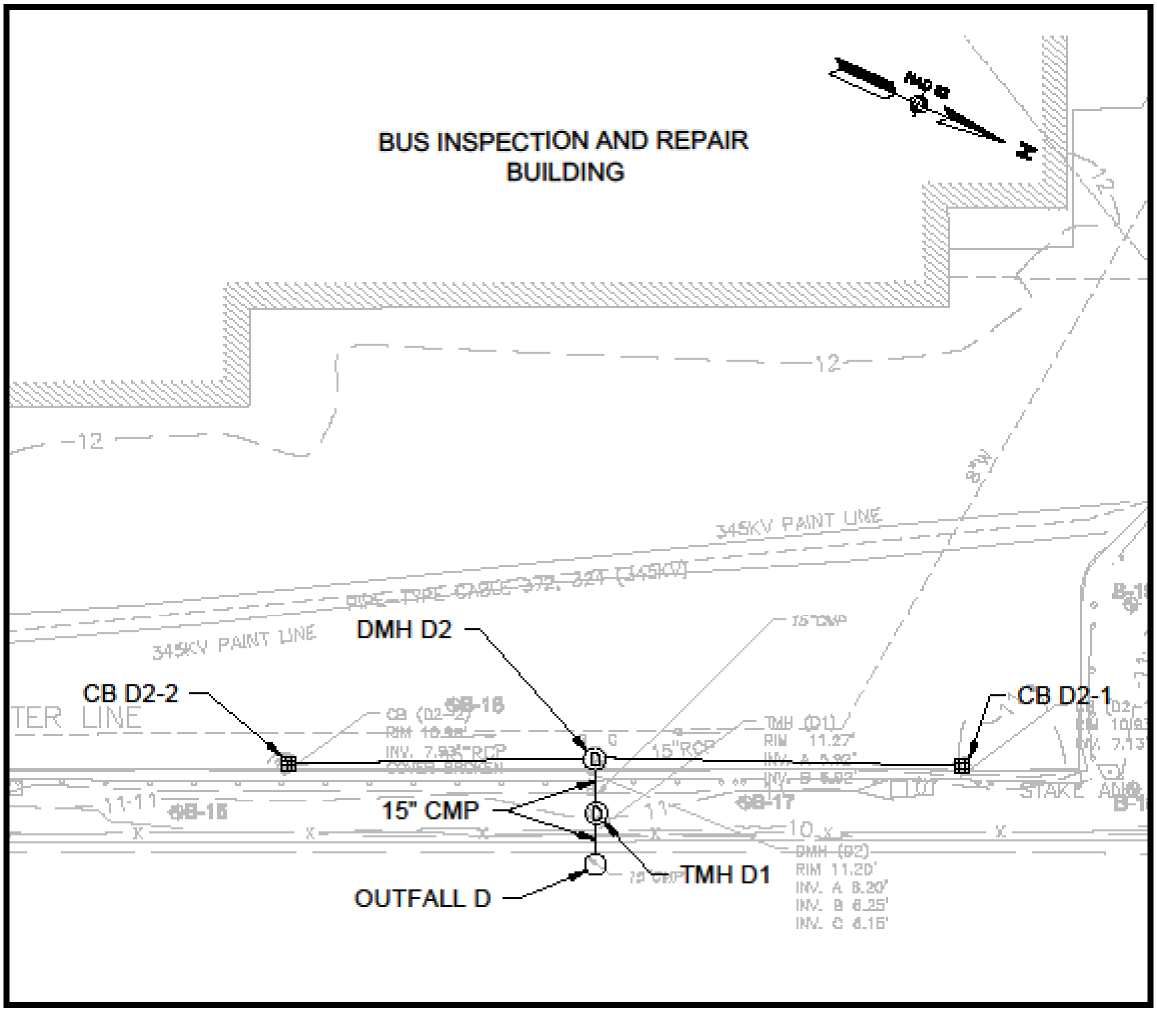

Figure 2-5. Existing Drainage System D

2.2.7 Existing Drainage System G

System G, the only MBTA drainage system in the Engineering Rail Yard Area, consists of 6 manholes with pipe sizes ranging from 18 inches to 30 inches in diameter, as shown on Figure 2-8. The current outfall pipe, which was originally a 30-inch ACCMP, is completely gone downstream of TMH G1, and the tide gate has corroded badly and has come away from the manhole wall rendering it ineffective.

While the MBTA record plans show 11 catch basins connected to System G, field investigations were conducted by EST Associates, Inc. (EST), Needham, MA as a subcontractor to C&C during the 30% design phase. Using a telescoping camera to look inside each manhole and catch basin, a visual record of the existing conditions of the structures was made. However, EST could not locate all of the catch basins shown on the record drawings, possibly due to being covered by stockpiled materials or that the catch basins were never installed. In particular, catch basins CB G2-1, CB G3-2, and CB G3-2A within the work zone were not found. While the EST crew observed a pipe in DMH G3 coming from the direction of

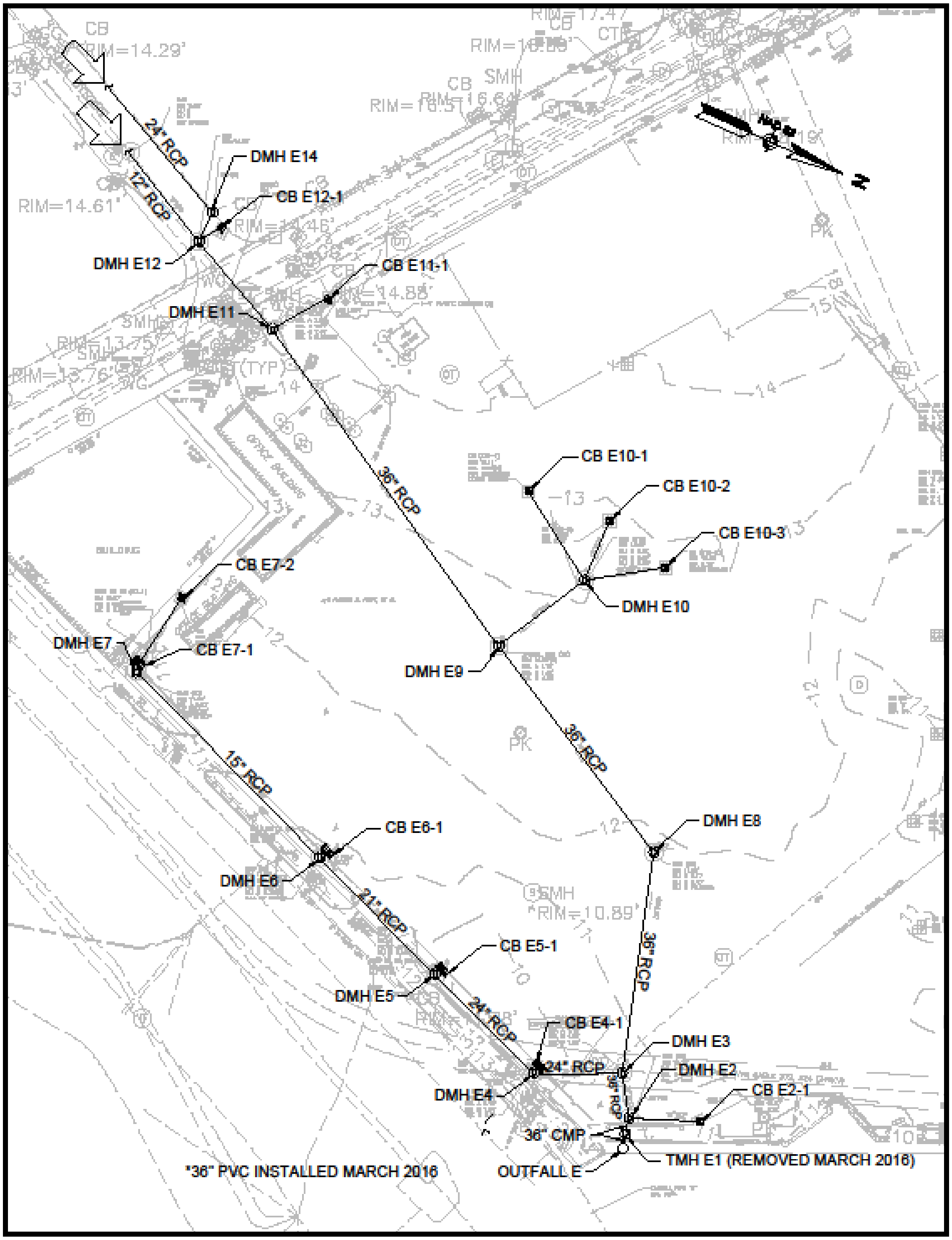

Figure 2-6. Existing Drainage System E

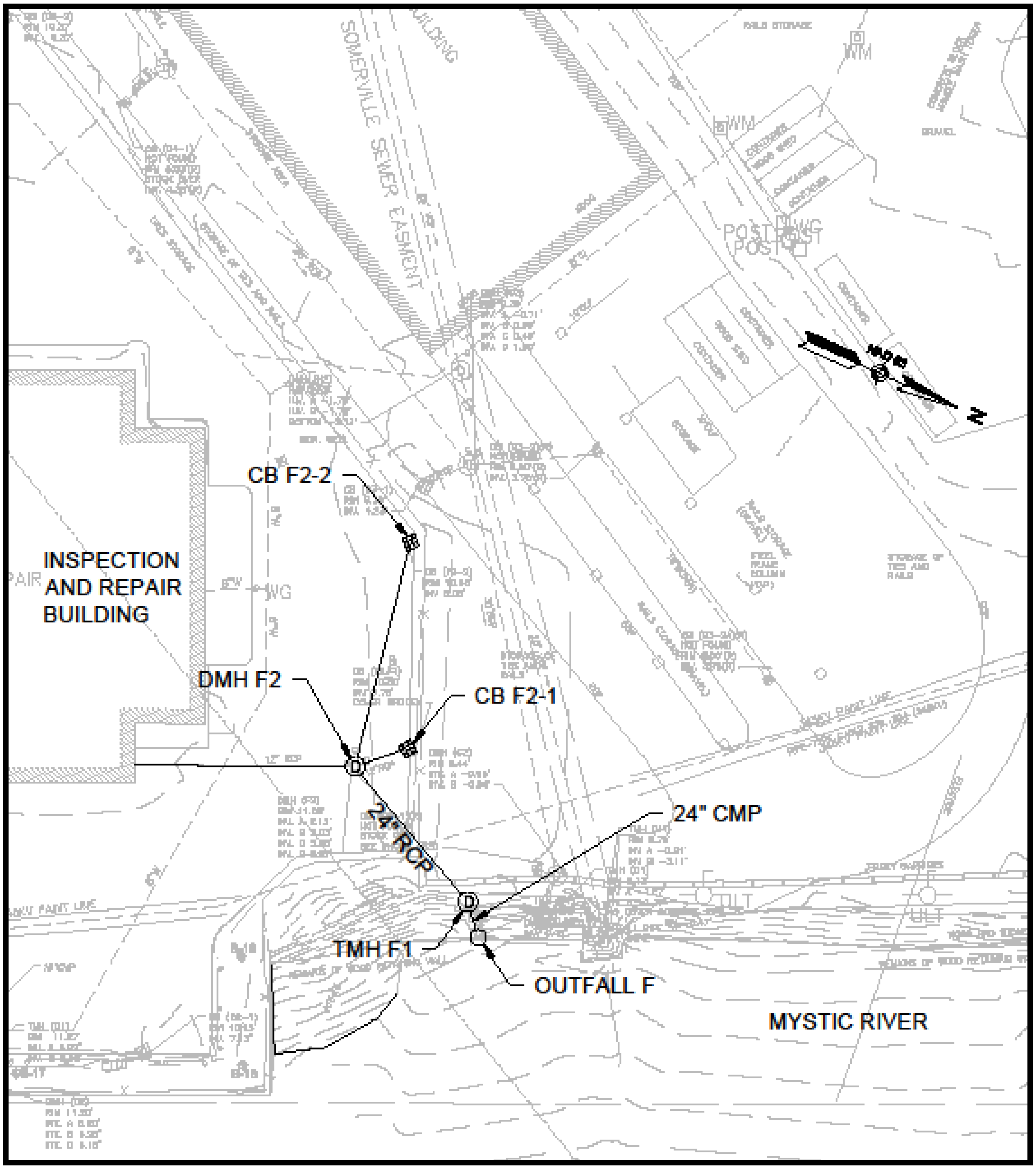

Figure 2-7. Existing Drainage System F

CB G3-2, the catch basin could not be located. Because these three catch basins are within the area to be drained overland to the proposed System G rain garden, no rehabilitation of the three catch basins is proposed. If these three catch basins are subsequently found, the catch basins will be removed and their drain lines plugged.

As indicated in Figure 2-8, EST also did not find CB G4-1, CB G5-1, and CB G6-1, although connecting pipes were observed in associated drain manholes DMH C5 and DMH C6. One catch basin, CB G5-2A, was subsequently located by C&C survey crews underneath a Conex storage container. Because these catch basins are critical to the surface drainage system in the Rail Yard, they will all be replaced with new deep sump catch basins with hooded outlets.

2.2.8 Somerville Outfall H

Outfall H is a former combined sewer overflow pipe owned by the City of Somerville. The pipeline, located in an easement in the MBTA's Engineering Rail Yard, consists of 4 manholes with pipe sizes of 18-inch and 20-inch diameter vitrified clay pipe (VCP). The current Outfall H is a 20 inch VCP. Figure 2-9 shows the layout of System H crossing the MBTA's Engineering Rail Yard.

As mentioned above, the pipes connected to Outfall H are a former combined sewer overflow (CSO) line from Somerville's combined sewage system. Combined sewage flows in this 18-inch and 20-inch diameter vitrified clay pipe (VCP) formerly originated in a CSO regulator manhole, located in North Union Street on the west side of the MBTA commuter rail tracks. More recent plans obtained from the City (date unknown) showed the proposed disconnection of the CSO regulator and construction of a new stormwater manhole as part of the development of the Home Depot and former Circuit City properties. A new 18-inch connection from an oil/water separator was also planned to serve the proposed Circuit City parking lot.

Following a site visit of Line H in September 2016 with MBTA and Somerville Department of Public Works (DPW) personnel, the City confirmed that the CSO regulator manhole had been disconnected and an oil-water separator treating the drainage from the Circuit City property along new Assembly Square Drive had been connected to an offsite drain manhole installed on former CSO line (Line H). This manhole was designated as DMH #21 on the City's sewer separation plans)

During field investigations and site visits on MBTA property, C&C personnel and other project personnel have observed clear water discharging from Outfall H, even on dry weather days. A note on the City's combined sewer separation plans indicated that the entire 18/20-inch line was cleaned and televised, with the recommended rehabilitation to eliminate infiltration in the 20-inch line from Tide Gate Manhole TMH H1 to DMH H2, along with a section of pipe beyond DMH H2 that lies underneath a portion of the Rail Bending Building. While the Somerville plans show this segment of line below the Rail Bending Building, from DMH H2 to DMH H3, as a 24-inch diameter pipe, the September 1978 MBTA record drawing Sheet No. C-2 of Contract No. 070-107 Part B did not show a 24-inch line replacing the original 20-inch line. Further discussions with the City of Somerville DPW have not been successful in locating a copy of the internal video recordings of the18/20-inch line nor could the City verify whether the recommended infiltration rehabilitation repairs had been made.

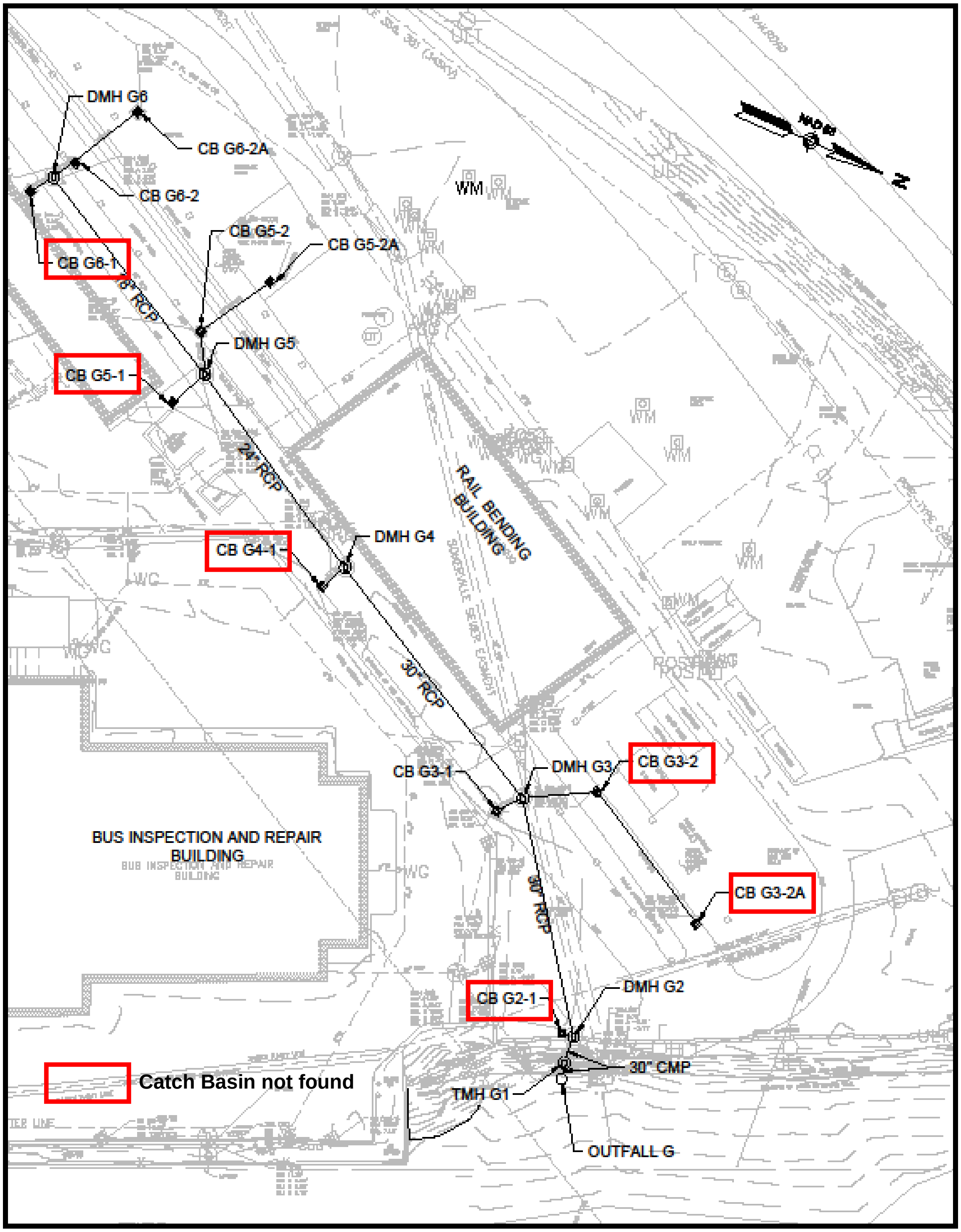

Figure 2-8. Existing Drainage System G

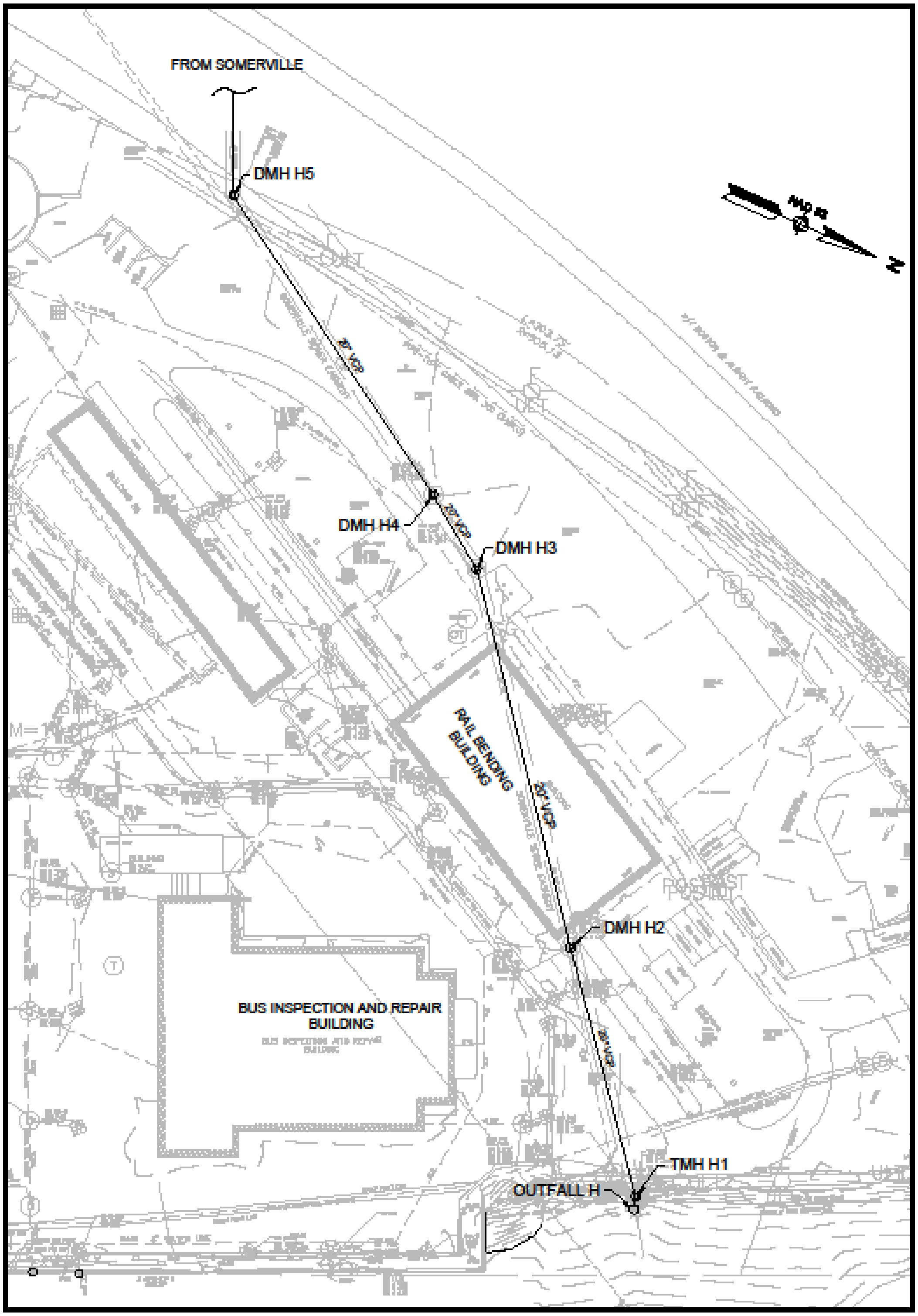

Figure 2-9. Somerville System H

Recently, C&C and SGH engineers, using a telescoping camera, observed that a block wall separates DMH H4 into two halves, but could not determine the function of short length of corrugated plastic pipe located on the upstream side of the wall. Subsequently, a joint MBTA-City of Somerville dye water flooding test conducted on February 8, 2017 confirmed that water flowed through an opening in the wall near the corrugated plastic pipe and was discharged to the downstream manhole DMH H3. Although a connection from DMH H4 to the higher System G was unlikely, a nearby System G catch basin was monitored during the test, with no dyed water appearing. Discussions with the City will be continuing to decide how costs for the repairs and/or improvements to Outfall H should be allocated.

