Appendix 4.17-B

Station Stormwater Analyses

Stormwater Report

North Easton Station

Town of Stoughton/Easton, Massachusetts

Prepared for

massDOT
Massachusetts Department of Transportation
10 Park Plaza
Boston, Massachusetts

Prepared by

VHB/Vanasse Hangen Brustlin, Inc.
Transportation, Land Development, Environmental Services
99 High Street
Boston, Massachusetts 02110
617 728 7777

June 2012

\\mabos\projects\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\North Easton\Stormwater Report\Stormwater Report - North Easton.doc

Table of Contents

List of Figures

List of Tables

Appendices

Checklist for Stormwater Report

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer’s Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☐ Redevelopment

☒ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

  ☐ Credit 1

  ☐ Credit 2

  ☐ Credit 3

☐ Use of “country drainage” versus curb and gutter conveyance and pipe

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☐ Other (describe): ____________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

---

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☒ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☒ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☒ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☒ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☐ Name of the stormwater management system owners;
- ☐ Party responsible for operation and maintenance;
- ☐ Schedule for implementation of routine and non-routine maintenance tasks;
- ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Water Quality Certification Regulations (314 CMR 9.00).

Project Description

The Applicant, Massachusetts Bay Transportation Authority, is proposing to construct a train station located at 21 Washington Street Stoughton and Easton, Massachusetts. This station will be known as the North Easton Station and is proposed along the existing Stoughton Railroad Line (the Project). As proposed, the Project consists of approximately 10.0-acres of land acquisition, of which approximately 9-acres will be developed for the new station.

The Project will entail the construction of a center platform with canopy, a parking lot with 506 spaces, access driveway, a bus stop drop-off area, a center platform, sidewalks, stairs and ramps associated with access from the parking lot to the platform, bicycle parking facilities, retaining walls and stormwater infrastructure.

The site is considered a Land Use with Higher Potential Pollutant Loads (LUHPPL) as defined in 310 CMR 10.04 and 314 CMR 9.02 because it is a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Site Description

The Project Site is located at 21 Washington Street on the Stoughton/Easton Town line in Massachusetts. The Site is bounded by undeveloped land to the north, a wetland to the south, office buildings to the east, and the existing but abandoned Stoughton Line tracks to the west. See Figure 1, Site Locus Map.

Wetland Resource Areas on the Site, shown on Figures 3 and 4, are described in Table 1. For additional information regarding the wetland resource areas present on the site see the Abbreviated Notice of Resource Area Delineation prepared by VHB dated May 2011.

Table 1: Wetland Resource Areas

Name	Critical Area	Zone 1 or Zone A	ORW or SRW	Zone II or IWPA	Description
Wetland ST-10 (100 Series)	No	No	No	No	PFO
Wetland ST-149.3	No	No	No	No	PFO
Wetland EA1 (100 Series)	No	No	No	No	PFO

Notes: Wetland Classifications: PEM = Palustrine Emergent, PFO = Palustrine Forested

According to the National Resources Conservation Service (NRCS), surface soils on the Site include Merrimac Fine Sandy Loam, Hinckley Sandy Loam, Woodbridge Fine Sandy Loam, Paxton Fine Sandy Loam, Scarboro and Birdsall, and Whitman Fine Sandy Loam. On-site soils are classified as Hydrologic Soil Groups (HSG) A, A, C, C, C, D, and D respectively.

The project is not located within the 100-year flood plain as shown on the FEMA Floodway Map, Town of Stoughton, Massachusetts Norfolk County, Community Panel Number 2502530004B, dated June 1, 1982 and the FEMA Floodway Map, Bristol County, Massachusetts (All Jurisdictions), Map Number 25005C0053F, dated July 7, 2009 included in Appendix B.

Existing Drainage Conditions

Under existing conditions, the Site is a vacant wooded area with a small paved area that is used to store construction equipment and material. For the existing conditions hydrologic analysis, the site was divided into four drainage areas that contribute to three design points. Additional there is an existing wetland onsite that acts as a detention pond for a portion of the site. The following is a summary of each drainage area.