The current Outfall H is a 20-inch diameter VCP that has collapsed entirely and has large granite blocks across the outlet opening in TMH H1. These granite blocks had been acting as a retaining wall for the river bank. Figure 2-10 shows pictures of TMH G1 behind the granite block retaining wall, looking from the river, along with a view of stormwater flowing between the fallen granite blocks and the base of the wall.

Figure 2-10. Outfall H showing (l) TMH H1 with granite block retaining wall and (r) water flowing below collapsed granite retaining wall blocks.

2.2.9 MassDOT Outfall X

Drainage System X is located within the right-of-way for Alford Street (Route 99) and carries surface drainage through 15-inch diameter lines connected to drain manhole DMH X1. A short length of 18-inch diameter cast iron pipe connects DMH X1 to Outfall X. Figure 2-11 depicts the location of DMH X1 and Outfall X.

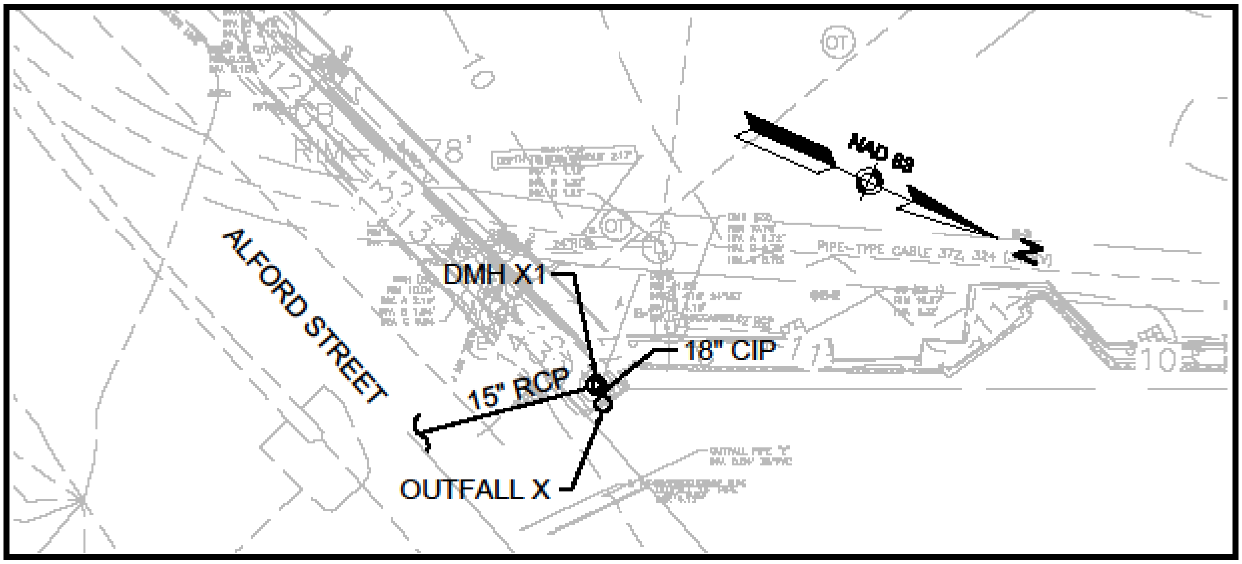

Figure 2-11. MassDOT Outfall X1 for Alford Street

2.3 Drain Line Camera Investigations

To investigate conditions inside the existing storm drains, EST inspected each tide gate manhole and the first drain manhole upstream in Systems A through E during the Phase I Investigations using a telescoping pole camera. Because of the concern for the condition of all drain lines in the "Tube Out" area, EST opened and inspected all catch basins in Drainage System B. C&C engineers reviewed short video clips of the pole camera inspections provided by EST. C&C then prepared and submitted on July 27, 2015 a technical memorandum of Drainage Systems A through E, recommending additional investigations during the 30% design phase.

2.3.1 Drain Line CCTV Study in Bus Operations Area

Because the telescoping camera has a limited range of recording conditions in the drain lines from each manhole, an internal closed circuit television (CCTV) inspection was recommended for portions of Systems A and C, as well as the entire length of System B, in the Bus Operations Area. The portions of Systems A and C selected ran the entire length across the entrances and exits of the Bus Storage and Maintenance Garage. These sections of pipe had been installed in the mid-1970s, were already 40 years old, and were considered critical to the continued, long-term operation of the bus facility. The entire length of System B drain line was also selected for the same reasons, because the pipes ran below the critical Tube Out roadway and they were next to the existing bulkhead wall.

EST cleaned the pipes of sediments and debris using a jet spray hose and vacuum truck and then used a CCTV camera to record the inside condition of the entire length of pipe between each manhole in November-December 2015. EST provided this video record of the current condition of these pipelines, and C&C prepared a separate technical memorandum summarizing the CCTV work and describing the conditions recorded.

The RCP lines inspected were found to be in good structural condition, with only minor groundwater infiltration observed. As a result, C&C recommends no rehabilitation of the drain lines.

2.3.2 Drain Line Camera Study in Engineering Rail Yard Area

Because the manholes and catch basins in Systems F, G and H had not been included in the Phase I Investigations, EST used their telescoping pole camera again in November-December 2015 to record conditions at the available manholes and catch basins in these three systems. As before, EST provided short video clips of the inspections, and C&C engineers summarized the findings in a separate technical memorandum of the Engineering Rail Yard, including System F that drains a portion of the Bus Garage site. Because the condition of the connecting pipes was found to be in overall good condition, no additional CCTV inspections of the pipelines in Systems F or G are recommended. However, as previously discussed, the source of clear water discharging from Outfall H must be determined, along with who will pay for needed repairs and improvements to the existing VCP line.

For the manholes and catch basins that could be found, some of the structures were missing some corbel bricks/blocks and were cracked. C&C recommends that these structures be replaced or repaired, accordingly. Also, all catch basins that will be replaced will have new, hooded outlets, which will facilitate future inspection of the catch basin outlet pipes. All three Outfall structures and tide gate manholes are in poor condition and would normally be replaced in place. However, due to the construction of the new sea wall and sloped embankment fill, the tide gate manholes must be relocated and new outfall pipes and headwalls installed.

2.4 Immediate Repairs

All of the existing outfall pipes draining the Bus Operations Area were extended using corrugated metal pipes in the 1970s as part of the existing steel bulkhead wall installation. Although the metal pipes were asphalt-coated to protect against corrosion from the saline Mystic River, several of them (Outfalls A, B and E) had collapsed as described previously. These three outfall pipes were replaced as part of the Task 1 Immediate Repairs work in the 30% design scope of work. Because sections of the existing steel bulkhead wall were also experiencing section loss, holes through the bulkhead wall were covered to reduce erosion. Sink holes four to six feet deep had developed as a result of the corroded outfall pipes, with smaller loss of site occurring through holes in the bulkhead wall. The areas near Outfalls A and B are along the only bus lane exit roadway known as the “Tube Out Area”, and this roadway was partially closed off in 2015 for safety reasons until the immediate repairs were completed.

SGH prepared the Immediate Repairs contract documents, with input from C&C. D’Allessandro Corporation completed the work in March 2016. Construction observation was provided by the MBTA construction division, with construction phase engineering services furnished by SGH with assistance from C&C.

All of the drainage systems from the MBTA Bus Operations and Engineering Rail Yard Areas were originally designed to drain into the Mystic River through tide gates. However, none of the tide gates had been functioning. As a result, the Immediate Repairs work also included installing new ProFlex™

740 in-line, slip-in rubber check valves manufactured by Proco™ inside the new replacement outfall pipes at Outfalls A, B and E.

Because a sloped embankment fill and flood protection are planned for the entire length of the Bus Operations and Engineering Rail Yard sites, respectively, these immediate repairs will be replaced by the proposed drainage system improvements. However, as a result of the Immediate Repairs work, the Tube Out area is once again safe for buses to use when moving around the site.

2.5 Existing Soil Conditions

Using the U. S. Department of Agriculture Natural Resources Conservation Service's (NRCS) Web Soil Survey (WSS), the general properties of the site soil were found. As noted on the web site, the WSS provides soil data and information produced by the National Cooperative Soil Survey (NCSS). NRCS has soil maps and data available online for local and wider area planning. The WSS data was supplemented by the team's Project geotechnical investigations and findings, summarized below.

To obtain the data from WSS, an Area of Interest (AOI) was first drawn online around the Project site, as shown on Figure 2-12. WSS characterizes the soil at the site as both "urban land, wet substratum" and "Udorthents, wet substratum[3]". Generally, the urban land, wet substratum is found in the Bus Operations area and the Udorthents, wet substratum is found in the Engineering Rail Yard area. Table 2-1 lists the acres of these two soil classifications, as determined from the NRCS Web Soil Survey for the AOI shown on Figure 2-12. Because the AOI spans two Massachusetts counties, the results are tabulated separately for Suffolk (City of Boston) and Middlesex (City of Somerville) Counties.

Based on the property of each soil and past studies, a Hydrologic Soils group of C was used for the urban land, and a Hydrologic Soils Group of B was used for the Udorthents soil. These soil groups were assumed based on the March 2016 Draft Geotechnical Data Report[4] prepared by SGH, past reports, as well as the description of the soil from the national survey. These soil groups were used in our hydrologic analysis using the rational method. While the soil classifications found in the WSS are broad, the SGH investigation of site soils along the Mystic River as described in their report confirmed the WSS results. As most of the area in the Bus Operations area is paved and impervious, the lack of more detailed information away from the river did not affect our calculations.

2.5.1 Geotechnical Data Report

As part of the current MBTA engineering contract, SGH performed geotechnical investigations and prepared a Draft Geotechnical Data Report based on their field investigations and geotechnical analyses. SGH found that the groundwater levels varied between Elevation 1.0 - 1.8 feet near System C Outfall (9.2 – 10 feet deep), while the groundwater levels were between Elevation 1.9 - 3.2 feet near System B

[3] Udorthents soils consist primarily of moderately coarse textured soil material and a few small areas of medium textured material.

[4] Zelada-Tumialan, Giuliana, Keppel, Steven F , P.E., and Kelly, Dominic J., P.E., Simpson Gumpertz & Heger, Inc., Geotechnical Data Report, Letter Report submitted 28 March 2016 to Mr. John Favorito, Project Manager, MBTA, 202 pages.

Figure 2-12. NRCS Web Soil Survey

City of Somerville, Middlesex County, Massachusetts (MA017)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Water	0.2	0.4%
603	Urban land, wet substratum, 0 to 3 percent slopes	3.6	7.8%
655	Udorthents, wet substratum	9.9	21.5%
Subtotals for Soil Survey Area, City of Somerville		**13.7**	**29.7%**
Totals for Area of Interest, Project Area		**46.3**	**100.0%**

City of Boston, Suffolk County, Massachusetts (MA616)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Water	0.7	1.6%
603	Urban land, wet substratum, 0 to 3 percent slopes	27.4	59.2%
655	Udorthents, wet substratum	4.4	9.5%
Subtotals for Soil Survey Area, City of Boston		**32.6**	**70.3%**
Totals for Area of Interest, Project Area		**46.3**	**100.0%**

Table 2-1. NRCS Web Soil Survey Results - Map Unit Legend

in the "tube out" area (8.3 – 9.6 feet deep). Their findings largely agreed with a past study done by Jacobs Engineering Group (Jacobs)[5], which stated that the groundwater levels ranged between 8.5 feet to 9 feet below ground surface.

Groundwater levels could not be obtained by SGH near System F because the observation well was backfilled with sand by others after the data logger was installed. While no observation wells were installed in the Engineering Rail Yard area, in two of the landside borings located there, water levels were observed after 17.5 hours at Elevation 0.00 feet (9.5 feet deep) near Outfalls F, G and H and at Elevation 0.50 feet (9.5 feet deep) further north, near the proposed location of Outfall H1.

SGH characterized the Engineering Rail Yard land side soil stratum generally as follows:

- Fill (15.5 – 19 feet),
- Slightly Organic to Organic Silt/Clay 23 – 32 feet),
- Marine Sand (2 – 4 feet),
- Marine Clay (18 feet), and then
- Glacial Till (encountered at Boring BGL-1 at Elevation -54 feet, approximately 62 feet deep).

[5] Jacobs Engineering Group, Capital Needs Assessment Alford Street Bus Garage Sinkhole and Bulkhead Assessment/Repair Option Alford Street, Charlestown, MA, 29 September 2011.

SGH's characterization of the Bus Operations area soil stratum was:

- Fill (16 - 30 feet),
- Slightly Organic Silt/Clay (10 feet),
- Marine Sand (2.5 – 5 feet), and then
- Marine Clay.

Marine Clay was encountered immediately underlying the Marine Sand layer in two borings along the Mystic River opposite the Inspection and Repair Building and the northern portion of the Tube Out area, while the marine clay was found immediately underlying the Fill stratum from the southern portion of the Tube Out area to Alford Street .

More detailed analysis, along with the individual Soil Test Boring Logs and Laboratory Soil Test Results, are presented in the Geotechnical Data Report.

2.6 Existing Utility Lines

There are existing 345 kV electrical Pipe Type Cables (PTC) in place in both the Bus Operations and Engineering Rail Yard areas. There are four of these lines in total, as shown in red on Figure 2-13. Two of them (PTC 372, 324) are contained in a duct bank that passes in a north-south alignment between the Mystic River and Bus Storage and Bus Inspection buildings. The other two lines (PTC 351, 358) are in a second duct bank located in an east-west alignment across the northern boundary of the Engineering Rail Yard area. The four lines join together in a single duct bank in the northeast portion of the Engineering Rail Yard to cross beneath the Mystic River.

Record plans from the utility, now EverSource, generally show the duct banks are buried approximately 4.5 to 5.5 feet below the existing surface. However, during the 30% design, the tops of the duct banks were exposed using vacuum extraction, and C&C surveyors surveyed the top of duct bank elevations. These measurements, also shown in red on Figure 2-12, revealed that the top of duct banks along the Mystic River average only 2.47 feet deep below existing grade and range from as shallow as 1.75 feet to 3.50 feet. However, at the northern end of the project in the Engineering Rail Yard area, both ducts are laid deeper (7.15, 7.37 and 8.71 feet below grade) before crossing below the Mystic River

Because of the critical nature of these lines and the potential danger they present during construction, future construction near these lines should be avoided where possible, with extreme caution used where they cannot be avoided. Work on drainage lines that cross the existing 345 kV lines is one such unavoidable example, as is installing a new bulkhead wall with tiebacks.

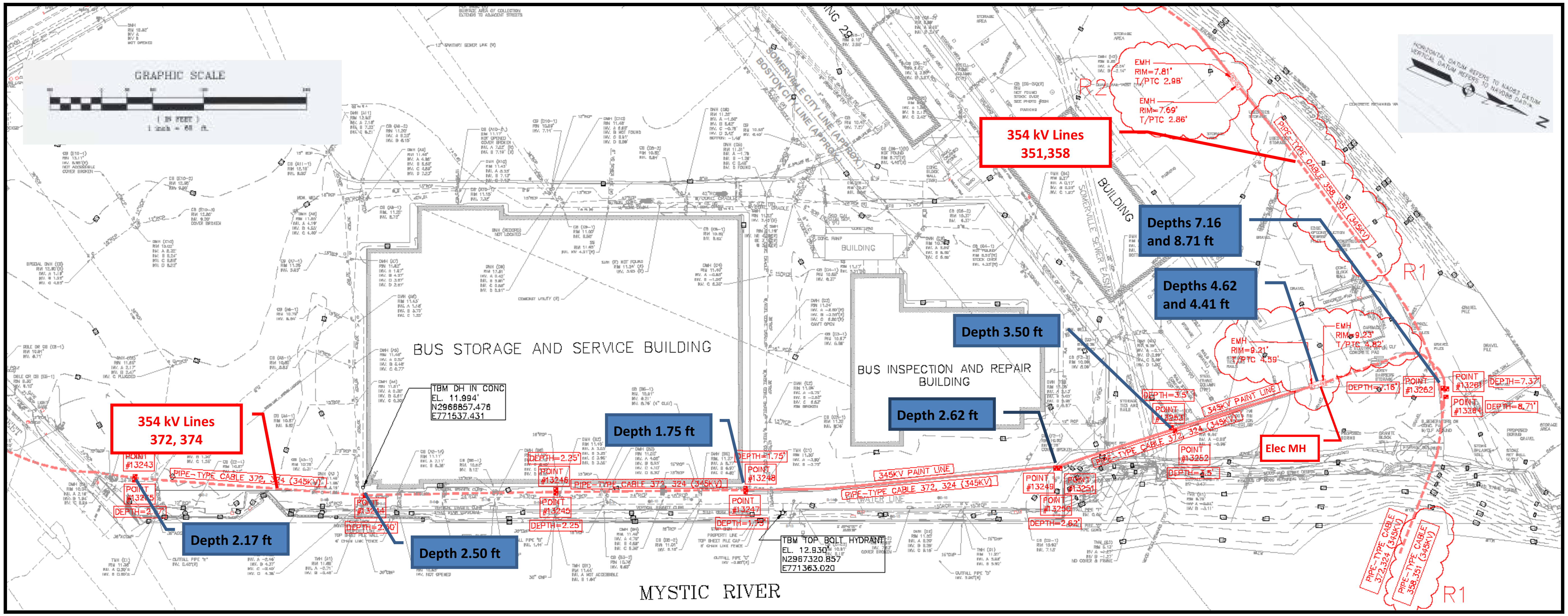

Figure 2-13. 345 kV Pipe Type Cable Locations

3 HYDROLOGIC ANALYSIS

3.1 METHODOLOGY

A hydrologic and hydraulic analysis of the existing and proposed site drainage systems was performed to identify problematic system components and to analyze proposed drainage system upgrades as applicable. The analysis used the Rational Method equation, Q (peak flow) = C•i• A, to approximate the peak rate of runoff from each tributary area, where: "C" is the dimensionless runoff coefficient; "i" is the rainfall intensity in inches per hour; and "A" is the sub-catchment drainage area in acres. The full-flow capacity of each drainage system was evaluated using Manning's equation with HydroCAD, $Q = (1.49/n)*A*R^{2/3}*S^{1/2}$, and assuming a free discharge condition. The Manning's roughness coefficients (n) used in the model were: 0.017 for the existing reinforced concrete pipes; 0.03 for existing corrugated metal pipes; and 0.013 for new reinforced concrete pipes. The resulting full flow capacities of the existing piping systems were compared to the peak rates of runoff from each applicable tributary area to identify over-capacity drains. These results are discussed and summarized in the following sections. Considering the importance of this key metropolitan transportation facility, the 25 year return period storm was selected as the design rainfall event for the evaluation of the site drainage systems.

Tributary areas for each storm drain were delineated and sub-catchment areas were created at key manholes within each drainage system. Drainage areas were identified as "on-site" or "off-site" for each of the systems, depending upon whether they were "inside" or "outside" the project area, respectively. These drainage areas, shown previously in Figure 2-1, were determined using the existing conditions field survey surface elevations, locations of the existing catch basins, and the MBTA's drainage system record drawings. C&C's field survey confirmed the data shown on the record drawings for drainage Systems B, D, F, and G; however, some discrepancies were found in Systems A, C, and E. For Systems A and E, the differences were in the invert elevations measured in the field. Additional field survey checks and engineering judgment resulted in adjustments to the inverts in the model to reflect existing conditions.

All site drainage systems discharge to the Mystic River, which is subject to tidal flows. The Mean High Water (MHW) and Mean Low Water (MLW) elevations are 4.33 (NAVD 88) and -5.16 (NAVD 88) respectively. This tidal range produces both a free discharge condition at MLW and a submerged tailwater condition for most outfalls at MHW. Detailed hydrodynamic analysis, e.g. modeling of backwater effects, flow reversal, pressurized flow regimes, approximation of surface ponding etc., is outside time scope of this analysis.

3.2 HYDROLOGIC MODEL

HydroCAD, a computer aided design tool, was used to perform the Rational Method hydrologic modeling for the 2-year, 5-year, 10-year, 25-year, and 100-year storm events, utilizing the metropolitan Boston Intensity-Duration-Frequency (IDF) curves available within HydroCAD. A runoff coefficient "C" of 0.95 was selected for both paved areas and roof areas, while a runoff coefficient "C" of 0.60 was used for the gravel surface (ballast) in the Engineering Rail Yard. The time of concentration (tc) for each catchment area was approximated using TR-55 methodology within the HydroCAD model, based on the length of the flow path, slope, and ground cover. The HydroCAD model utilizes the Stor-Ind+Trans Reach Routing Method. Appendix B contains the HydroCAD model output for each drainage system for the 25-year return period design event, while the output for all return periods (2-year, 5-year, 10-year, 25-year, and 100-year) are available electronically on a DVD disk.

Figure 3-1 displays a representative drainage system model (System C). The pipes and manhole junctions are shown as orange squares and the tributary drainage area for each catch basin are shown as green hexagons.

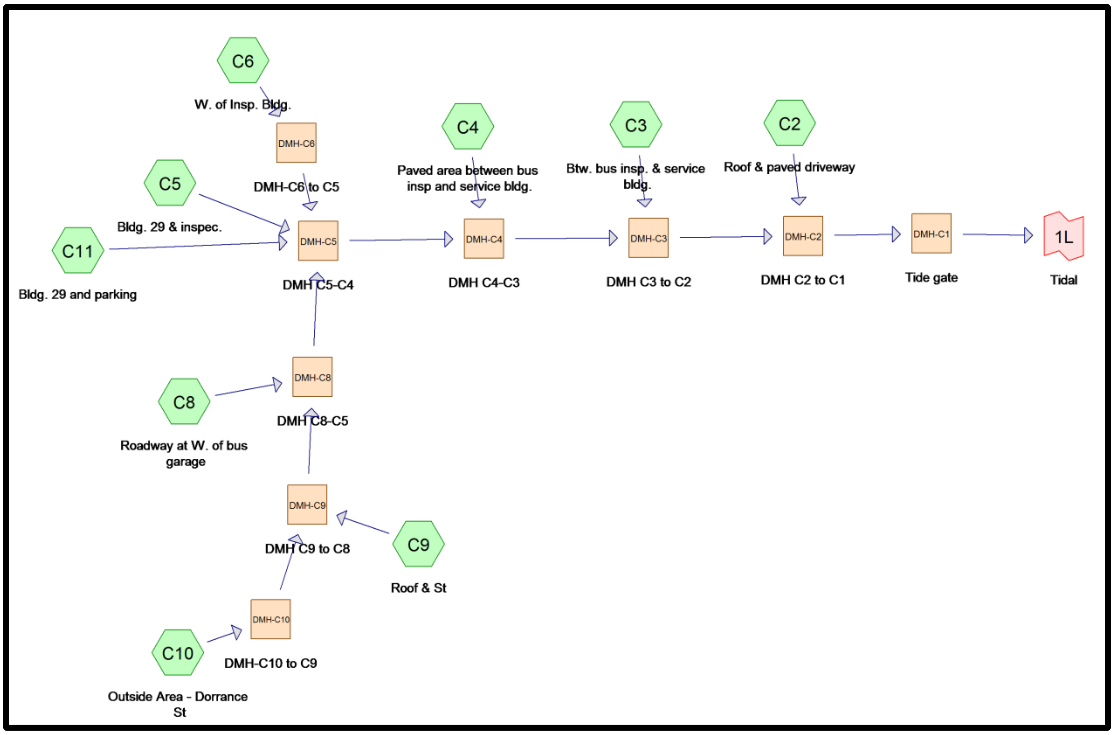

Figure 3-1. System C HydroCAD Model

3.3 Existing System Flows

Table 3-1 summarizes the existing peak flow results from the HydroCAD model at each outfall, along with the tributary area, time of concentration, and outfall pipe diameter. The shaded cells in Table 3-1 indicate peak flows in excess of the full flow pipe capacity (surcharged) in at-least one location in the drainage system. As previously explained, a detailed hydrodynamic analysis for surcharged conditions is beyond the scope of this evaluation. Instead, the values shown in these shaded cells are the peak rates of runoff that would have been transported without surcharging if the pipes had sufficient capacity.

System ID	Area (ac)	Outfall Pipe		T_c 10-yr (min)	Existing Peak Flow (cfs) Storm Events				
		Diam. (in)	Invert (ft)		2 Yr.	5 yr.	10 yr.	25 yr.	100 yr.
A[I]	3.53	30	-2.39[e]	6	13.14	15.78	18.04	22.07	30.97
B[I]	2.18	30	1.14[R]	6	8.17	9.78	11.17	13.67	18.59
C	13.41	48	-4.35[R]	9	39.78	47.06	53.61	64.65	93.28
C1A	0.39	12	8.09[e]	7	1.38	1.64	1.87	2.06	2.13
D	0.37	15	5.90[R]	5	1.43	1.71	1.96	2.41	3.25
E[I]	9.14	36	0.34[R]	7	35.64	41.07	50.33	61.86	82.83
F	1.10	24	0.45	4	4.41	5.29	6.05	7.44	9.97
G	2.59	30	-0.51[R]	5	9.60	11.60	13.31	16.42	23.57
TOTAL	32.71							170.41	

Indicates surcharged conditions in pipeline
[R] From Record drawing, converted to NAVD88 datum.
[e] Estimated from upstream manhole outlet and length of pipe to outfall.
[I] Includes March 2016 Immediate Repairs.

Table 3-1. Existing Outfall Peak Flow Rates

System E experienced surcharged flow during the 10-year return period storm and requires improvement under proposed conditions. The existing System C1A, which consists of only one catch basin CB C-C2 with a direct discharge to the Mystic River, also surcharged for the 25-year return period event; however, this catch basin is proposed to be re-routed to Outfall C, under proposed conditions. Except for System F, all drainage systems experienced surcharging during the 100-year storm event. As stated above, the 25-year return period event is our design storm; however, the peak flow rates for the 100-year event are provided for reference.

3.3.1 Existing Peak Rate of Runoff

While the peak discharge flows might not occur at the same time due to the varying times of concentrations of each drainage system, the sum of all existing peak flow rates listed in Table 3-1 for the 25-year frequency storm totals approximately 170 cfs.

As shown in Table 3-1, the maximum flow rate occurs in System C at approximately 65 cfs for the 25-year return period event, including the small area tributary to catch basin CB-C-C2.

3.3.2 Somerville System H

Because System H is owned by the City of Somerville and conveys flows from off site, the existing System H was not modeled with HydroCAD. As previously described and shown in Section 2.2.8, additional follow-up discussions with the Somerville DPW were held to determine the source of the water observed flowing from the Outfall H on a daily basis. The current assumption is that the source of water is from groundwater infiltration, because it appears clear and flows continuously (see Figure 2-10). Figure 3-2 depicts the conditions inside the last manhole, TMH H1, with debris floating on standing water inside the manhole. Also observed on several field visits are sand, gravel and sediments covering the pipes inside, resulting in speculation on how this existing system is functioning. Based on repeated survey field measurements of the TMH H1 inverts and river bank elevations, the existing bottom of the river is higher than the drain line's pipe invert, due to decades of silt and sediments deposits. Water being discharged is finding its way below or around TMH H1 and to the surface as a result of surcharging within System H. The pressure of the water backed up in the system is forcing the water to the surface.

Figure 3-2. Looking inside Somerville Outfall H

No estimated flows for Line H have been obtained from the City of Somerville, and an evaluation of the tributary drainage area is beyond the scope of this study. For the purpose of designing a replacement and extension of the existing 20-inch line through the proposed flood wall/embankment improvements, the capacity and physical characteristics of the existing 20-inch pipe were evaluated. The resulting 7.0 cfs flow capacity will be provided in a new 21-inch diameter reinforced-concrete pipe.

3.3.3 MassDOT System X

Estimating flows for System X from the Alford Street roadway area is also beyond the scope of this study. The existing 18-inch diameter outfall pipe will be replaced with a longer, 18-inch diameter RCP extended through the new embankment.

3.4 Proposed System Flows

The proposed conditions do not include any additional tributary area or significant changes to site runoff characteristics. In general, the Bus Operations area retains the same amount of impervious pavement under proposed conditions, and proposed paving in the Engineering Rail Yard will replace existing pavement. The runoff coefficient for the existing pervious railroad ballast (C=0.6) covering the 100-foot buffer zone area under existing conditions is assumed as similar for the proposed grass surface.

The proposed drainage systems include minor improvements to the existing drainage conveyance systems, as summarized in Section 6 and as indicated on the attached figures. The improvements generally include the replacement of damaged pipes and under-capacity pipes, replacement of damaged or inadequate structures, construction of extended outfalls in the proposed embankments, as well as stormwater quality improvements as summarized in Section 4. Additionally, the proposed improvements include increasing the pipe diameter of Somerville's Outfall H, extending MassDOT's Alford Street drainage outfall, and adding a new Outfall H1 to serve the northern portion of the Engineering Rail Yard.

3.4.1 New Outfall H1

The current Project includes a new outfall, Outfall H1, which is associated with Rain Garden H1. Outfall H1 may also be used as part of the future work in the Engineering Rail Yard that is not part of the current Project. For this future work, a new storm drainage system (referred to as "System H1") is proposed to collect stormwater runoff from a proposed Rail Yard layout to the west and north of the existing Rail Bending Building. At a later date, the MBTA plans to revise the site layout to better accommodate the storage and handling of materials on the site. As part of this future work, it is anticipated that materials storage bins will be created within the Engineering Rail Yard and that stormwater runoff from the storage bins will be directed into additional drainage lines that will be connected to the new Outfall H1. The future System H1 will include new structural BMPs, such as deep sump catch basins with hooded outlets and an inline proprietary separator. Provisions and sizing for the future installation of an inline proprietary separator have been provided in the proposed drain manhole DMH H12. The new drainage System H1 will serve the area designated "H", as shown in Figure 2-1.

The proposed System H1 was designed to accommodate the rainfall for the Engineering Rail Yard area, assuming no changes to the existing pervious railroad ballast surface treatment is proposed under this project. Data from the existing soil, slopes, and area were placed into the HydroCAD model to size the system. Based on the length of the potential catchment area, surface grades, and available slope, the proposed system would accommodate the quantity of flow contributed from a drainage system that was designed and installed in the future. The future drainage system would include five standard 4-foot diameter drain manholes, one 6-foot diameter manhole (DMH H12) that would contain a future water quality treatment device, five deep sump catch basins, and an overflow drain manhole for the proposed Rain Garden H1. The proposed drain line would be RCP pipe, with diameters ranging from 15-inch to 30-inch, and invert elevations ranging from Elevation 2.75 feet to Elevation 0.93 feet.

The proposed System H1 was designed to accommodate the rainfall for the Engineering Rail Yard area, assuming future surface runoff characteristics equivalent to existing conditions. The future drainage system was based on an MBTA layout plan for the future Rail Yard and included five standard 4-foot diameter drain manholes, one 6-foot diameter manhole (DMH H12) that would contain a future water quality treatment device, five deep sump, hooded outlet catch basins, and an overflow drain manhole for the proposed Rain Garden H1. RCP pipes connected the drainage structures, with diameters ranging from 15-inch to 30-inch, and invert elevations ranging from Elevation 2.75 feet to Elevation 0.93 feet, based on the length of the future system, surface grades, and available slope.

3.4.2 Proposed System Peak Flows

Table 3-2 summarizes the proposed peak flow results from the HydroCAD model at each outfall, along with the tributary area, time of concentration, and outfall pipe diameter. The shaded cells in Table 3-2 indicate peak flows in excess of the full flow pipe capacity (surcharged) in at least one location in the drainage system. As shown, surcharging still occurs in six of the eight drainage systems, but only for the 100-year storm. As explained for the existing flows above, the values shown in the shaded cells are the peak rates of runoff that would have been transported without surcharging.

System ID	Area (ac)	Outfall Pipe		t_c 10-year (min)	Proposed Peak Flows (cfs) Storm Events				
		Diam. (in)	Invert (ft)		2 Yr.	5 yr.	10 yr.	25 yr.	100 yr.
A	3.53	30	-3.92	6	13.17	15.77	18.03	22.08	30.97
B	2.18	30	0.66	6	8.15	9.76	11.15	13.64	18.59
C(1)	13.80	48	-4.67	9	40.92	48.41	55.02	66.92	80.17
D	0.37	15	5.46	5	1.44	1.73	1.97	2.43	3.25
E	9.14	36	-0.25	5	35.63	42.83	48.97	58.97	82.83
F	1.10	24	4.28	5	4.41	5.30	6.05	7.44	9.96
G	2.59	30	-1.48	5	9.62	11.60	13.29	16.38	23.57
H1(2)	4.73	30	0.93	6	10.87	13.04	14.91	18.21	20.82
TOTAL	37.44							206.07	

[shaded] Indicates surcharged conditions in pipeline

(1) Includes System C1A

(2) Includes entire future drainage area H in Engineering Rail Yard

Table 3-2. Proposed Outfall Peak Flow Rates

3.4.3 Proposed Peak Rate of Runoff

As described above, while the peak discharge flows do not occur precisely at the same time due to the varying times of concentrations of each drainage system, the sum of all proposed peak flow rates listed in Table 3-2 for the 25-year frequency storm totals 206 cfs.

The maximum future flow rate estimated still occurs in System C; however, with improved system hydraulics resulting from the pipe replacement, System C no longer surcharges during the 100-year storm event.

3.4.4 Outfall X

As previously stated, Outfall X will be extended by matching the existing 18-inch diameter cast iron pipe, which can convey a flow rate of approximately 9.0 cfs at a slope of 0.007 feet/foot, with a new 18-inch diameter reinforced concrete pipe. This flow rate approximates the capacity of the 15-inch diameter RCP coming into drain manhole DMH X1, based on available MassDOT Project File No. 603370 Drainage and Utility Plan drawing for Alford Street (Route 99) Bridge Replacement.

4 BMP RECOMMENDATIONS

For compliance with Standard 7 and removing 80% of the average annual TSS loads to the maximum extent practicable, various BMPs (Best Management Practices) were considered based on the existing site conditions. Different BMP systems are proposed for the Engineering Rail Yard Area and the Bus Operations Area, due to different space constraints and land uses.

In the Bus Operations area, the proposed improvements include pretreatment BMPs such as inline hydrodynamic separators, catch basin filtration devices, and deep sump catch basins with hooded outlets. In the Engineering Rail Yard area, pretreatment BMPs like those proposed for the Bus Operations area are recommended, along with two rain gardens incorporating overflow drain manholes and the restoration of a large portion of the 100-foot buffer zone.

Overall, the proposed BMPs are estimated to remove approximately 77% of the TSS from stormwater runoff within the project area. Because 43% of the total drainage area discharging through the eight existing MBTA outfalls comes from outside the project area, the total TSS removal percentage for the site is 44%, which is still a significant improvement from existing conditions for this redevelopment project.

As described in the following sections, the applicability of a BMP was evaluated for each drainage subsystem. Each system has varying impervious areas contributing to the Water Quality Volumes (WQV) requiring total suspended solids (TSS) treatment as well as different site constraints. In accordance to Standard 4 from the MassDEP, the underlying objective is to remove 80% of the average annual TSS from each sub-drainage system to the maximum extent practical.

The following specific site constraints affected the BMP selection:

- Shallow groundwater throughout the project site excludes infiltration systems due to the system installation requirements;
- Deep drainage systems preclude excavation for in-line and offline treatment units for some drainage systems; and
- Critical existing utility infrastructure and space constraints preclude adjacent deep excavation for some systems.

Generally speaking, systems will be retrofitted using deep sump, hooded catch basins with inline treatment units provided prior to the drainage system outfall. In systems where a downstream treatment unit is not feasible or practicable, all catch basins will also receive a sediment screening device, such as a Silt Prison® or equal, to improve capture and removal of suspended sediments. Finally, bioretention areas or rain gardens will be located in project site areas not required for existing bus operations or engineering rail yard operations.

4.1 PROPRIETARY BMP SIZING

To size the proprietary BMPs, the method required by the MassDEP was used to determine the water quality flow rate for a given Water Quality Volume.[6] These MassDEP water quality flow rates are used to size many BMPs and can easily be used to determine the size necessary for each unit. Because the stormwater runoff is largely coming from heavy traffic areas of buses and rail yard machinery with greater risk of containing pollutants, such as oil, the required WQV was sized for the first 1-inch of runoff times the total impervious area in each drainage system.

4.1.1 MassDEP Sizing Methodology

For the portions of the drainage areas that are impervious, the Curve Number (CN) 98 was specified by the MassDEP methodology, along with an Initial Abstraction (I_a)/ Rainfall Precipitation (P) in inches factor of 0.034. Then, based on the Time of Concentration (Tc) as determined by the HydroCAD model for each drainage area, the Unit Peak Discharge (qu) in cubic feet per second/ square mile/watershed inches (csm/in) was derived from the MassDEP chart for a Type III storm and an I_a /P Curve of 0.034. Finally, using the Unit Peak Discharge (qu), the impervious drainage area (A), and the 1-inch WQV, the Water Quality Flow (WQF) rate for each of the subsystems was calculated using the equation,

$$\text{WQF Rate } (Q_1) = (qu)(A)(WQV).$$

Using the WQF rate as well as our peak flow rates for each subsystem, the sizes of several different proprietary BMPs were estimated to determine space requirements, installation feasibility, and costs. These factors were used to evaluate applicability, feasibility, and affordability of each unit.

The resulting WQF rates to treat the 1-inch of rainfall over a drainage system's impervious area, along with the values used to calculate it, are presented in Table 4-1.

SYSTEM ID	T_c		AREA		qu (csm/in)	WQF (cfs)
	hour	min.	sq. mi.	sq. ft.		
A	0.100	6	0.005522509	153,968	752	**4.153**
B	0.100	6	0.003410125	95,074	752	**2.564**
C	0.167	10	0.021549225	600,792	677	**14.589**
D	0.083	5	0.000579085	16,144	773	**0.448**
E	0.083	5	0.014287631	398,339	773	**11.044**
F	0.067	4	0.001713222	47,765	794	**1.360**
G	0.083	5	0.004055175	113,058	773	**3.135**
H1	0.100	6	0.007385454	205,906	752	**5.554**

Table 4-1. Water Quality Flow (WQF) Rates

[6] MassDEP, Standard Method to Convert Required Water Quality Volume to a Discharge Rate for sizing Flow Based on Manufactured Proprietary Stormwater Treatment Practices, September 10, 2013.

4.2 Drainage System BMPs Evaluation

4.2.1 Deep Sump Catch Basins With Hooded Outlets

Deep sump catch basins with hooded outlets will be installed for any catch basin, which is scheduled to be replaced, and hooded outlets will be provided for any catch basin being repaired or replaced. These improvements will help remove some TSS and is an economical and realistic BMP to add for a redevelopment project. According to the Massachusetts Stormwater Handbook, Volume Two: Stormwater Technical Handbook (February 2008), the percentage of TSS removal for deep sump catch basins is 25%. To maintain this level of treatment, the catch basins should be inspected four times a year, with captured sediments removed at least twice per year. The inspections must be conducted by a qualified professional, such as an environmental scientist or civil engineer.

4.2.2 Offline Hydrodynamic Separators

For System C and System E, the two largest drainage systems, proprietary, offline hydrodynamic separators were evaluated. These systems are proven to remove at least 80% of TSS in compliance with MassDEP regulations. Comparable offline hydrodynamic separators are available from at least three manufacturers - Downstream Defender® by Hydro International, Vortechs® Stormwater Treatment by Contech, or Crystal Stream Technologies' Piped Internal Bypass® System. Manufacturer's data supplied by Hydro International were used to size and evaluate their Downstream Defender treatment unit. Both drainage systems would require an 8-foot diameter Downstream Defender®, installed in an offline configuration, as shown in Figure 4-1.

The 8-foot diameter offline unit requires a weir wall in the upstream diversion structure manhole, a bypass system for flows greater than the treatment unit's capacity, and 24-inch diameter inlet and outlet pipes. Untreated stormwater enters the diversion manhole and is directed through the Downstream Defender for treatment, before being discharged to the downstream manhole. With the Downstream Defender sized to treat the 10-year storm event, incoming flows greater than 10-year event will spill over the weir wall, through the bypass pipe to the downstream manhole, where the treated and untreated flows combine before being discharged through the outfall.

Offline systems are designed to protect the treatment unit and to keep the solids removed from being washed out, while allowing flows greater than the design storm to pass.