Drainage Area 1 – This 1.55-acre area in the northern portion of the site consists mainly of an undeveloped wooded area. There is also a small area comprised of dirt cover. Runoff from this area flows in a northerly direction to Wetland ST-10 (100 Series) (Design Point 1). When the wetland overflows, runoff flows through a culvert under the tracks to the west.

Drainage Area 2 – This 7.28-acre area in the center of the site consists mainly of paved area used to store construction equipment and materials. There are small wooded areas located among the pavement. Runoff from this area flows untreated in a westerly direction to Wetland ST-149.3 located on the western side of the site, between the site and the existing train tracks. This wetland acts as an existing pond that when overflows travel overland to the south into Wetland EA1 (100 Series) (Design Point 3).

Drainage Area 3 – This 3.19-acre area in the southern portion of the site consists mainly of open space and woods. There are also small areas of gravel access drives and utility infrastructure. The existing detention basin, which takes runoff from the retail/office development, is not included in this analysis. Runoff from the basin is directed to the Wetland. Runoff from this area flows directly into Wetland EA1 (100 Series) (Design Point 3).

Drainage Area 4 – This 0.65-acre area in the southern portion of the site consists mainly of open space and woods. Runoff from this area flows directly into Wetland EA1 (100 Series) (Design Point 4).

Figure 3 illustrates the existing drainage patterns on the Site. Table 2 below provides a summary of the existing conditions hydrologic data.

Table 2:
Existing Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland ST-10 (100 Series)	1	1.55	67	8.5
2	Wetland ST-149.3	3	7.28	75	9.2
3	Wetland EA1 (100 Series)	3	3.19	62	14.8
4	Wetland EA1 (100 Series)	4	0.65	81	5.0

Proposed Drainage Conditions

Figure 4 illustrates the proposed "post construction" drainage conditions for the project. As shown, the Site will be divided into nine (9) drainage areas that discharge treated stormwater to the three existing Design Points. Existing drainage and grading patterns were maintained to the maximum extent possible. Stormwater management techniques have been incorporated into the design. These BMPs are focused on decentralizing stormwater management and reduce peak runoff rates, maximize groundwater recharge and treat for water quality. The following is a summary of each drainage area.

Drainage Area 1 – This 1.34-acre area in the northern portion of the site consists of an undeveloped wooded area. It will generally remain in its existing condition. Runoff from this area flows directly to Wetland ST-10 (Design Point 1).

Drainage Area 2 – This 1.42-acre area in the northern portion of the site consists of a portion of the paved parking area for the station, some undeveloped wooded area, and Bioretention Basin 1 to the north of the parking. Runoff from this area sheet flows across the parking area and is then carried via a grassed channel to Bioretention Basin 1, which discharges to Wetland ST-10 (Design Point 1).

<u>Drainage Area 3</u> – This 2.10-acre area in the central portion of the site consists of the eastern portion of the paved parking area for the station, some undeveloped wooded area, and some ancillary landscape areas. Runoff from the parking area will sheet flow into deep sump hooded catch basins and travel through the closed drainage system passing through a oil/grit separator prior to discharging to a sediment forebay, and terminating in Infiltration Basin 2. Basin 2 discharges to Wetland EA1 (Design Point 3).

<u>Drainage Area 4</u> - This 0.13-acre area in the central portion of the site consists of paved access drive for the station parking, some ancillary landscape areas and Infiltration Basin 2. Runoff from the access drive will flow into a deep sump hooded catch basin and travel through the closed drainage system passing through a oil/grit separator prior to discharging to a sediment forebay, and terminating in Infiltration Basin 2, which discharges to the rail swale to Wetland EA1 (Design Point 3).

<u>Drainage Area 5</u> – This 0.30-acre area in the southeastern portion of the site consists of a paved access drive for the station parking and some ancillary landscape area. Runoff from this area sheet flows to a deep sump hooded catch basin and travels through the closed drainage system prior to discharging to a sediment forebay and terminating in Infiltration Basin 3, which discharges through a closed drainage system to Wetland EA1 (Design Point 3).