System C. The System C unit was evaluated for an installation between drain manholes DMH C2 and TMH C1. This location was chosen because of space available immediately north of the existing TMH C1 and the ability to treat all System C flows, except for a small, downstream area draining to catch basin CB C-C2. The advantages of an offline separator are that they can treat larger volumes of flow in a small space, while retaining the solids within the treatment unit. A major disadvantage, as can be seen from the Elevation View in Figure 4-1, is the bottom of the treatment unit is nearly 8 feet below the invert of the storm drain pipe entering the system. In the case of the existing System C, the 48-inch drain at DMH C2 is already over 14-feet deep and another 8 feet required for installing the treatment unit would result in an excavation approaching 24 feet, including the bottom slab and subbase, under high groundwater conditions. Construction would be very difficult and expensive, as would be maintenance and removal of captured solids. While the proposed location has sufficient room to accommodate the offline system, bus operations would have to be detoured during the construction, and ongoing accommodations would be required during solids removal and maintenance activities. For all of these reasons, installation of such an offline treatment system is not considered practical and is not recommended.

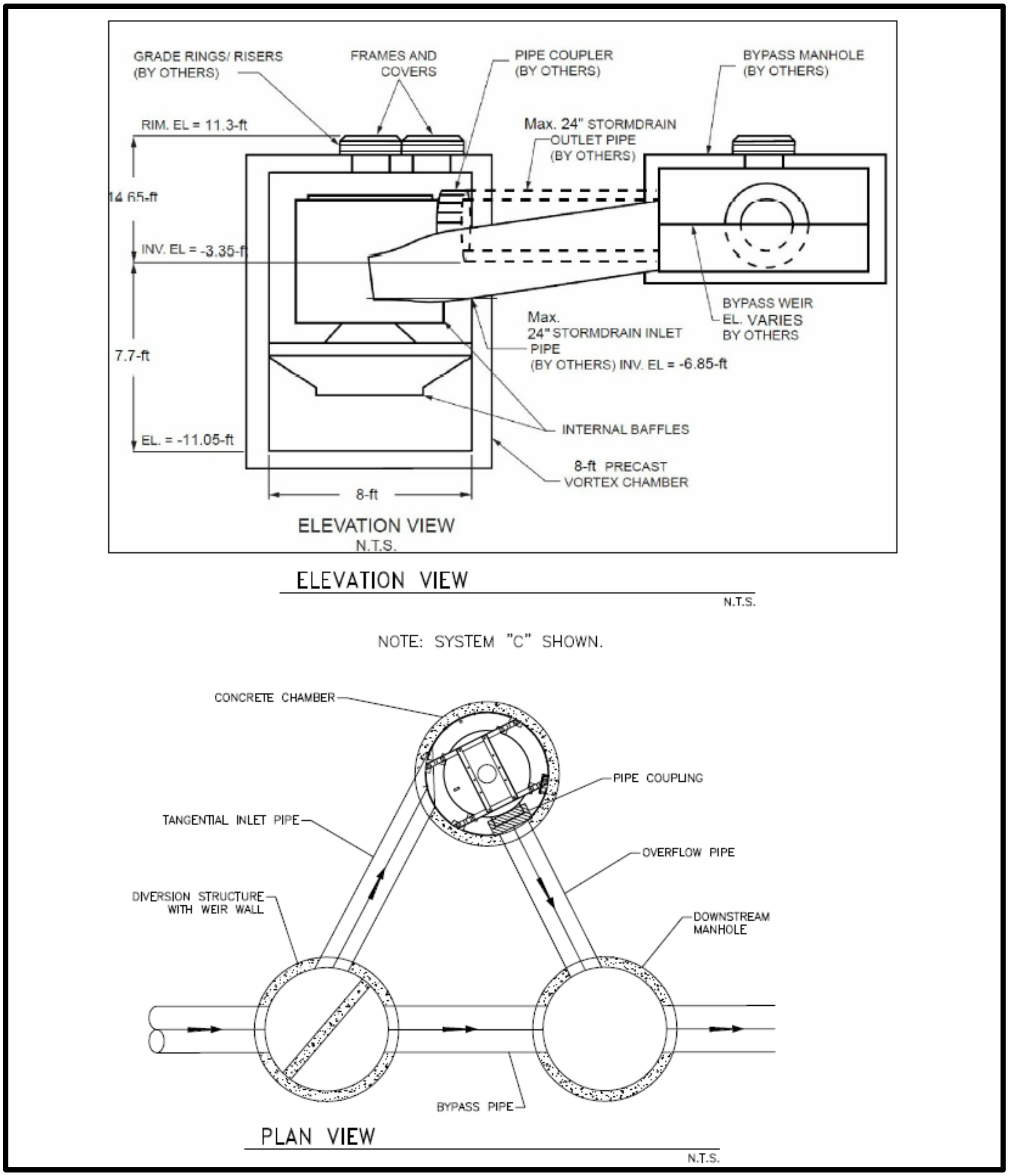

Figure 4-1. Downstream Defender Typical Layout

System E. The System E unit was evaluated for installation between drain manholes DMH E3 and DMH E2. This location was chosen because it was downstream of two large diameter drain lines connected to DMH E3. As with the System C location, only one catch basin serving a small area was not connected to DMH E3.

While the existing 36-inch diameter drain line at DMH E3 is not as deep at 10 feet below the surface, the bottom of the excavation would still be around 20 feet deep, with extensive groundwater dewatering required during construction. In addition, in laying out the space requirements for the 8-foot diameter offline system, insufficient room exists between DMH E3 and DMH E2 for a hydraulically efficient configuration. Taking all these factors into consideration, an offline hydrodynamic separator is also not considered practical at System E.

4.2.3 Inline Hydrodynamic Separators

Unlike their offline counterparts, inline hydrodynamic separators present a much smaller footprint. However, they also cannot treat the flows possible with an offline unit. For this reason, inline separators are not feasible for System C, due to its high rates of flow, while in System E, two inline units are proposed at locations to treat most of the System E flows.

Two of the three manufacturers mentioned above, Hydro International and Contech, also furnish inline units with their First Defense® and VortSentry HS® units, respectively. A third manufacturer, Rinker Materials, furnishes the Stormceptor STC®, which was one of the first hydrodynamic separators offered.

These systems are typically either 4-foot or 6-foot in diameter and can fit in a standard size manhole. If desired, the units can also be placed inside an existing manhole structure. Vortex separation provides sediment, trash and oil removal to treat stormwater and can remove 80% of TSS up to a unit’s design WQF. The units have an internal bypass to pass flows greater than the design flow, which saves construction costs for an external bypass. Maintenance is readily accomplished using a vacuum truck to easily remove sediments from the sump, along with floatable oils, grease, trash and other debris from the unit.

Manufacturer’s data from Hydro International for its First Defense unit was used to size and estimate the costs of the recommended installations. The typical layout as well as the typical cross section for a First Defense inline hydrodynamic separator is shown in Figure 4-2. Inline hydrodynamic separators are recommended for Systems A, B, F, and G, while two units are proposed for System E. In System D, the requirement for an Outfall Sluice Gate Structure, OGS D, precluded installing any type of treatment system, except for a sedimentation filter installed in both catch basins. This type of a small scale treatment unit is described further in the next section. For System H1, because only the outfall and proposed Rain Garden H1 will be installed, provisions will be provided in DMH H12 for the future installation of an inline hydrodynamic separator.

4.2.4 Catch Basin Sedimentation Filters

As discussed above, a water quality treatment unit for System C is not feasible, and in System E, two catch basins are located downstream of the proposed locations of the two inline hydrodynamic separators. Thus, stormwater entering these catch basins would only receive around 25% treatment as a result of their deep sumps and hooded outlets.

In order to improve the overall TSS removal efficiencies in both System C and System E, a sediment screening device will be installed in all on site System C catch basins and in the two System E catch basins. Figure 4-3 shows one such device, the Silt Prison® as manufactured by the Stormwater Buffer Zone. As shown, stormwater flows entering the catch basin drop into the deep storage sump after first passing through a trash strainer, which captures large pieces of debris. As the flows continue, the water passes through the Silt Prison's Primary Flow Region area, where particles larger that 20-50 microns are retained within the catch basin. If the flow rate coming in is greater than the flow rate out, the water level continues to rise until the Secondary Flow Region is reached, which allows larger particles up to 212 microns in size to pass. If the storm continues and stormwater runoff is entering the catch basin faster than what is flowing out through the screening, then the third and highest region of screening is reached. This High Flow Region has an 850 micron sized mesh, which allows even greater flows out while capturing particle sizes less than 850 microns, which is approximately 1/32 inch.

With a Silt Prison® installed, each catch basin is capable of removing up to 63% TSS entering the catch basin. Silt Prison® has been reviewed by the Massachusetts Stormwater Technology Evaluation Project (MASTEP) and has been awarded a "2" on their rating system, denoting sound field or laboratory performance studies exist for our technology.

4.2.5 Bioretention BMPs

As there is more pervious area and, in fact, more room for BMP improvements in the Engineering Rail Yard area, bioretention areas, or rain gardens, are proposed in both System G and System H1 drainage areas. The rain garden area is sized to be 5% to 7% of the tributary area, with the ponding area and void space in the planting zone designed to capture and treat the required WQV. Rain gardens remove pollutants and studies show that these areas can remove 75% of phosphorous and nitrogen, 95% of metals, and 90% of organics, bacteria, and total suspended solids, according to MassDEP standards. These rain gardens will have overflow drain manholes with grated covers to prevent any flooding during rain events greater than the 10-year storm.

Figure 4-4 shows a typical cross-section of a rain garden depicting the key components and construction. Both rain gardens will be excavated to a depth between 4.5 - 5 feet, with the banks graded at a 3:1 (Horizontal:Vertical) slope. A minimum of 30 inches of planting soil medium will be placed on top of the underdrainage system, consisting of 6-inch diameter, perforated pipe surrounded by an 8-inche gravel base at the bottom of the excavation. A filter fabric may be placed around the underdrainage system to minimize plugging. An overflow manhole with a beehive-type grate will be installed to allow a maximum ponding depth of 8 inches. Rain gardens should be designed to drain within 72 hours and should have a vertical separation of at least 2 feet from the bottom of the planting soil to the water table.

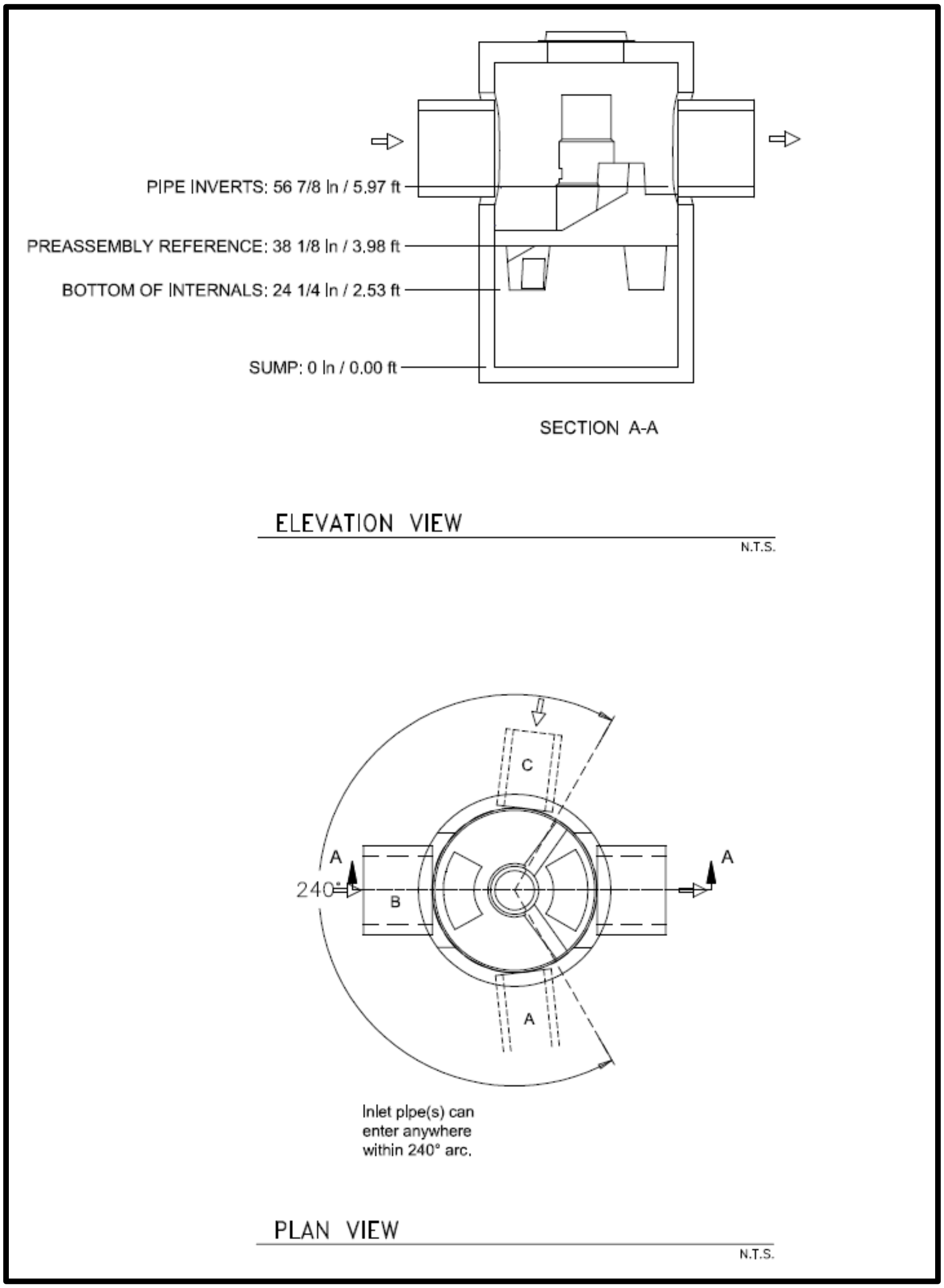

Figure 4-2: First Defense Typical Layout

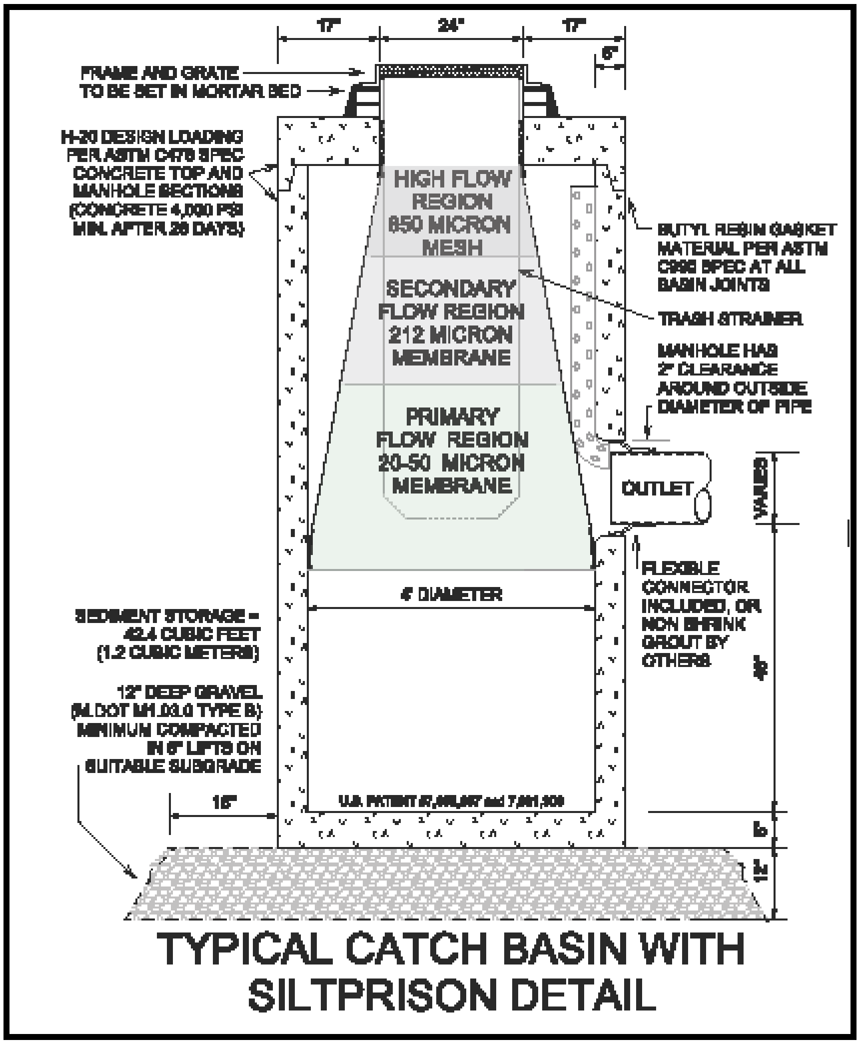

Figure 4-3. Typical Silt Prison Installation

Rain Garden G. Figure 4-5 shows the conceptual layout for Rain Garden G, which will be located northeast of the existing Rail Bending Facility. For System G, the overflow manhole DMH G1A will be installed as part of the proposed 30-inch RCP drain upstream of Outfall Gate Structure (OGS) G1. The proposed rain garden is sized to treat the tributary WQV (water quality volume) and is in the shape of a triangle, measuring approximately 63 feet long by 48 feet wide across the base, with a surface area of approximately 2,200 SF and a water storage volume of 1,530 CF, or 11,400 gallons. The surrounding area of the rain garden will be re-graded for grassed filter strips between the edge of pavement and the rain garden and drainage channels/swales to convey runoff to the garden.

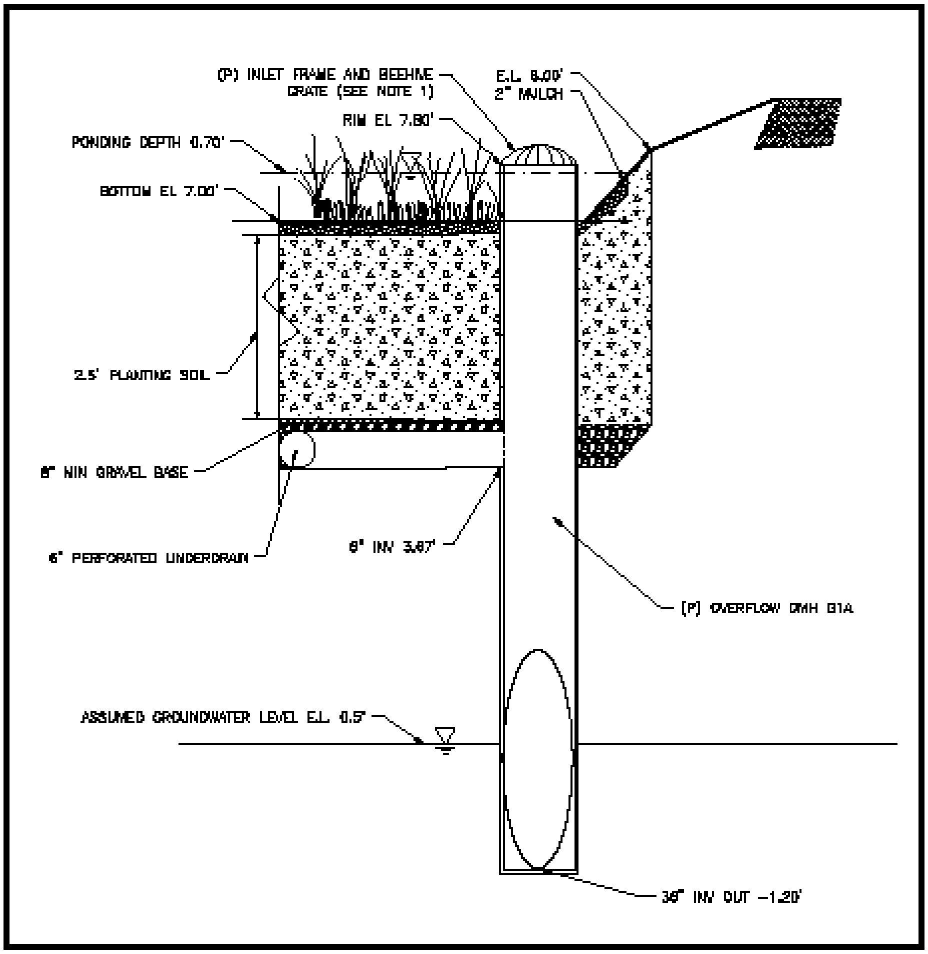

Figure 4-4. Typical Rain Garden

Rain Garden H1. For Rain Garden H1, the oval-shaped garden measures approximately 73 feet long by 34 feet wide, with a surface area of approximately 2,750 SF and a water storage volume of 1,925 CF, or 14,400 gallons. Rain Garden H1's overflow manhole DMH H11A is situated over a 30-inch diameter RCP drain and is located upstream of OGS H11, which is connected to Outfall H1.

As shown on Figure 4-6, Rain Garden H1 is situated within the 100-foot buffer zone in the northeast corner of the Engineering Rail Yard. The area surrounding Rain Garden H1 will be re-graded and seeded with grass to provide groundwater infiltration and filtered overland flow of the runoff directed to the rain garden. For areas between paved surfaces and the rain garden, these grassed areas will function as vegetated filter strips, slowing runoff velocities, trapping sediments, and promoting infiltration. A shallow drainage channel, or swale, has also been incorporated into the proposed re-grading plan to convey overland flows from the edge of the tributary area of the rain garden.

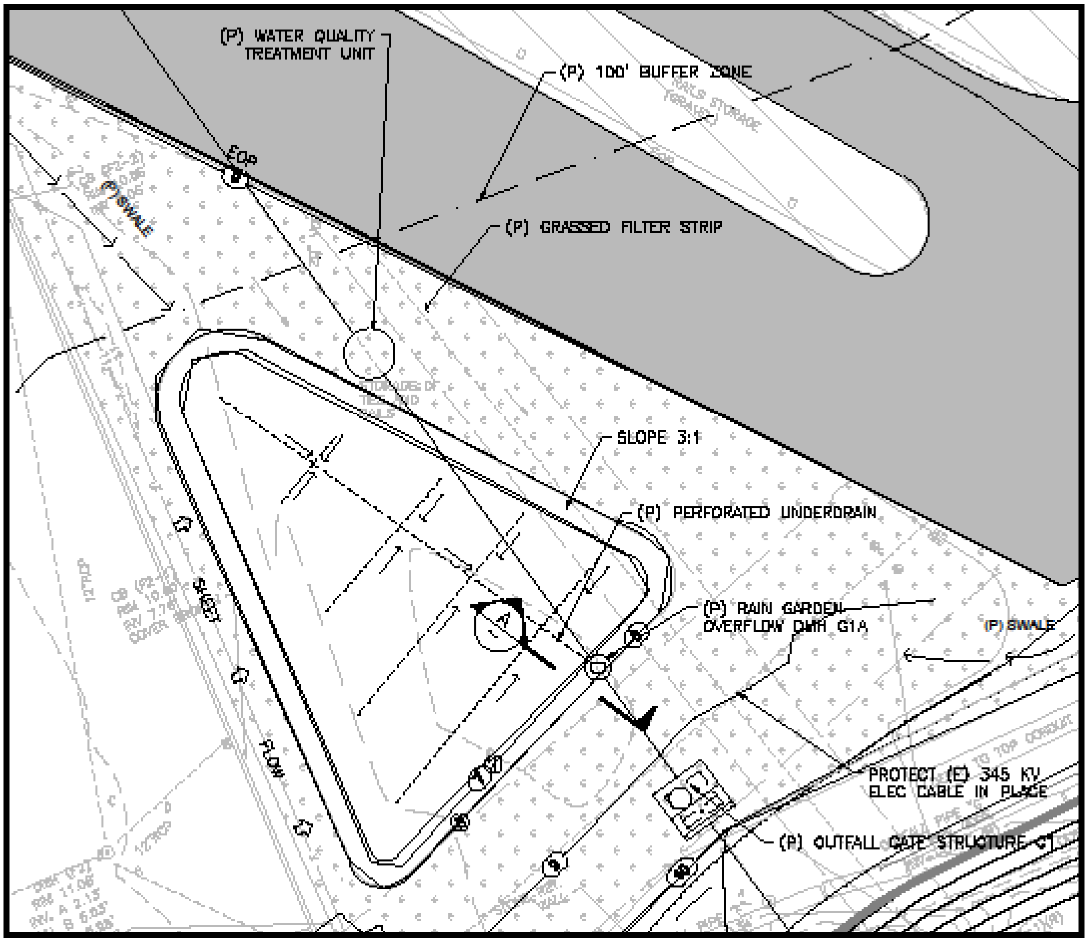

Figure 4-5. Rain Garden G Conceptual Layout

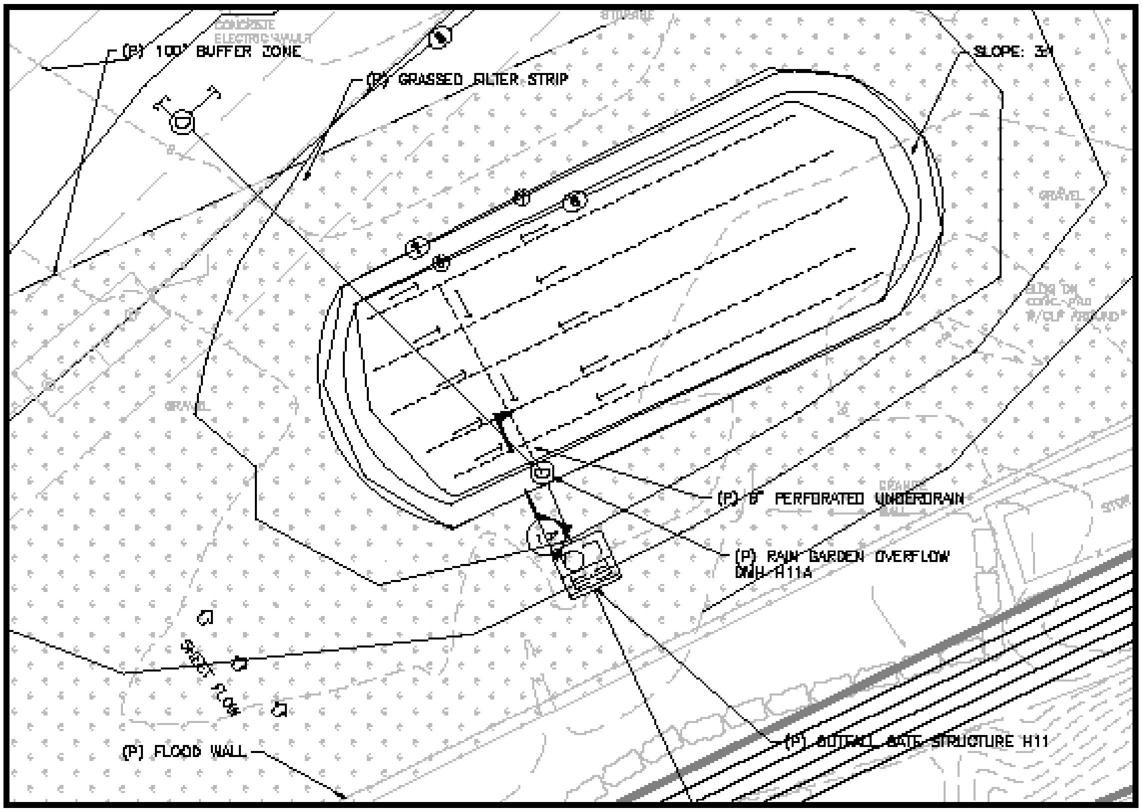

Figure 4-6. Rain Garden H1 Layout

4.4 Other Considerations

Other stormwater treatment options were considered but were not recommended due to site constraints and the existing usage of the site. For example,

- Tree box filters, which consist of an open bottom concrete barrel filled with a porous soil media, an underdrain in crushed gravel, and a tree[7], provide TSS removals in highly developed urban areas, but suitable locations that would add to the overall stormwater quality of the site while not impeding MBTA operations were not found.
- Infiltration trenches, which are shallow excavations 3 – 7 feet deep filled with stone and sized for the needed WQV, were also considered but were eliminated due to siting constraints. Also, for the Rail Yard area, the same or better level of treatment will be accomplished by the proposed rain gardens.
- Water quality swales are vegetated channels designed to treat the required WQV while conveying runoff from the 10-year storm[8]. They typically have a trapezoidal cross-section with maximum of 3:1 slopes and bottom widths of 2 – 8 feet. Two different types of water quality

[7] MassDEP, Volume 2, Chapter 2:Structural BMP Specifications for the Massachusetts Stormwater Handbook, page 61

[8] Ibid., page 77.

swales, wet swales and dry swales, were considered but both had site constraints and neither one offered advantages over the proposed rain gardens.

As mentioned before in discussing MassDEP Stormwater Management Standard 3, infiltration systems were ruled out based on high groundwater constraints. For example, dry wells were not applicable due to the large amount of impervious areas and the resulting large required water quality volume for each system. Other subsurface infiltration systems, such as infiltration basins, required a large surface area, had limiting setback requirements, and were screened out as not feasible due to site constraints.

Stormwater Standards require Low Impact Design (LID) measures be considered in the planning and design of any project.

> *The Wetlands Regulations, 310 CMR 10.04, and the Water Quality Certification Regulations, 314 CMR 9.02, define low impact development (LID) techniques to mean innovative stormwater management systems that are modeled after natural hydrologic features. Low impact development techniques manage rainfall at the source using uniformly distributed decentralized micro-scale controls. Low impact development techniques use small cost-effective landscape features located at the lot level.*[9]

LID measures, which are being implemented as part of the overall site design, include treating stormwater at its source using deep sump catch basins with hooded outlets. Also, for those catch basins not connected to a downstream water quality treatment device, sediment filtration devices will be installed within the catch basin. Reducing the amount of impervious surface was also examined but was not feasible due to bus and rail yard operational needs; however, the proposed improvements will not increase the existing impervious area. Improved water quality should result from the restoration of a portion of the 100-foot buffer zone in the Engineering Rail Yard. Storage of construction materials have already been relocated from this area, and a grassed surface will replace the existing gravel one.

Some LID techniques, such as rain barrels and cisterns, green rooftops, open channels and permeable paving, were not feasible or practical or were beyond the scope of the present project. However, bioretention areas, or rain gardens, and vegetated buffer areas will be implemented along with the proposed shoreline and drainage improvements.

The net result for this redevelopment project of a highly developed, urban area is a project that will improve the overall stormwater quality to the maximum extent practicable.

[9] MassDEP, Volume 1, Chapter 1: Overview of Massachusetts Stormwater Standards, page 4.

5 RECOMMENDED PAVING AND GRADING IMPROVEMENTS

The objective of the paving and grading improvements was to prepare site repaving and layout plans for the existing Bus Garage Operations area as well as for the Engineering Rail Yard without increasing significantly the amount of impervious surface. Opportunities to create overland flows through re-grading, providing drainage swales or other LID techniques to reduce the stormwater runoff or peak flows were also examined.

Regrading the existing pavement in the Bus Operations area was not feasible, due to the limited scope of the project. The only paved areas proposed in the Bus Operations area are pavement replacement in the "Tube Out" roadway, a small area (823 SF) of new pavement resulting from the proposed embankment, and pavement patching along the edge of the bus area parking/driveways.

However, in the Engineering Rail Yard, the proposed removal of the last overhead crane bay of the Rail Bending Facility and the reconfiguration of the U-shaped access/delivery roadway allowed the area to be regraded. Stormwater runoff, which currently discharges directly through two catch basins into System G, will be directed overland to one of the two proposed rain gardens in Systems G and H1. The proposed truck turnaround area is shown in Figure 5-1. This small improvement will help decrease the peak flows during rain events and will promote groundwater infiltration.

While opportunities to decrease the total area of pavement were examined, no decrease was possible. However, as previously discussed, the project will only increase the amount of impervious area of the site by 823 SF, which is approximately 0.05% of the total site impervious area. With the proposed restoration of the 100-foot buffer zone and the installation of two rain gardens incorporating overland flow as discussed in the previous section, this increase in impervious area will be more than offset. The proposed rain gardens and restored buffer zone comprise just over 33,000 SF in area.

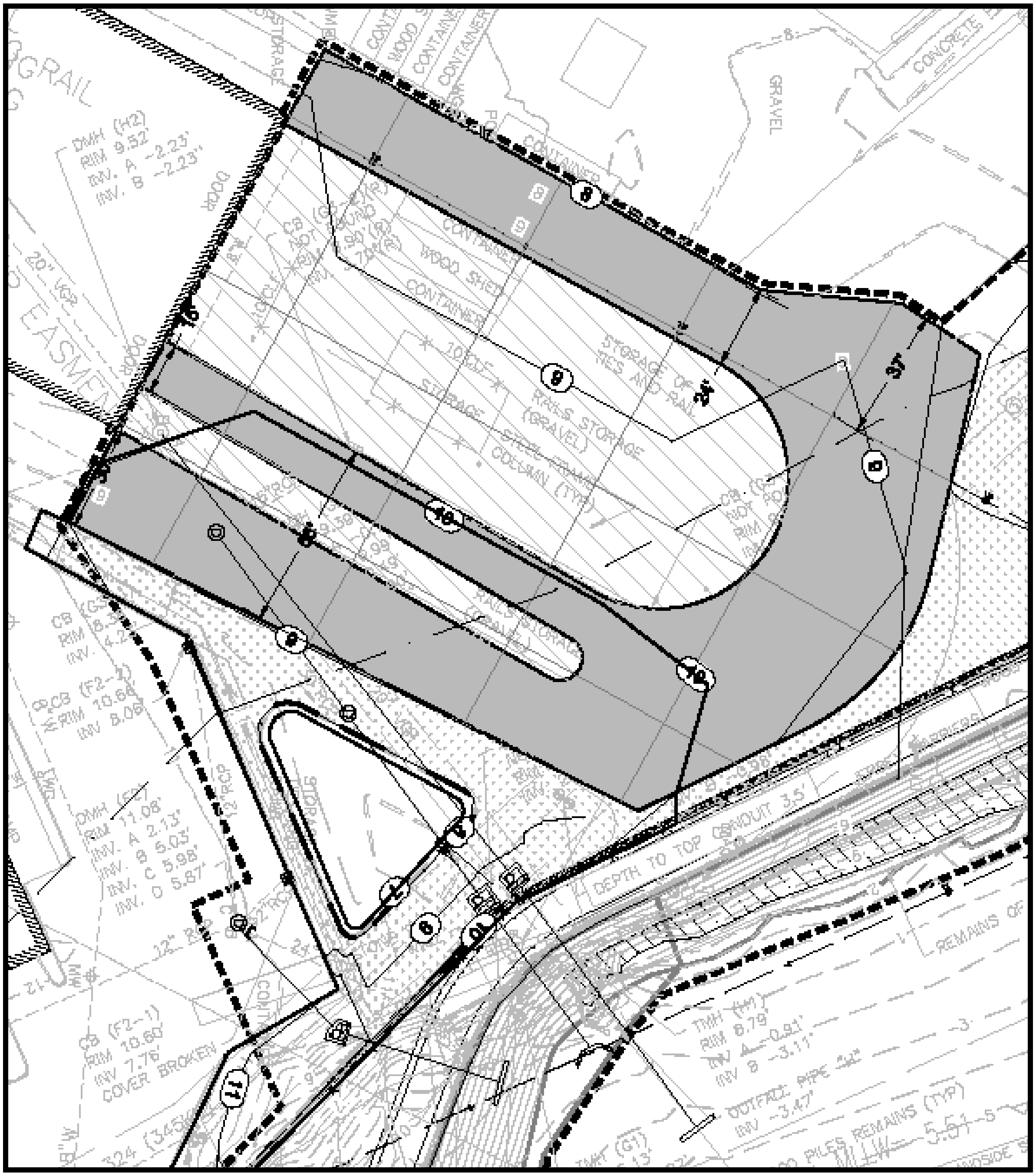

Figure 5-1: Paving and Grading Plan, Engineering Rail Yard

6 Recommended Drainage Improvements

Based on the analysis of the storm drainage system, a series of improvements for the current drainage conditions are recommended. These recommendations are an integral part of the proposed embankment/flood wall improvements, and they provide improved performance and reliability of the existing storm drainage system.

All of the outfalls, which are all in very poor condition, will be replaced. Every catch basin that is proposed to be replaced will be replaced with a deep sump hooded catch basin to help meet MassDEP standards for TSS removal. Many of the existing drainage systems will receive inline water quality treatment devices to remove at least 80% suspended solids, while the catch basins on the remaining systems will be fitted with sediment screening devices to capture 65% TSS within the catch basin.

6.1 Outfall Sluice Gate Structures

Another level of protection from accidental spills of petroleum products into the storm drainage system will be provided by proposed Outfall Sluice Gate Structures (OGS) installed on each drainage system. Intended to provide another level of protection in case of future sea level rise in the Mystic River, these sluice gate structures will contain motor operated sluice gates that can be closed in case of a tide gate failure or when storm surges or water levels rise above the existing grades. Figure 6-1 depicts the proposed arrangement of OGS C1 and the 48-inch diameter outfall pipe and headwall through the new embankment. This arrangement is typical of other nine outfalls.

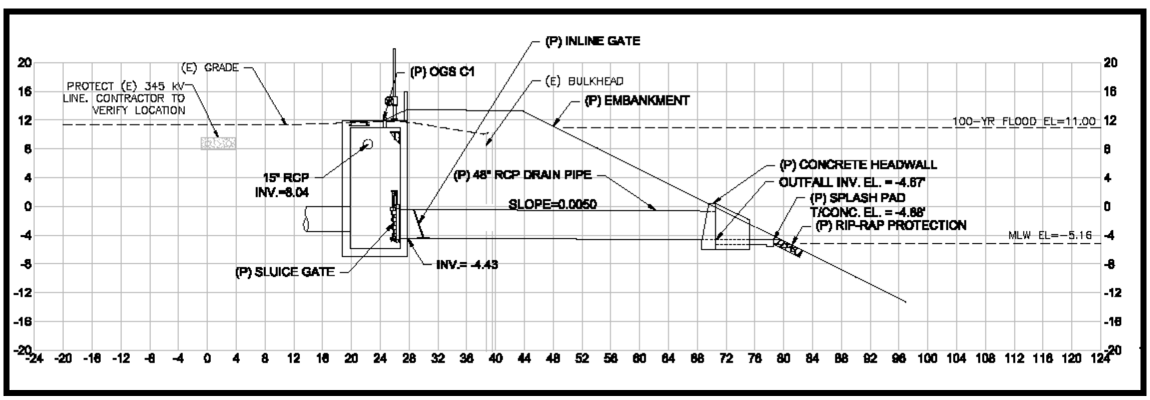

Figure 6-1. Typical Outfall Section

Either a flap gate mounted on the headwall structure or an inline gate (as shown) will normally prevent the Mystic River from entering the drainage system whenever the tide levels in the river rise above the outfall's invert elevation. The sluice gate will be motor operated and controlled locally. Normally, the sluice gate will remain in the open position, but operators can close the gate should the downstream flap gate or check valve fail or in the event of a storm surge which threatens the site. In the extreme event of the embankment/flood wall being overtopped by a storm surge, the sluice gate structure may also be used in recovery as a wet well with the gate closed to dewater the site.

6.2 Individual System Improvements

The following sections briefly describe the proposed improvements for each drainage system. The proposed diameters of lengths of pipe and locations of water quality treatment units, manholes, catch basins, outfall sluice gate structures and outfall headwalls can be seen on Figure 6-2, Figure 6-3, and Figure 6-4.

6.2.1 System A

Proposed improvements for System A include installing 65 LF of a 30-inch RCP outfall pipe from OGS A1 to a concrete headwall with 30-inch diameter tide gate. Because drain manhole DMH A2 must be removed to provide room for installing OGS A1, the three catch basins CB A2-1, A2-1A, and A2-2 must be re-connected to OGS A1 by replacing approximately 135 LF of 15-inch diameter RCP. The existing DMH A2 and 30-inch CMP outfall pipe will be removed and disposed. Figure 6-5 shows these proposed improvements located along the shoreline.

In addition, because it was not feasible to install either an offline or inline hydrodynamic separator, all 13 catch basins within Drainage Area A will be replaced with deep sump, hooded outlet catch basins containing sediment screening devices, such as Silt Prison®.

6.2.2 System B

Figure 6-6 depicts the recommended improvements for System B. System B improvements will replace all six existing catch basins (B6-1, B6-2, B5-1, B5-2, B3-1, and B3-2) with deep sump hooded catch basins. Three of these catch basins are currently curb inlets and must be replaced as they are outdated. A new inline Water Quality Treatment (WQT) Unit B will replace the existing DMH B2, will be located immediately upstream of a new outfall sluice gate structure OGS B, and will be connected by 10 feet of 30-inch diameter RCP. Another 51 LF of 30-inch diameter RCP will transport stormwater flows from the OGS B to the proposed outfall headwall with a 30-inch diameter tide gate.

The existing DMH B2, tide gate manhole TMH B1 and 30-inch CMP outfall pipe will be removed and disposed.

6.2.3 System C

The proposed improvements in System C near the shoreline will remove approximately 50 LF of existing 48-inch diameter ACCMP (asphalt coated corrugated metal pipe) from existing tide gate manhole TMH C1 to the current outfall in the existing sheet metal wall. Since the tide gate is gone but the manhole structure is in good condition, TMH C1 will function in the future as a normal drain manhole. A new 34-foot length of 48-inch diameter RCP drain line will connect TMH C1 to the proposed outfall sluice gate structure OGS C1, which will control flows through the proposed 48 LF RCP and outfall headwall containing a 48-inch diameter tide gate. A new catch basin CB C-C2 will be connected to OGS C1 by 37 LF of 15-inch RCP. These System C improvements located along the shoreline are shown in Figure 6-7.

Because it was not feasible to provide either an inline or offline water quality treatment unit for System C flows, all 10 catch basins within the System C project area will be removed and replaced with deep sump, hooded outlet catch basins containing sediment screening devices, such as Silt Prison®.