<u>Drainage Area 6</u> - This 1.26-acre area in the south portion of the site consists of a paved exit drive for the station parking, some ancillary landscape area, and Infiltration Basin 4. Runoff from this area flows to a deep sump hooded catch basin and travels through the closed drainage system prior to discharging to a sediment forebay and terminating in Infiltration Basin 4, which discharges to the rail swale to Wetland EA1 (Design Point 3).

<u>Drainage Area 7</u> - This 2.80-acre area in the central portion of the site consists of the western portion of the paved parking area for the station, some undeveloped wooded area, and some ancillary landscape areas. Wetland 149.3 will be filled and replicated at an offsite location. Runoff from the parking area will sheet flow into deep sump hooded catch basins and travel through the closed drainage system passing through a oil/grit separator prior to discharging to a sediment forebay, and terminating in Infiltration Basin 5, which discharges directly to Wetland EA1 (Design Point 3).

<u>Drainage Area 8</u> – This 0.55-acre area in the southern portion of the site consists of landscape area and some undeveloped wooded areas. Runoff from this area flows directly to Wetland EA1 (Design Point 4).

<u>Drainage Area 9</u> – This 1.49-acre area in the southern portion of the site consists of landscape area, existing leaching basin, and Infiltration Basin 5. Runoff from this area flows directly to Infiltration Basin 5, which discharges directly to Wetland EA1 (Design Point 3).

Table 3 below provides a summary of the proposed conditions hydrologic data.

Table 3: Proposed Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland ST-10	1	1.34	70	14.6
2	Wetland ST-10	1	1.42	75	15.0
3A	Wetland EA1	3	1.50	78	16.8
3B	Wetland EA1	3	0.60	98	5.0
4	Wetland EA1	3	0.13	82	5.0
5	Wetland EA1	3	0.30	92	5.0
6	Wetland EA1	3	1.26	77	5.0
7	Wetland EA1	3	2.80	95	5.0
8	Wetland EA1	4	0.55	81	6.7
9	Wetland EA1	3	1.49	68	7.3

Integrated into the site design is a comprehensive stormwater management system that has been developed in accordance with the Massachusetts Stormwater Handbook. Because the Project is located within an area of rapid infiltration and is considered a LUHPPL, the proposed stormwater management system has been designed to treat the one inch Water Quality Volume and provide 44% Total Suspended Solids (TSS) pretreatment prior to infiltration.

Environmentally Sensitive and Low Impact Development (LID) Techniques

Low Impact Development (LID) techniques and stormwater Best Management Practices (BMPs) implemented into the site design include:

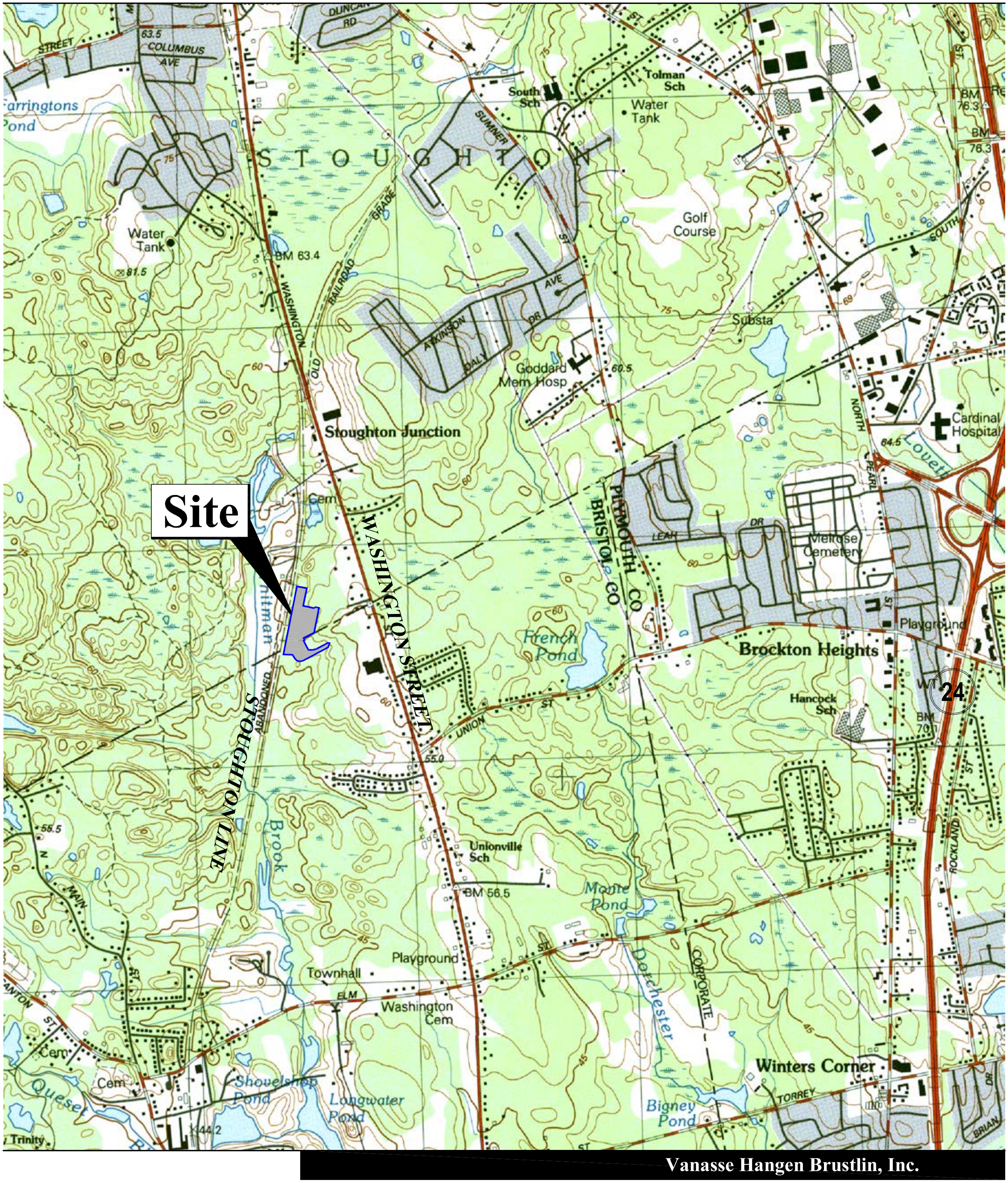
- Infiltration basins
- Bioretention basin
- Minimal disturbance to existing trees and vegetation
- Grassed swales
- Oil/grit separator
- Light colored pavement sidewalks

In general stormwater runoff from the northern portion of the site sheet flows off of the impervious surface and is conveyed via a grassed swale to a Bioretention basin. Stormwater runoff from the southern portion of the site is collected in deep sump hooded catch basins and travels through the closed drainage system and passes through an oil/ grit separator prior to discharging to the sediment forebays, and terminating at the infiltration basins. Wooded areas in the northern portion of the property are to be maintained in their existing conditions as much as possible.

Hydraulic Analysis

The closed drainage system was designed for the 25-year storm event, in accordance with the Massachusetts Bay Transportation Authority, Railroad Operations, Commuter Rail Design Standards Manual, Volume 1.

Drainage pipes were sized using Manning's Equation for full-flow capacity and the Rational Method. Pipe sizing calculations are included in Appendix A of this Stormwater Report.



Vanasse Hangen Brustlin, Inc.