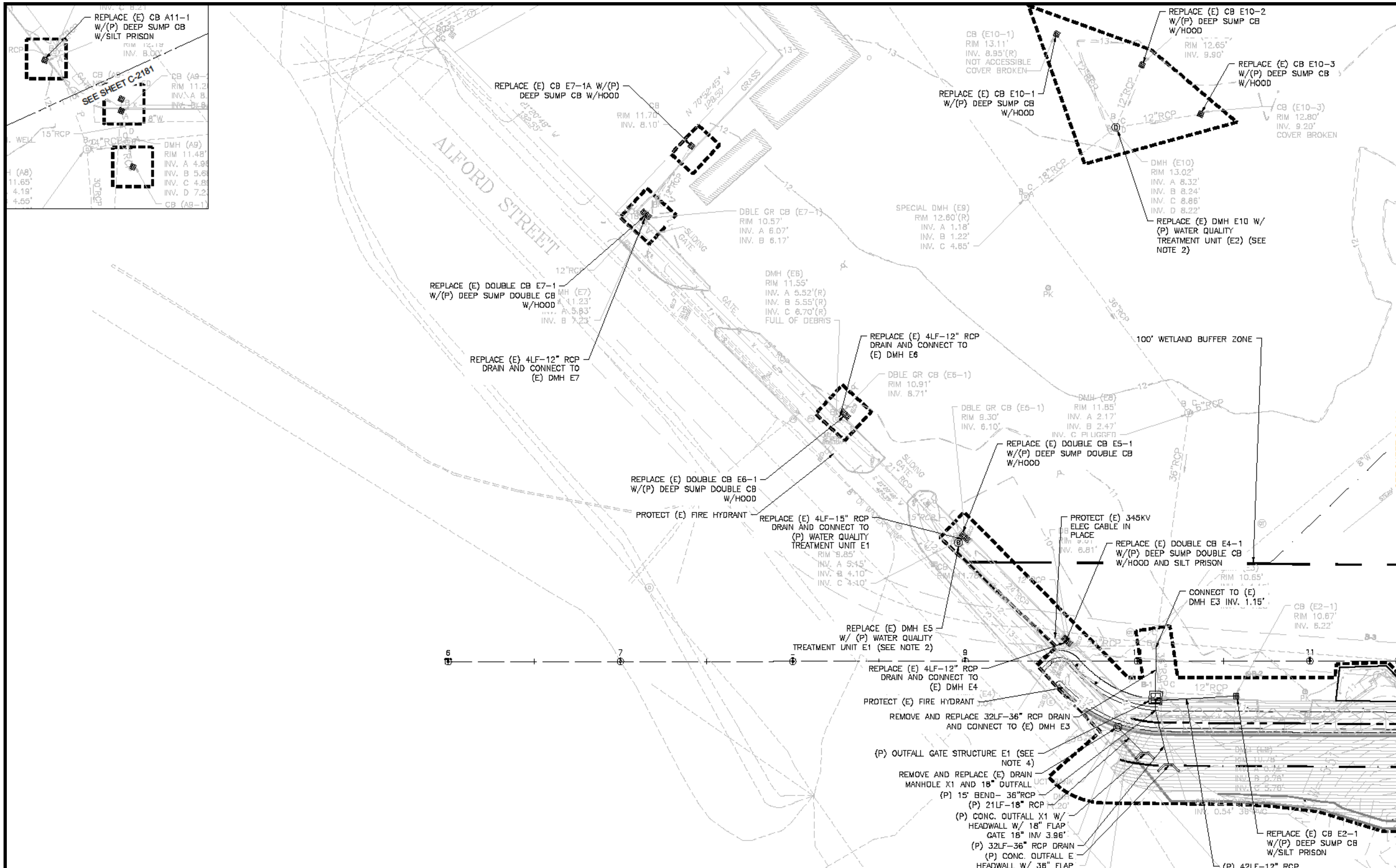

Figure 6-2. Proposed Drainage and Utility Plan 1

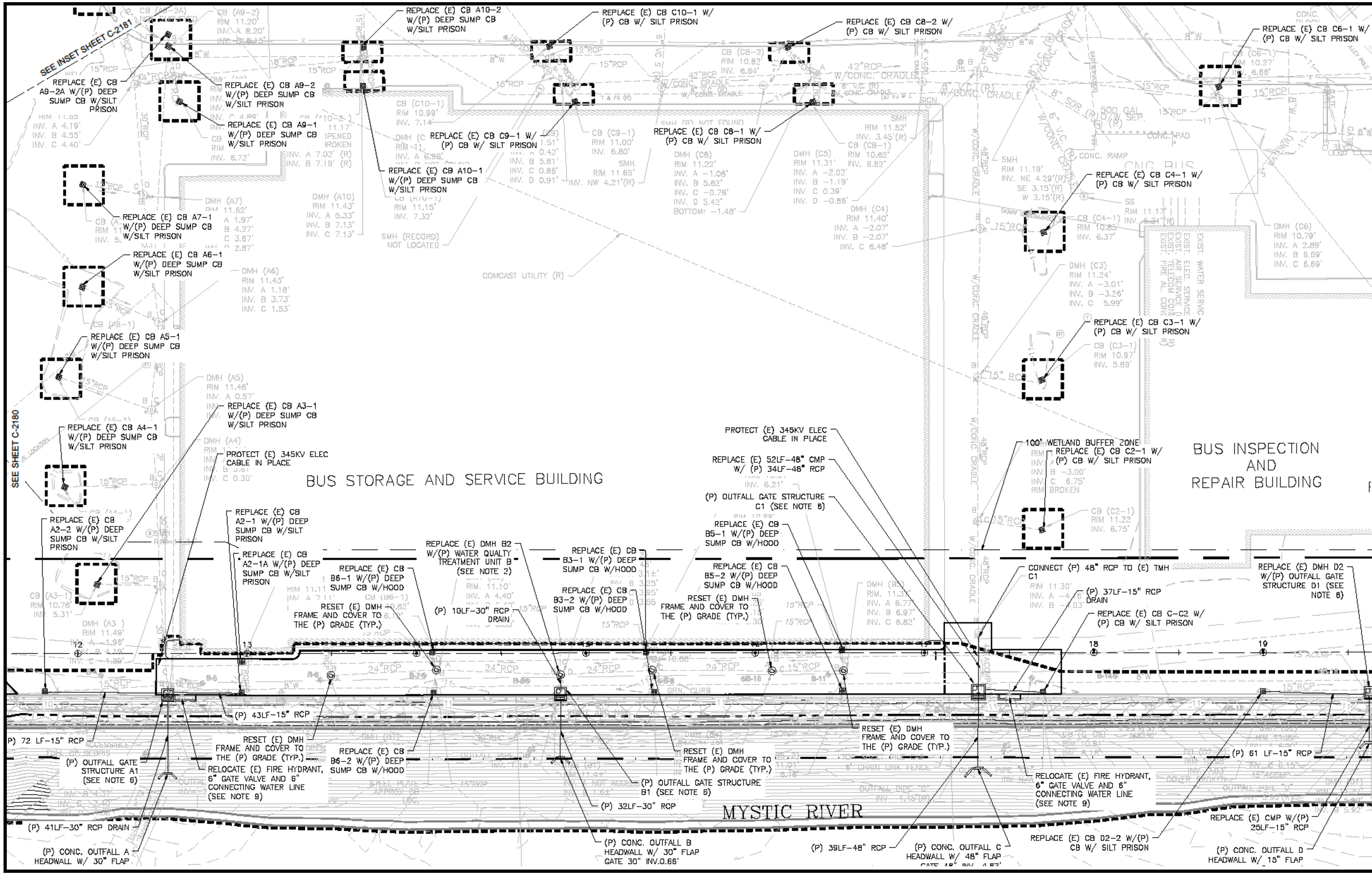

Figure 6-3. Proposed Drainage and Utility Plan 2

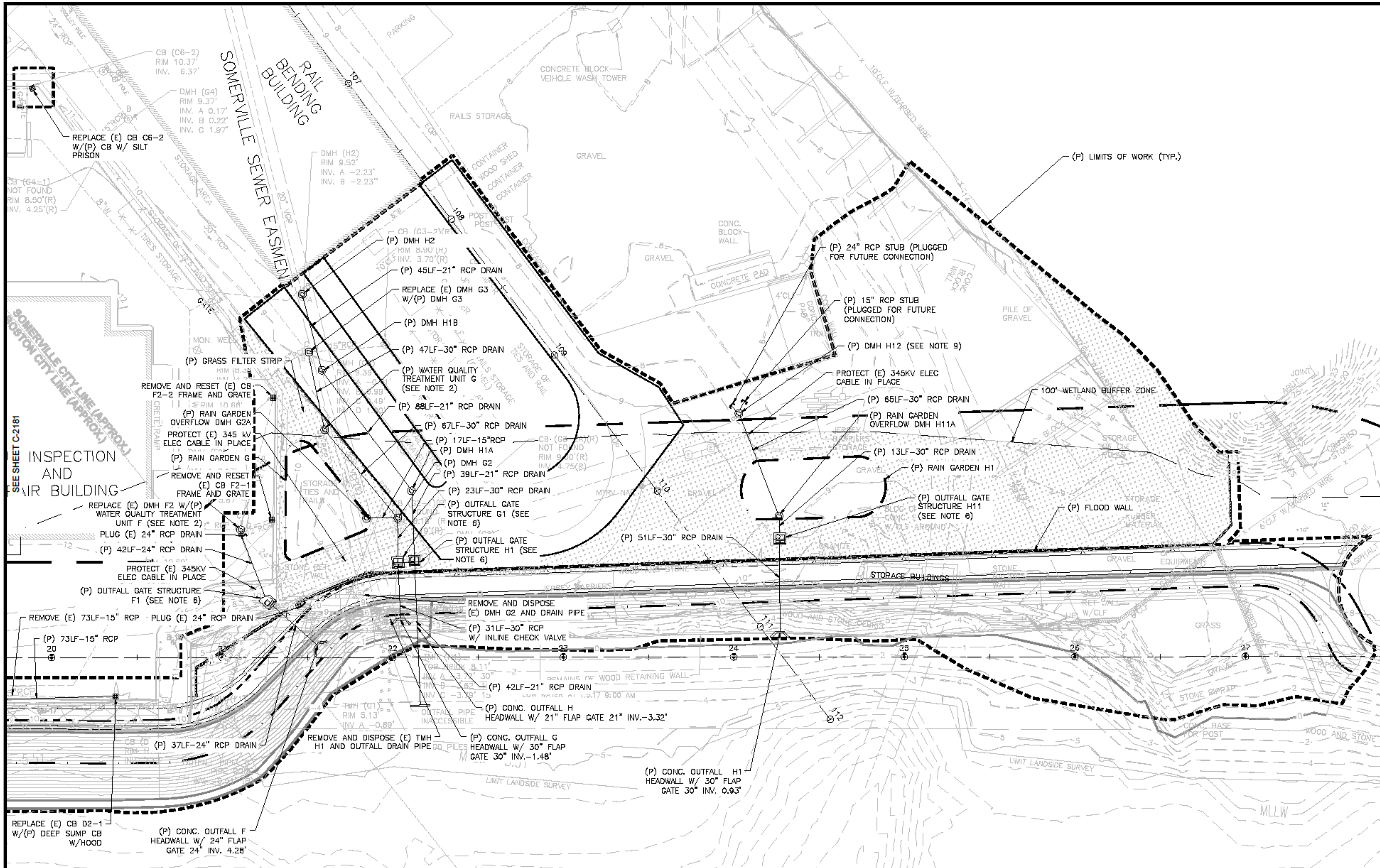

Figure 6-4. Proposed Drainage and Utility Plan 3

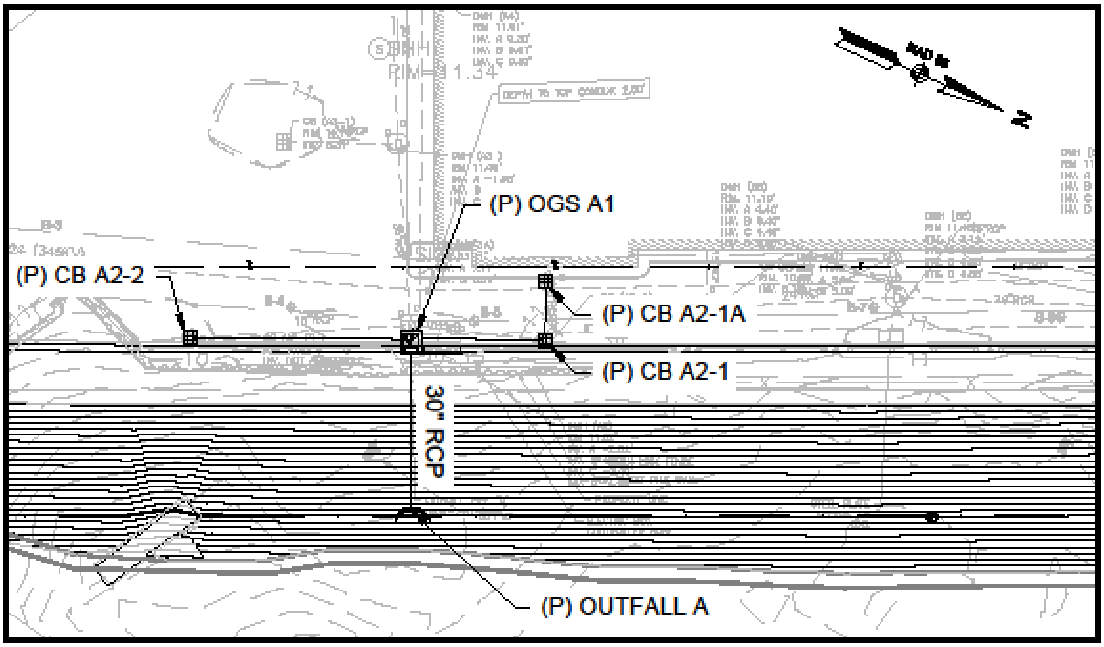

Figure 6-5. Proposed System A Outfall Improvements

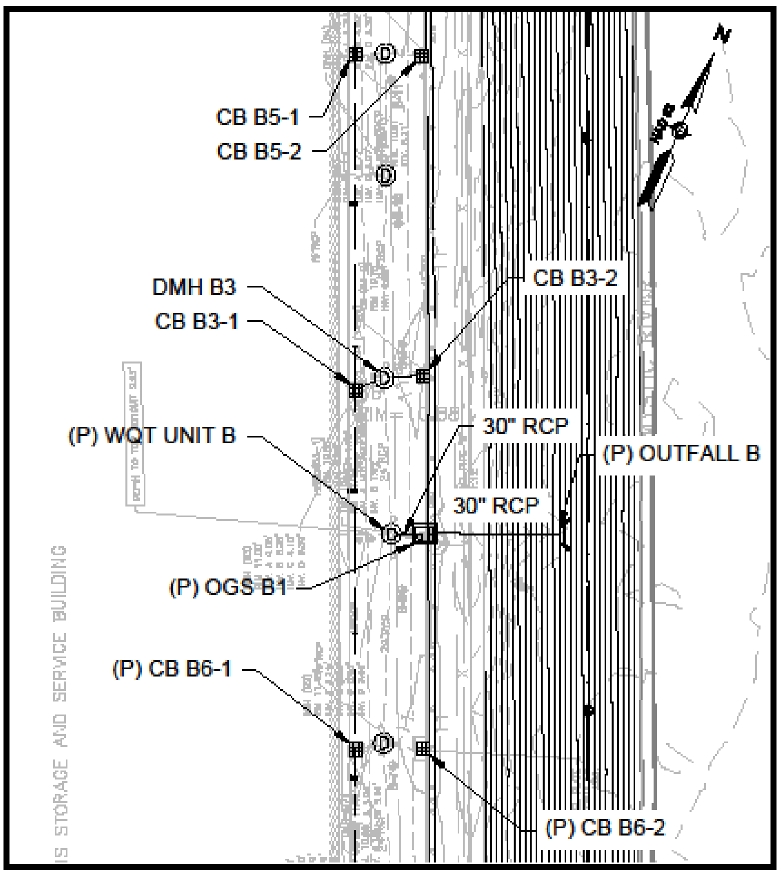

Figure 6-6. Proposed System B Outfall Improvements

6.2.4 System D

The proposed work in System D will remove the entire existing small drainage system (two drain manholes, TMH D1 and DMH D2; two catch basins, CB D2-1 and CB D2-2, approximately 135 LF of 15-inch diameter RCP, and 16 LF of 15-inch diameter ACCMP.) The two proposed catch basins will have deep sumps, hooded outlets, and sedimentation screening devices connected to the proposed outfall sluice gate structure OGS D1 by 135 LF of 15-inch diameter RCP. OGS D1 replaces both drain manholes and 38 LF of 15-inch RCP will connect it to a new outfall headwall with a 15-inch diameter tide gate.

Locating a water quality treatment unit for this system was not feasible due to the installation of OGS D1. With the sedimentation screening devices installed, a high level of treatment is provided for the small amount of flow generated by System D.

6.2.5 System E

In System E, the second largest drainage area in the project, two proposed inline water quality treatments, WQT E1 and WQT E2, will provide TSS removal for nearly all of System E on the MBTA Bus Garage site. Two units were required, because of site constraints downstream of drain manhole DMH E3. Figure 6-2 shows these two locations at DMH E5 (WQT E1) and DMH E10 (WQT E2). As also shown, nine catch basins, four of which (CB E7-1, CB E6-1, CB E5-1, and CB E4-1) have double grates, will be replaced with deep sump, hooded outlets. Because two of the nine catch basins are located downstream of the water quality treatment units, CB E4-1 and CB E2-1 will also have sediment screening devices.

The locations of these last two catch basins are also shown on Figure 6-9, along with WQT E1 and the proposed improvements adjacent to the proposed shoreline improvements. These proposed improvements will include connecting the existing drain manhole DMH E3 to a new outfall sluice gate structure OGS E1 with approximately 30 LF of 36-inch diameter RCP, while a 40-foot length of 12-inch diameter RCP will tie into OGS E1 from catch basin CB E2-1. Finally, all System E drainage flows will pass through a 40-foot length of 36-inch diameter RCP outfall from OGS E1 to the proposed headwall with a 36-inch diameter tide gate.

The existing DMH E2 and 36-inch diameter PVC outfall will be removed and disposed.

6.2.6 System F

Because C&C's inspections of the two catch basins in System F, CB F2-1 and CB F2-2, found the structures in good condition, only removal and resetting of the catch basin frames and covers is required. Flows from both catch basins will be treated by the proposed downstream inline water quality treatment unit WQT F, which will replace the existing drain manhole DMH F2. A 30-foot length of 24-inch RCP will convey the treated stormwater to the proposed outfall sluice gate structure OGS F1, followed by a 50-foot length of 24-inch diameter RCP leading to the proposed outfall headwall with a 24-inch diameter tide gate.

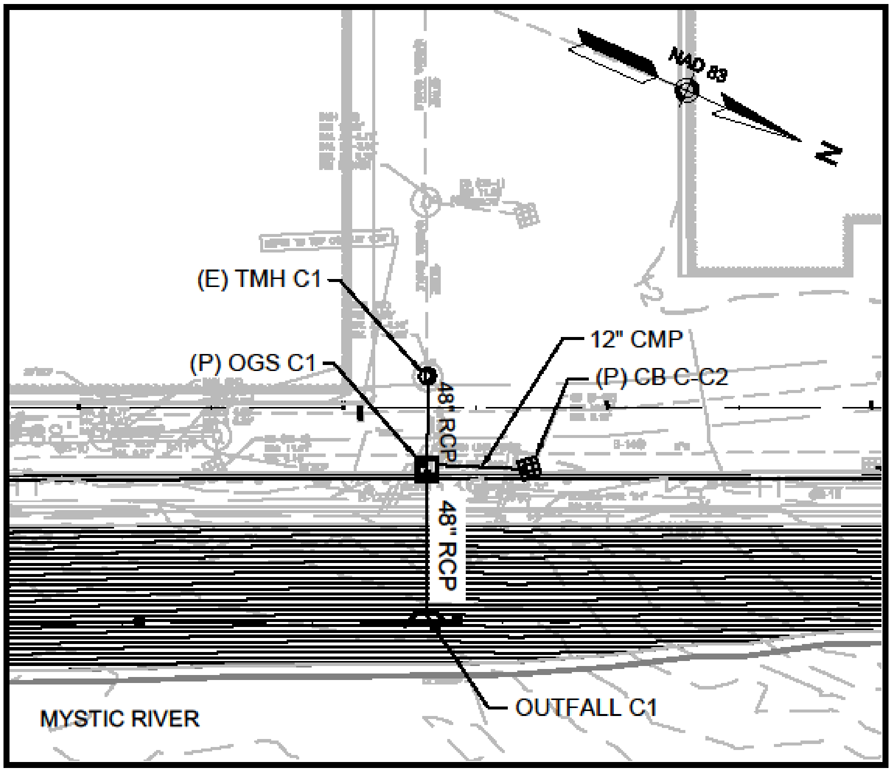

Figure 6-7. Proposed System C Outfall Improvements

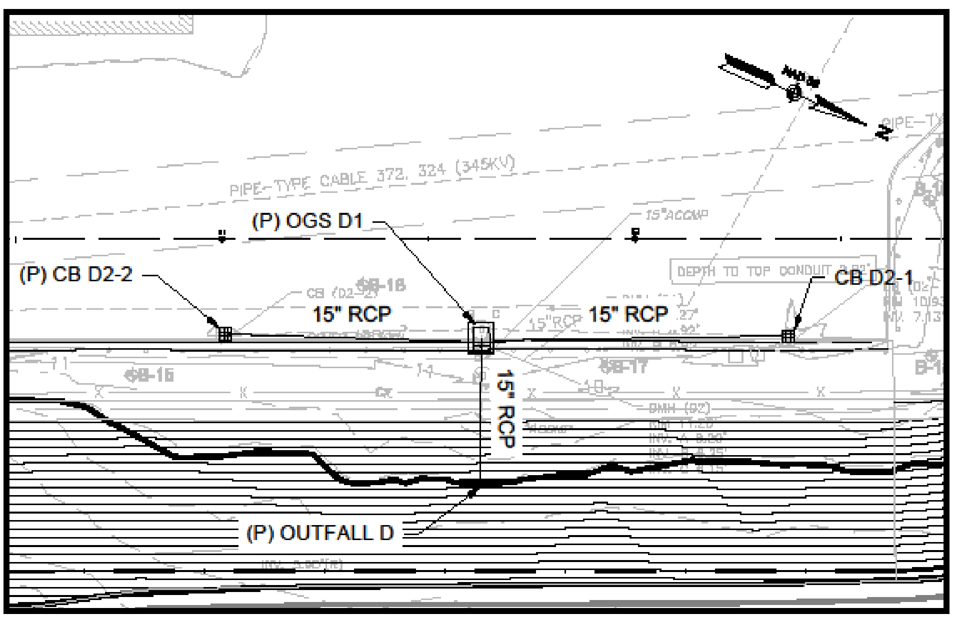

Figure 6-8. Proposed System D Outfall Improvements

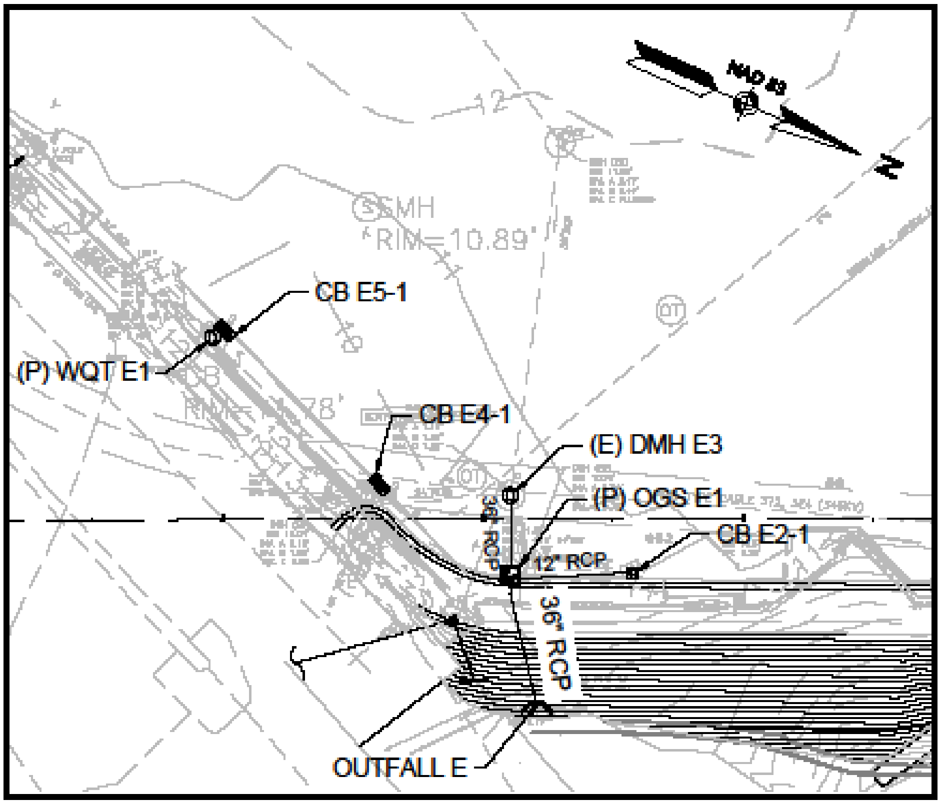

Figure 6-9. Proposed System E Outfall Improvements

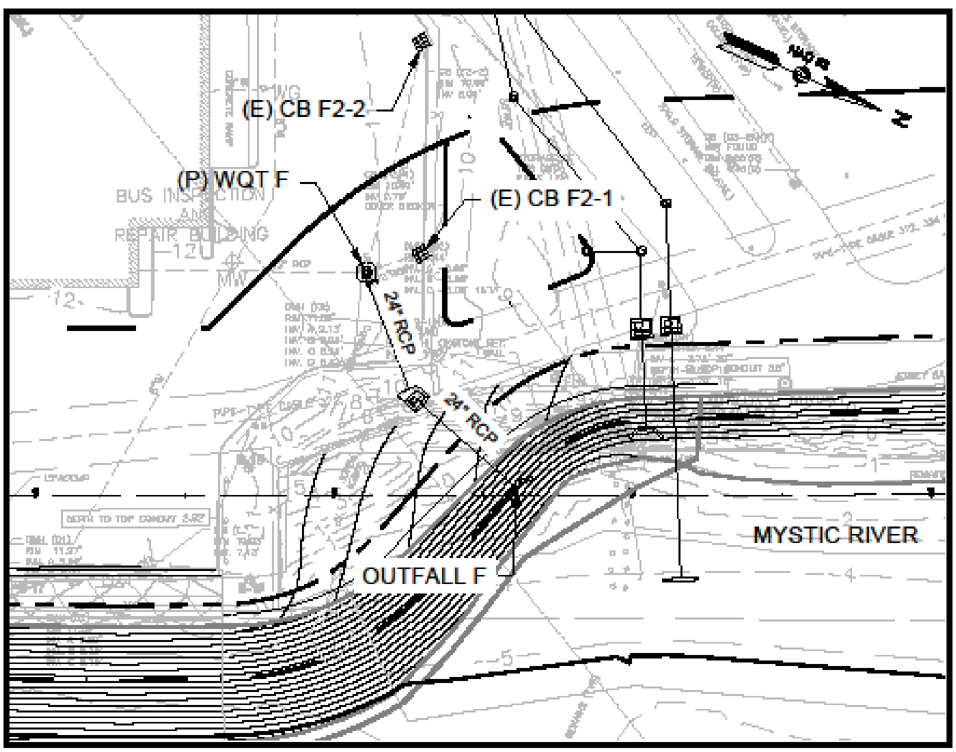

Figure 6-10. Proposed System F Outfall Improvements

The existing tide gate manhole TMH F1 and outfall headwall will be removed and disposed, with the existing 24-inch diameter RCP plugged and the existing 24-inch diameter ACCMP outfall removed and disposed.

6.2.7 System G

System G drainage improvements involve re-directing stormwater overland from the existing piped system downstream of drain manhole DMH G3 to a proposed Rain Garden G, which was previously described in Section 4. The proposed improvements shown on Figure 6-11 will replace one existing drain manhole DMH G3, will remove and relocate drain manhole DMH G2, and will install a new drain manhole DMH G2A, which will have a beehive grate and frame to provide an overflow point into the drainage system for Rain Garden G. A 15-inch diameter RCP will convey any rain garden overflows approximately 15 feet to the relocated DMH G2. A 6-foot diameter inline water quality treatment unit located between DMH G3 and DMH G2 will provide TSS treatment of all stormwater flows upstream of DMH G3, while the outfall sluice gate structure OGS G1 will be located downstream of DMH G2 between the existing concrete-encased 345 kV electrical pipe-type cables and the proposed flood wall.

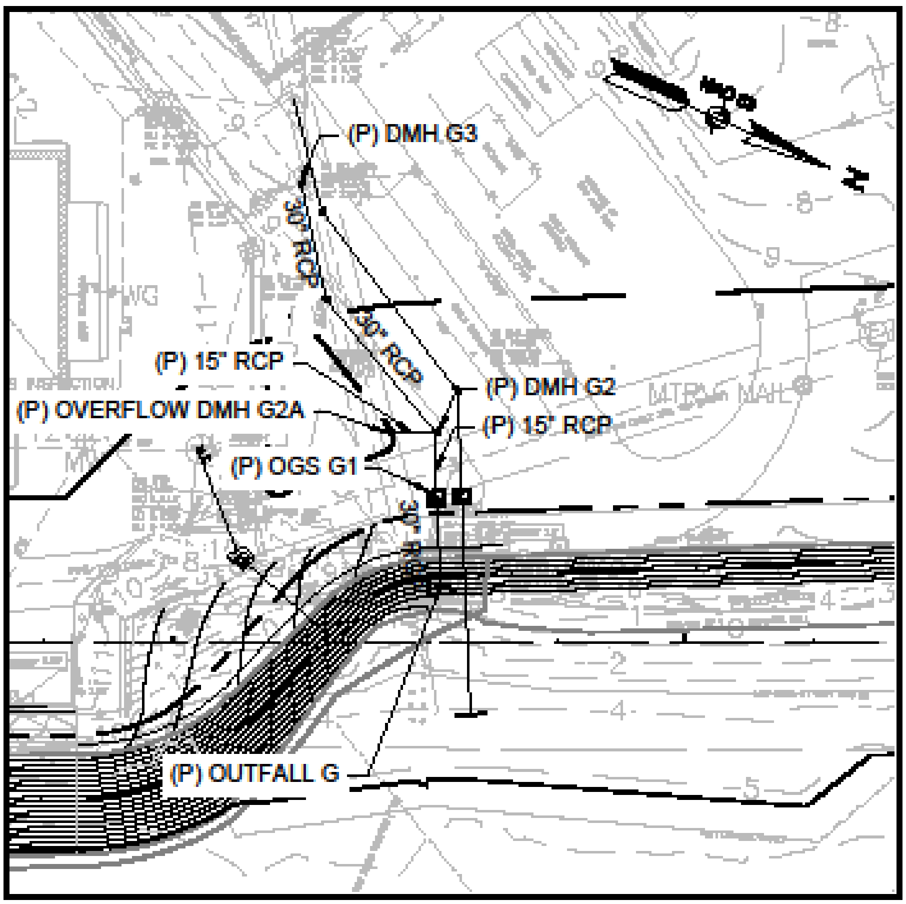

Figure 6-11. Proposed System G Outfall Improvements

Connecting all of these structures will be approximately 140 LF of 30-inch diameter RCP drain lines, with another 30 LF of 30-inch diameter RCP connecting the OGS G1 structure to the new concrete headwall with a 30-inch diameter tide gate.

Removal and disposal of the existing TMH G1, the existing DMH G2, and the 30-inch diameter ACCMP drain connecting them to the outfall will be included as part of the System G improvement. The abandoned section of 30-inch diameter RCP drain between the WQT G structure and the new flood wall will be plugged on both ends, with the remaining section below the flood wall removed and disposed.

6.2.8 System H1

System H1 is a new outfall designed to serve the northern portion of the Engineering Rail Yard, which has no existing storm drainage system. Currently, rainfall falling on the site either percolates into the ground or runs overland to System G catch basins located to the south. The proposed System H1 improvements, shown on Figure 6-12, will provide provisions in a special 6-foot diameter drain manhole DMH H12 for the connection of future storm drains with 24-inch and 15-inch diameter pipe stubs and for the installation of a 6-foot diameter inline water quality treatment device. Lengths of 65 feet, 13 feet and 54 feet of 30-inch diameter RCP will transport the estimated future flows to DMH H12, DMH H11A, and OGS H11 before discharging through the new outfall headwall fitted with a 30-inch diameter flap gate valve. DMH H11A will have a beehive catch basin grate, so it can serve as an overflow for the proposed Rain Garden H1.

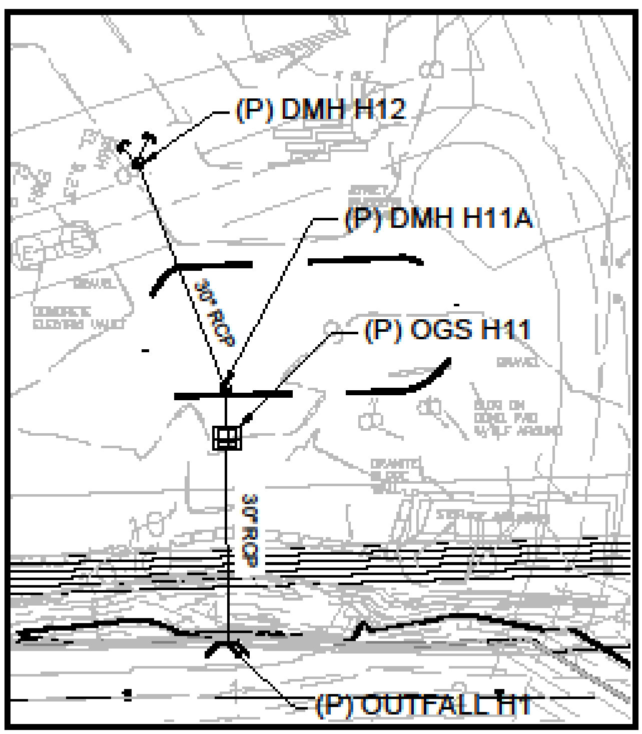

Figure 6-12. Proposed System H1 Outfall Improvements

6.2.9 Somerville System H

System H, a Somerville-owned outfall carrying stormwater runoff from off site, will require a new Outfall H through the proposed floodwall. Due to site constraints with the new flood wall and the existing EverSource 345 kV electric line, the location of the Outfall H will be moved to allow the installation of outfall sluice gate structure OGS H. Figure 6-13 shows the proposed location for OGS H, as well as the proposed realignment of the existing line from DMH H2 to a new concrete headwall containing a 21-inch diameter tide gate.

The proposed improvements include replacing the existing drain manhole DMH H2, adding two new drain manholes DMH H1A and DMH H1B, and installing OSG H along with the headwall and tide gate. As previously explained, the proposed outfall pipe will be 21-inch diameter RCP, matching the existing 20-inch diameter pipe's capacity. A total length of approximately 215 LF of 21-inch diameter RCP will connect DMH H2 to the new outfall headwall.

Removal and disposal of the existing TMH H1, DMH H2, and 190 LF of 20-inch VCP being replaced will be part of the System H improvements.

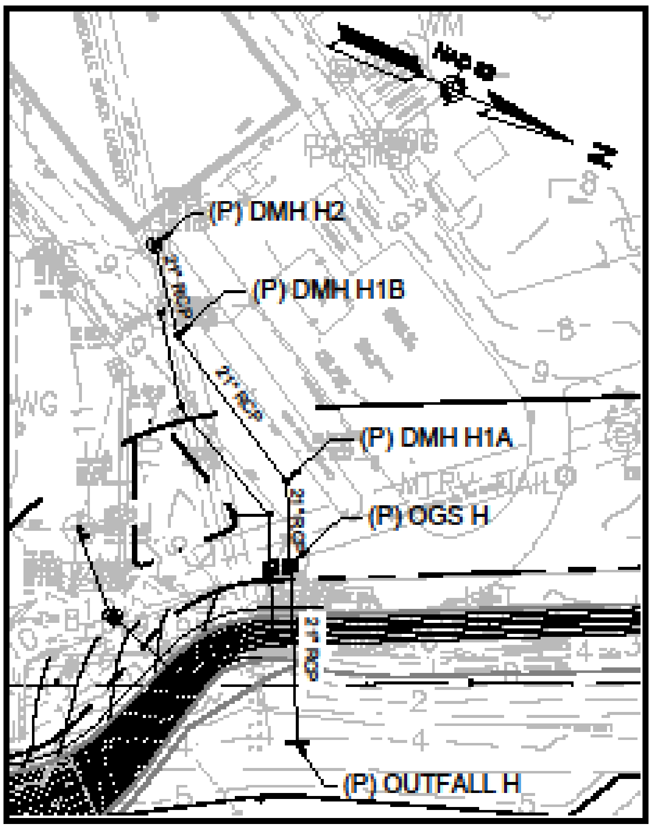

Figure 6-13. Proposed Somerville Outfall H Improvements

6.2.10 Alford Street System X

The existing 18-inch diameter cast iron pipe carrying stormwater drainage from Alford Street will be replaced from DMH X1 by a longer, 25-foot length of 18-inch diameter RCP as a result of the proposed embankment. A new headwall with 18-inch diameter tide gate will be constructed, and drain manhole DMH X1 must also be replaced due to the higher embankment. The proposed improvements are shown on Figure 6-14.

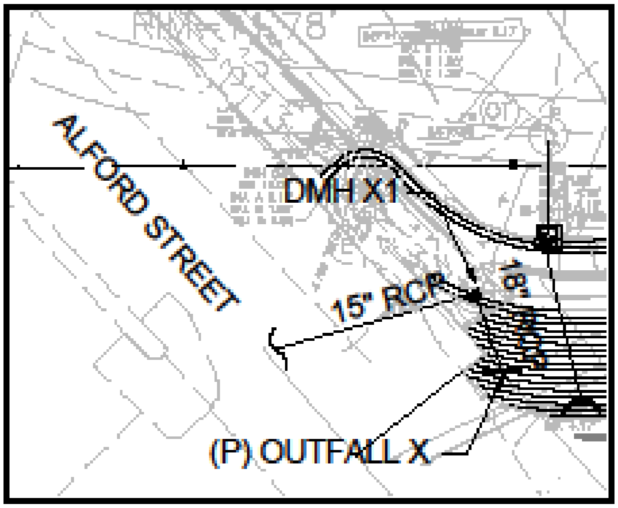

Figure 6-14. Proposed MassDOT Outfall X Improvements

6.3 Other Considerations

Both flexible in-line tide gates and standard cast iron tide gates at the outfall structure were considered to protect the drainage system from the tide levels in the Mystic River. -Flap gates installed on each of the proposed headwalls were selected for their demonstrated durability, available access for inspection and maintenance, and protection provided for the entire drainage system.

7 MassDEP Stormwater Standards

This section summarizes the considerations for meeting the Massachusetts Stormwater Management Standards. Section 4 (above) identifies the specific BMPs selected for each drainage system.

7.1 Standard 7 – Redevelopment Project

The proposed improvements qualify as a redevelopment project under the definition of Standard 7 for a previously developed site, since the improvements will result in no net increase in impervious area, and the drainage systems have been designed to comply with the Stormwater Management Standards to the "maximum extent practicable". How the applicable Standards 1, 2, 3, 4, 5 and 6 are met for this project is summarized in the following paragraphs.

7.1.1 Standard 1 – No New Untreated Discharges

Only the proposed System H1 is a new outfall with a proposed drainage system consisting initially of surface runoff through a new, vegetated 100-foot buffer zone draining to a proposed Rain Garden H1. Only the overflow from the rain garden will be discharged to the new Outfall H1. The proposed system has been designed to allow a future drainage system to be connected to drain manhole DMH H12, which will be designed with provisions for the future installation of a proprietary, inline hydrodynamic separator. Thus, no untreated stormwater will be directly discharged in the waters of the Commonwealth.

7.1.2 Standard 2 – No Increase in Peak Discharges Post-Development

Drainage calculations were conducted to evaluate peak discharges from the project site under the existing conditions compiled from past projects, as well as from field survey work conducted by C&C's survey crew for the project. As required under Standard 2, peak discharges under post development condition will be the same or less than the pre-development conditions, except for three subsystems in the Bus Operations area. Peak discharges from Systems C, D and E will be higher due to improved hydraulics of the new piping systems. However, this standard has been met for this redevelopment project to the maximum extent practicable with no additional drainage areas added to any of the existing outfalls and no increase to the existing impervious area.

Methods to reduce future peak flows, such as infiltration chambers, were evaluated but were found to be infeasible for the site. However, the future peak flows from System G in the Rail Yard area have been decreased as a result of removing the direct connection of the area tributary to the proposed Rain Garden G. In a similar manner, the peak flows from the proposed System H1 have been attenuated by providing Rain Garden H1.

7.1.3 Standard 3 – Minimize Loss of Annual Groundwater Recharge

As required under Standard 3 of the Massachusetts DEP, the groundwater recharge volume must be the same or less under post development condition as exists for the predevelopment conditions. Because no additional impervious area that would increase runoff is proposed, no additional runoff will be added to the site. Also, opportunities to reduce the amount of pavement were considered, but a reduction in the paved area, especially in the Bus Operations area, was not realistic given the operational use at the site.

Infiltration devices in the Bus Operations area were also considered but eliminated due to existing high groundwater levels. Members of the project team monitored the groundwater level in the "tube out" area of the Bus Operations area from April 2015 to June 2015 and found that the groundwater hit its peak at approximately Elevation 3 feet (NAVD 88). MassDEP requires that there must be at least a 2-foot separation between the bottom of the infiltration structure and the seasonal high groundwater table. The existing ground surface elevation in the Bus Operations area is around Elevation 11 feet. For infiltration systems, a minimum cover of 2 – 3 feet above these systems is generally used in order to not structurally damage the system, which only leaves approximately 3 vertical feet to install an infiltration system and to connect it to the existing drainage system. Because most of the existing drainage lines are deeper than seven feet and standard infiltration systems require more than 4 feet of vertical space, infiltration systems were not considered practical or possible and were eliminated from further consideration.

Within the Engineering Rail Yard area, two rain gardens are proposed to capture and treat a portion of the site surface runoff are proposed. While no groundwater monitoring wells were installed in the Rail Yard area, groundwater levels were observed in two landside borings taken by the project team. As reported earlier in Section 2.5.1, measurements recorded water levels at Elevation 0.00 feet near Outfalls F, G, and H and at Elevation 0.50 feet near the proposed Outfall H1. Since the groundwater levels in the Rail Yard may be influenced by the rising and falling tides of the Mystic River, readings taken at a different time of day may produce different results. However, these data points are sufficient to allow the use of rain gardens in the Engineering Rail Yard.

The treated water from the rain gardens will infiltrate into the ground, with excess runoff overflowing into one of two drainage systems. With these considerations, Massachusetts DEP Standard 3 has been followed to the maximum extent practical.

7.1.4 Standards 4, 5 and 6

Structural BMPs have been recommended and designed in accordance to the Massachusetts DEP Standard 4 of water quality to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS) to the maximum extent practicable, as explained previously in Section 4.