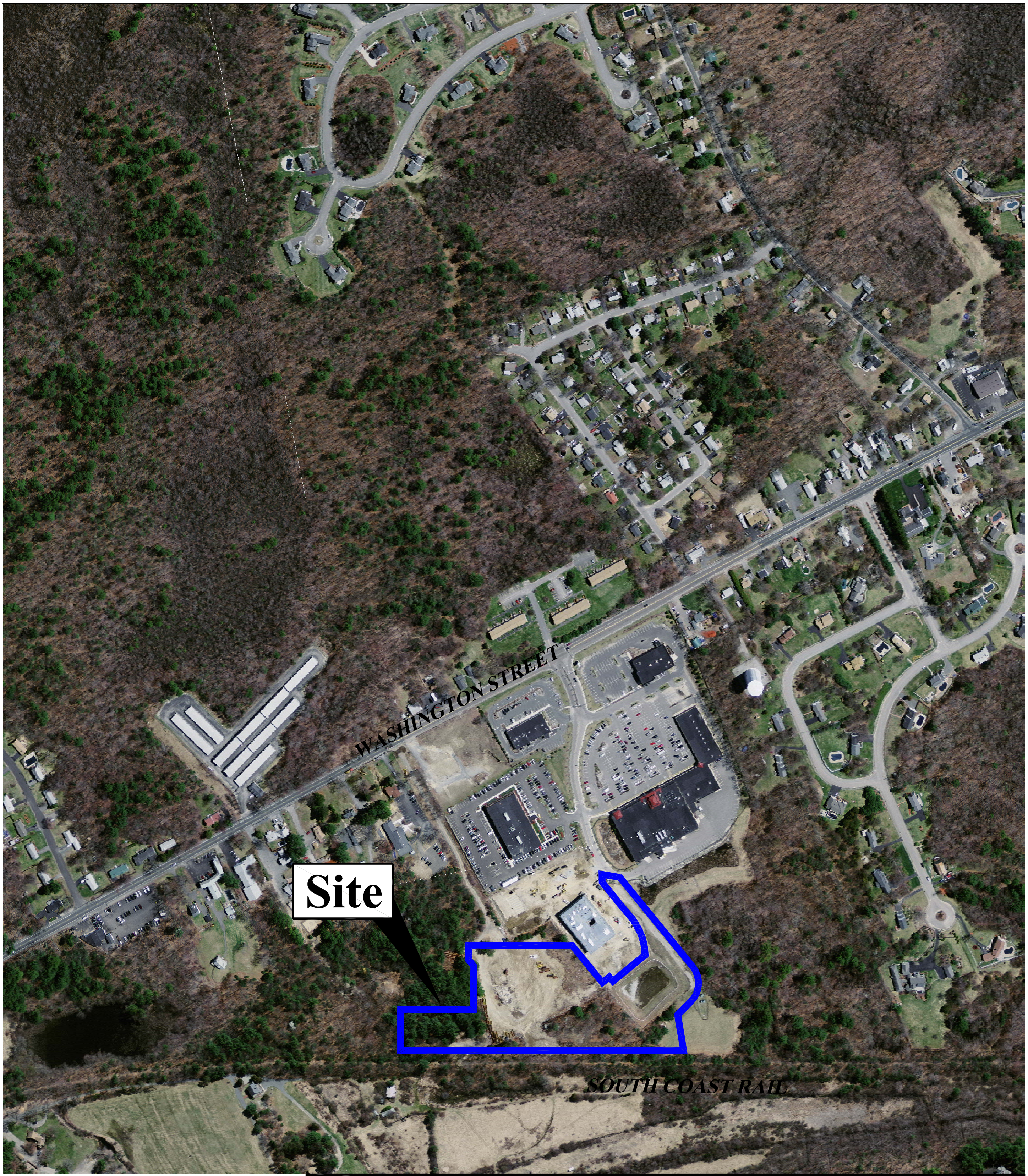
0 1000 2000 Feet

USGS Locus Map

North Easton Station
South Coast Rail
Stoughton/Easton, Massachusets

Figure 1
May 2012

\\mabosdata\PROJECTS\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\North Easton\Stormwater Figures\Figure 2\Figure 2-Site Aerial.dwg