Standard 5 is met by the MBTA's existing source controls and pollution prevention measures, while Standard 6 does not apply to this site.

7.1.5 Standard 7 Conclusion

In summary, this redevelopment project complies with Massachusetts DEP Standard 7 by meeting Standards 2 and 3, as well as the pretreatment and structural BMP requirements Standards 4, 5, and-6 to the maximum extent practicable. In fact, the proposed project improves existing conditions through best management practices and satisfies the redevelopment standards to the maximum extent practicable.

7.2 COMPLIANCE WITH REMAINING STANDARDS

The remaining three standards, Standards 8, 9 and 10, are not included within the scope of this report but will be furnished at a later date.

7.2.1 Standard 8 – Construction

A Construction Period Pollution Prevention/Soil Erosion and Sediment Control Plan will be developed to address activities associated with the Project in a manner that minimizes erosion, sediment, debris, and other pollutants from contaminating the resource areas and receiving waters. The installation of soil erosion and sediment controls will comply with the *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas* (Massachusetts Executive Office of Environmental Affairs et. al.; 2003), and all aspects of Standard No. 8. These controls will be inspected daily and after each rainfall event, and maintained, as required, until such time that all disturbed areas associated with construction have been stabilized with vegetation.

While portions of the project will occur within resource areas regulated by the Massachusetts Wetland Protection Act/Regulations or their buffer zones, the above-referenced soil erosion and sediment control plan will protect the adjacent wetland resource areas during and following the proposed construction activities. These controls will be shown on the project plans.

As the proposed project will involve more than one (1) acre of earth disturbance, a National Pollutant Discharge Elimination System (NPDES) Stormwater General Permit for construction will be required. In conjunction with this permit, a project specific Stormwater Pollution Prevention Plan (SWPPP) will be generated for construction-related activities. The SWPPP, to be prepared by the contractor prior to construction, will incorporate the soil erosion and sediment controls indicated on the project plans as well as any other structural and non-structural controls that will or may be used, as appropriate, to control erosion/sedimentation within the construction zone. These measures are anticipated to consist of compost filter tubes, silt fencing, check dams, catch basin/storm drain inlet protection, and seeding/mulching, although not all of these BMPs necessarily will be implemented. The SWPPP also will document procedures associated with the inspection of erosion/sedimentation controls to ensure that all such controls are functioning properly.

To apply for coverage under the EPA General Permit, a 'Notice of Intent for Stormwater Discharges Associated with Construction Activity under an NPDES General Permit' will be filed with the U.S. Environmental Protection Agency (EPA) prior to the commencement of construction. As required, the SWPPP also will be kept at the construction site for review by regulatory agency staff.

7.2.2 Standard 9 –Operation and Maintenance Plan

The MBTA is responsible for the operation and maintenance of the redevelopment project and proposed safety improvements. The proposed schedule for inspection and maintenance is included in Appendix A..

7.2.3 Standard 10 – Prohibition of Illicit Discharges

A 'No Illicit Discharge Compliance Statement' will be submitted prior to the discharge of any stormwater to post-construction BMP's.

8 Cost Estimates

Based on the recommendations, Tables 8-1 and 8-2 present the Estimates of Construction Costs for each drainage system, tabulated for the Bus Operations and Engineering Rail Yard areas, respectively. A multiplier factor of 1.74 was applied to the detailed construction cost estimates for markups for such items as General Conditions, Project Requirements, Permits, Bonds, Insurance, and fees, and for design, estimating and construction contingencies to determine the estimated Total Project Cost. These estimates were done in coordination with overall 100% design estimates prepared by team member, VJ Associates.

The estimated Bus Operations Area drainage improvements total $1,660,000, while the drainage work proposed in the Engineering Rail Yard area is estimated at $968,000. These estimates are subject to change as the design process moves forward toward final construction documents. The total preliminary estimate for construction costs of the recommended drainage system improvements is $2,628,000.

Table 8-1. Estimates of Construction Cost - Bus Operations Area

ESTIMATES OF CONSTRUCTION COST - BUS OPERATIONS AREA		
DRAINAGE SYSTEM/ WORK ITEM		ESTIMATED COST
DRAINAGE SYSTEM "A"		
A.1	Demolition	5,700.00
A.2	Temporary Protection and Safety (345 kV electric cable)	20,000.00
A.3	Replace existing CBs with deep sump CBs w/ sediment screens (12)	61,600.00
A.4	30” RCP Drain	22,400.00
A.5	15” RCP Drain	38,200.00
A.6	Outfall A Headwall w/ 30” Tide Gate	6,200.00
A.7	Outfall Sluice Gate Structure A1	45,400.00
A.8	Mobilization/Demobilization	22,000.00
	SUBTOTAL	$ 221,500.00
	Markups & Contingencies included in Construction Cost	X1.74
	SYSTEM "A" SUBTOTAL	**$ 385,410.00**

ESTIMATES OF CONSTRUCTION COST - BUS OPERATIONS AREA		
DRAINAGE SYSTEM/ WORK ITEM		ESTIMATED COST
DRAINAGE SYSTEM "B"		
B.1	Demolition	5,700.00
B.2	Temporary Protection and Safety (345 kV electric cable)	20,000.00
B.3	Replace existing CBs with deep sump CBs w/ Hood (6)	33,400.00
B.4	Reset existing DMH frames and covers for Proposed Repaving Grades	5,000.00
B.5	30” RCP Drain	13,800.00
B.6	Water Quality Treatment Unit B	11,900.00
B.7	Outfall B Headwall w/ 30” Tide Gate	6,200.00
B.8	Outfall Sluice Gate Structure B1	38,900.00
B.9	Mobilization/Demobilization	6,000.00
	SUBTOTAL	$ 140,900.00
	Markups & Contingencies included in Construction Cost	X1.74
	SYSTEM "B" SUBTOTAL	**$ 245,166.00**
DRAINAGE SYSTEM "C"		
C.1	Demolition	7,400.00
C.2	Temporary Protection and Safety (345 kV electric cable)	15,000.00
C.3	Replace existing CBs with deep sump CBs w/ sediment screens (10)	51,400.00
C.4	48” RCP Drain	37,100.00
C.5	15” RCP Drain	10,600.00
C.6	Outfall C Headwall w/ 48”Tide Gate	6,500.00
C.7	Outfall Sluice Gate Structure C1	52,300.00
C.8	Mobilization/Demobilization	6,000.00
	SUBTOTAL	$ 186,300.00
	Markups &Contingencies included in Construction Cost	X1.74
	SYSTEM "C" SUBTOTAL	**$ 324,162.00**

ESTIMATES OF CONSTRUCTION COST - BUS OPERATIONS AREA		
	DRAINAGE SYSTEM/ WORK ITEM	ESTIMATED COST
DRAINAGE SYSTEM "D"		
D.1	Demolition	4,100.00
D.2	Temporary Protection and Safety	5,000.00
D.3	Replace existing CBs with deep sump CBs w/ sediment screens (2)	10,300.00
D.4	15” RCP Drain	38,400.00
D.5	Outfall D Headwall w/ 15” Tide Gate	5,500.00
D.6	Outfall Sluice Gate Structure D1	31,600.00
D.7	Mobilization/Demobilization	6,000.00
	SUBTOTAL	$ 100,900.00
	Markups & Contingencies included in Construction Cost	X1.74
	SYSTEM "D" SUBTOTAL	**$ 175,566.00**
DRAINAGE SYSTEM "E"		
E.1	Demolition	5,700.00
E.2	Temporary Protection and Safety (345 kV electric cable)	15,000.00
E.3	Replace existing CBs with deep sump CBs w/ sediment screens (2)	10,300.00
E.4	Replace existing CBs with deep sump CBs w/ Hood (4)	13,800.00
E.5	Replace existing Double CBs with deep dump Double CBs w/ Hood (3)	10,300.00
E.6	36” RCP Drain	25,000.00
E.7	15” RCP Drain	1,200.00
E.8	12” RCP Drain	15,000.00
E.9	Water Quality Treatment Unit E1 and E1	24,300.00
E,10	Outfall E Headwall w/ 36” Tide Gate	6,900.00
E.11	Outfall Sluice Gate Structure E1	38,800.00
E.12	Mobilization/Demobilization	6,000.00
	SUBTOTAL	$ 172,300.00
	Markups & Contingencies included in Construction Cost	X1.74
	SYSTEM "E" SUBTOTAL	**$ 299,802.00**

ESTIMATES OF CONSTRUCTION COST - BUS OPERATIONS AREA		
	DRAINAGE SYSTEM/ WORK ITEM	**ESTIMATED COST**
DRAINAGE SYSTEM "F"		
F.1	Demolition	4,100.00
F.2	Temporary Protection and Safety (345 kV electric cable)	20,000.00
F.3	Remove and reset existing CB frame and grates (2)	2,500.00
F.4	24" RCP Drain	23,900.00
F.5	Water Quality Treatment Unit F	12,200.00
F.6	Outfall F Headwall w/ 24"Tide Gate	6,100.00
F.7	Outfall Sluice Gate Structure F1	31,900.00
F.8	Mobilization/ Demobilization	6,000.00
	SUBTOTAL	106,700.00
	Markups & Contingencies included in Construction Cost	X1.74
	ESTIMATED SYSTEM "F" CONSTRUCTION COST	**$ 156,658.00**
DRAINAGE SYSTEM "X"		
F.1	Demolition	4,100.00
F.2	Replace existing DMH X1	3,100.00
F.3	18" RCP Drain	6,400.00
F.4	Outfall X Headwall w/ 18" Tide Gate	5,500.00
F.5	Mobilization/ Demobilization	6,000.00
	SUBTOTAL	25,100.00
	Markups & Contingencies included in Construction Cost	X1.74
	ESTIMATED SYSTEM "X" CONSTRUCTION COST	**$ 43,674.00**
	TOTAL COST – BUS OPERATIONS AREA	**$ 1,659,438.00**
	say	**$ 1,660,000**

Table 8-2.Estimates of Construction Costs - Engineering Rail Yard Area

ESTIMATES OF CONSTRUCTION COSTS - ENGINEERING RAIL YARD AREA		
	DRAINAGE SYSTEM/ WORK ITEM	**ESTIMATED COST**
DRAINAGE SYSTEM "G"		
G.1	Demolition	5,000.00
G.2	Temporary Protection and Safety (345 kV electric cable)	25,000.00
G.3	30” RCP Drain	53,400.00
G.4	15” RCP Drain	4,900.00
G.5	Install Drain Manholes (3)	8,100.00
G.6	Water Quality Treatment Unit G	11,900.00
G.7	Outfall G Headwall w/ 30”Tide Gate	6,200.00
G.8	Outfall Sluice Gate Structure G1	33,500.00
G.9	Rain Garden Overflow Structure G2A	2,700.00
G.10	Rain Garden G	66,800.00
G.11	Mobilization/ Demobilization	6,000.00
	SUBTOTAL	237,600.00
	Markups & Contingencies included in Construction Cost	X1.74
	ESTIMATED SYSTEM "G" CONSTRUCTION COST	**$ 413,424.00**
DRAINAGE SYSTEM "H"		
H.1	Demolition	4,100.00
H.2	Temporary Protection and Safety (345 kV electric cable)	20,000.00
H.3	21" RCP Drain	62,000.00
H.4	Install Drain Manholes (3)	8,100.00
H.5	Outfall H Headwall w/ 21” Tide Gate	5,600.00
H.6	Outfall Sluice Gate Structure H1	38,300.00
H.7	Mobilization/ Demobilization	6,000.00
	SUBTOTAL	144,100.00
	Markups & Contingencies included in Construction Cost	X1.74
	ESTIMATED SYSTEM "H" CONSTRUCTION COST	**$ 250,734.00**

ESTIMATES OF CONSTRUCTION COSTS - ENGINEERING RAIL YARD AREA		
	DRAINAGE SYSTEM/ WORK ITEM	**ESTIMATED COST**
DRAINAGE SYSTEM "H1"		
H.1	Demolition (none)	0.00
H.2	Temporary Protection and Safety (345 kV electric cable)	10,000.00
H.3	30" RCP Drain	45,200.00
H.4	6-foot diameter Drain Manhole H12 (future Water Quality Treatment unit)	7,800.00
H.5	Outfall H1 Headwall w/ 30" Tide Gate	6,200.00
H.6	Outfall Sluice Gate Structure H11	40,600.00
H.7	Rain Garden Overflow Structure H11A	2,700.00
H.8	Rain Garden H	55,700.00
H.9	Mobilization/ Demobilization	6,000.00
	SUBTOTAL	174,200.00
	Markups & Contingencies included in Construction Cost	X1.74
	ESTIMATED SYSTEM "H1" CONSTRUCTION COST	**$ 303,108.00**
	TOTAL COST – ENGINEERING RAIL YARD AREA	**$ 967,266.00**
	say	**$ 968,000**

Appendix A – Operation and Maintenance Plan (O&M) and Long Term Pollution Prevention Plan (LTPPP)

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

CHARLESTOWN BUS GARAGE SHORELINE STABILIZATION AND YARD IMPROVEMENTS PROJECT

CHARLESTOWN AND SOMERVILLE, MA

STORMWATER MANAGEMENT SYSTEM

OPERATION AND MAINTENANCE PLAN (O&M)

AND

LONG TERM POLLUTION PREVENTION PLAN (LTPPP)

FEBRUARY 2017

8.1 RESPONSIBLE PARTY

The Massachusetts Bay Transportation Authority (MBTA) will be responsible for the maintenance of their site, facilities and associated stormwater management features. Boston Water and Sewer will be responsible for the maintenance of one of the drainage lines that outfall on the Charlestown portion of this site. Somerville will be responsible for the maintenance of one of the drainage lines that outfall on the Somerville portion of this site.

8.2 MAINTENANCE MEASURES

The stormwater management system covered by this Operation and Maintenance Plan consists of the following components:

- Deep Sump/Hooded Catch Basins
- Deep Sump Drainage Manholes
- In-Line Water Quality Units
- Flared Concrete Headwall Outfall Structure with Placed Riprap Aprons
- Tidal Sluice Gates
- Tidal Flap Gates at Concrete Head Walls
- Bio-retention Areas (Rain Gardens)

Maintenance of these components will be conducted in accordance with the maintenance practices noted in the attached Table 1 – Best Management Practices - Operation and Maintenance Measures, which summarizes the pertinent inspection and maintenance activities.

If inspection indicates the need for major repairs of structural surfaces, the inspector will contact the MBTA to initiate procedures to effect repairs.

8.3 Spill Prevention and Response

The MBTA will implement response procedures for releases of significant materials such as fuels, oils, or chemical materials onto the ground or other areas that could reasonably be expected to discharge to surface or groundwater.

- Reportable quantities will immediately be reported to the applicable Federal, State, and local agencies as required by law. The local Fire Department will be notified.
- Applicable containment and cleanup procedures will be performed immediately. Impacted material collected during the response must be removed promptly and disposed of in accordance with Federal, State, and local requirements. A licensed emergency response contractor may be required to assist in cleanup of releases depending on the amount of the release and the ability of the responsible party to perform the required response.
- Sluice gate structures are provided in each drainage outfall and will be closed if required to prevent materials from discharging to the Mystic River.
- Reportable quantities of chemical, fuels, or oils are established under the Clean Water Act and enforced through DEP.

8.4 Snow and Ice Management

Snow and Ice Management shall be conducted consistent with the typical MBTA management practices. The raised embankment and flood wall structure will prevent snow from being plowed into the river. Snow will not be plowed directly into the Mystic river and will not be piled within 100 feet of the top of shoreline (Buffer Zone). Salt use will be minimized to the amounts required for safe bus operations on site. The paved area will be swept for excess salts each spring after the snow removal season.

8.5 Prohibition of Illicit Discharges

The DEP Stormwater Management Standards prohibit illicit discharges to the stormwater management system. Illicit discharges are discharges that do not entirely consist of stormwater, except for certain specified non-stormwater discharges.

Discharges from the following activities are not considered illicit discharges: Firefighting; foundation drains; water line flushing; footing drains; landscape irrigation; individual resident car washing; uncontaminated groundwater; flows from riparian habitats and wetlands; potable water sources; dechlorinated water from swimming pools; water used to clean residential buildings without detergents; water used for street washing; air conditioning condensation.

There are no known or proposed illicit connections associated with this project. If a potential illicit discharge to the facilities covered by this plan is detected (e.g., dry weather flows at any pipe outlet, evidence of contamination of surface water discharge by non-stormwater sources), the appropriate municipality shall be notified for assistance in determining the nature and source of the discharge, and for resolution.

Table 1. Best Management Practices: Operation & Maintenance Measures

BMP	Inspect	Clean	Repair
Deep Sump/ Hooded Catch Basins	**First 2-3 Years:** • Twice per year After foliage season • After snow removal season **After 2-3 Years:** To be determined based on initial monitoring, minimum once per year after snow removal season	• As needed based on inspection. • Litter and debris clogging inlet grate or cub inlet opening • More than 50% full of solids	• As needed based on inspection • Damage to inlet grate • Damage to hood
Deep Sump Drainage Manholes	**First 2-3 Years:** • Semi-annual **After 2-3 Years:** To be determined based on initial monitoring, minimum annual	• As needed based on inspection. • More than 50% full of solids	• As needed based on inspection
In-Line Water Quality Units[1]	**First 2-3 Years:** • Minimum frequency recommended by manufacturer. • Twice per year • After foliage season • After snow removal season **After 2-3 Years:** • To be determined based on initial monitoring, minimum annual	• As needed based on inspection • Litter and debris clogging inlet • Sediment depth >15% of unit's storage capacity • Minimum frequency specified by manufacturer	• As needed based on inspection
Flared Concrete Headwall Structures with Placed Riprap Aprons	• Annually • Before & after major coastal storm events	• As needed based on inspection. • Litter and debris clogging outlet	• As needed based on inspection • Damage or erosion of outlet protection • Structural damage or displacement of flared end
Tidal Sluice Gates	• Operate motor and hand cranks twice per year.	• Remove corrosion by products as needed based on inspections • Remove debris from structure as needed based on inspections	• As needed based on inspection
Tidal Sluice Gates	• Operate motor and hand cranks twice per year.	• Remove corrosion by products as needed based on inspections • Remove debris from structure as needed based on inspections	• As needed based on inspection

[1] Final inspection and maintenance schedule subject to the submittal of documentation of the specific WQU by the contractor and approval by the conservation commission.

Table 1. Best Management Practices: Operation & Maintenance Measures

BMP	Inspect	Clean	Repair
Tidal Flap Gate at Each Concrete Head Wall	• Visually inspect annually using a binocular survey at low tides • Before & after major coastal storm events	• As needed based on inspection	• As needed based on inspection
Grass Filter Strips	• Semi-annual inspections for sediment accumulation	• Mow monthly during Growing Season*[2] (5 times per year); mow to height not less than 3 inches. • Remove sediment accumulation biannually, as necessary	• Re-seed bare spots as needed • Prevent formation of berm at top of strip due to sediments buildup
Rain Gardens	• Identify woody trees and shrubs to be removed. • Identify MA Invasive grasses, perennials, biennials and annuals to be removed.[3] • Visually inspect mulch each April. • Visually inspect for dead vegetation and litter/debris.	• Mechanically cut (weed trimmer) native grasses to height of 8 inches each March. • Manually remove woody species each March. • Manually remove invasive species and litter monthly during Growing Season.*	• Replace dead plantings as needed based on inspections. • Dispose of all grass trimmings and woody material off-site. • Add mulch as necessary.
Vegetated Shoreline Slope	• Identify all MA Invasive plant species** to be removed. • Visually inspect for drought-stressed plantings. • Visually inspect for dead vegetation and litter/river detritus.	• Manually remove invasive species, river detritus and litter monthly during Growing Season.* • Mow turf shoulder monthly during Growing Season* (5 times per year); mow to height not less than 3". • Water (irrigate) **First Three Years** all plants subject to drought conditions[4]	• Replace dead plantings as needed based on inspections. • Dispose of all grass trimmings and woody material off-site.
Pavement Sweeping	•	• Annually after snow removal season	•

[2] **Growing Season** extends from May 1st to October 1st annually.

[3] **Official Invasive Plant List – Massachusetts (**IPANE (Invasive Plant Atlas of New England) http://massnrc.org/mipag/docs/MIPAG_FINDINGS_FINAL_042005.pdf. Included within the Evaluation of Invasive Plant Species in Massachusetts, page 8.

[4] **Drought Conditions -** As identified in the months of July, August and September when rainfall events are forecasted to be less than 50% normal for those months.

Table 1. Best Management Practices: Operation & Maintenance Measures

BMP	Inspect	Clean	Repair
Tidal Sluice Gates	• Operate motor and hand cranks twice per year.	• Remove corrosion by products as needed based on inspections • Remove debris from structure as needed based on inspections	• As needed based on inspection
Tidal Flap Gate at Each Concrete Head Wall	• Visually inspect annually using a binocular survey at low tides • Before & after major coastal storm events •	• As needed based on inspection	• As needed based on inspection
Rain Gardens	• Mow 2 times per year • Mulch once each, • Fertilize, Remove Dead Vegetation and Prune Annually	• Monthly to remove trash	• Replace dead plantings as needed based on inspections.
Pavement Sweeping	•	• Annually after snow removal season	

APPENDIX B –HYDROCAD ANALYSIS – 25-YEAR STORM

HydroCAD printouts of the 25-year frequency storm for each of the eight MBTA drainage systems modeled are available upon request.