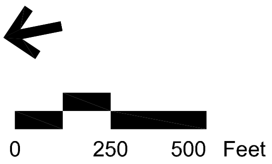


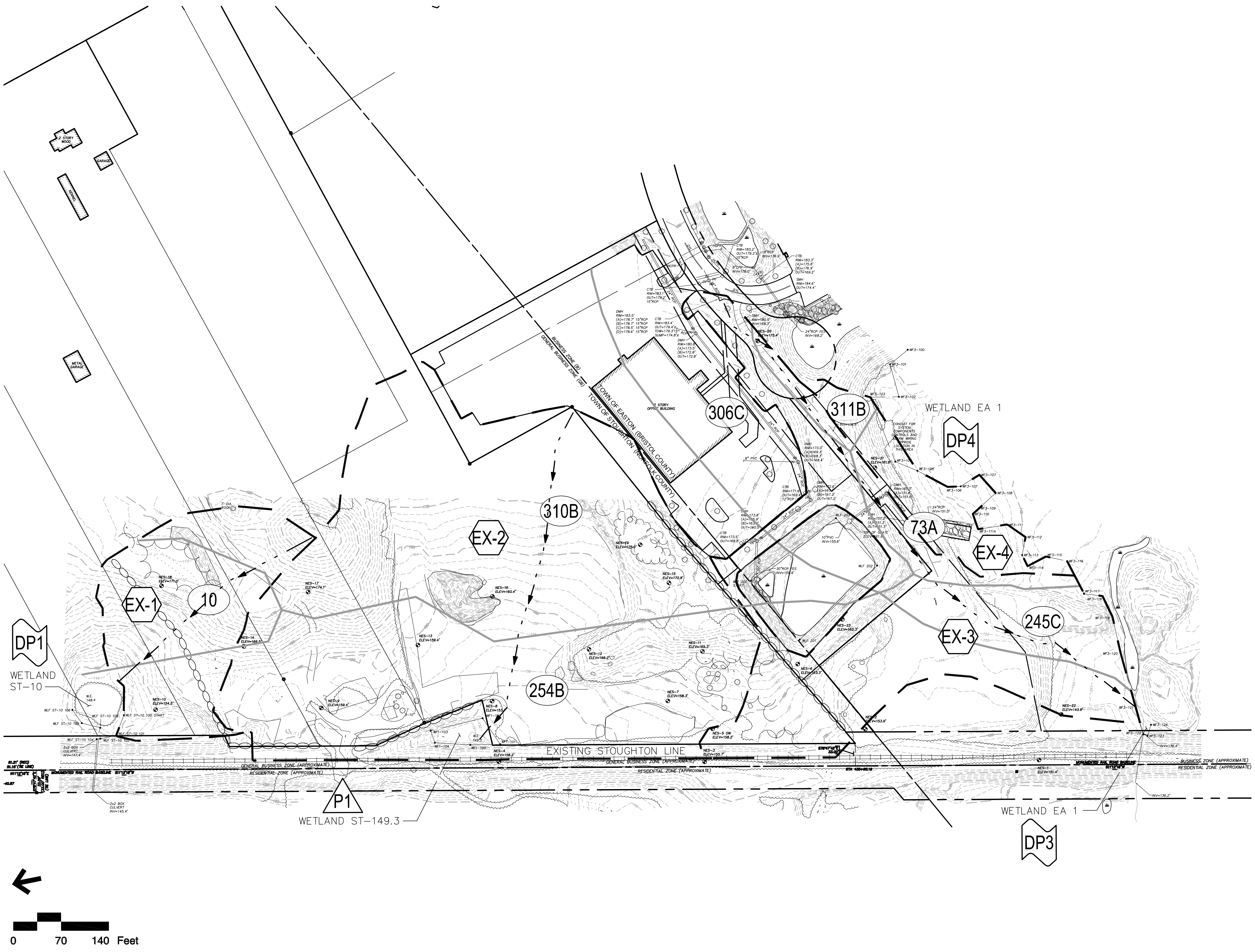
Vanasse Hangen Brustlin, Inc.

Site Aerial Map

Figure 2
May 2012

North Easton Station
South Coast Rail
Stoughton/Easton, Massachusets





LEGEND

1 SUBCATCHMENT DRAINAGE AREA DESIGNATION

1 POND

1 DESIGN POINT

DRAINAGE AREA BOUNDARY

TIME OF CONCENTRATION FLOW LINE

SOIL TYPE BOUNDARY

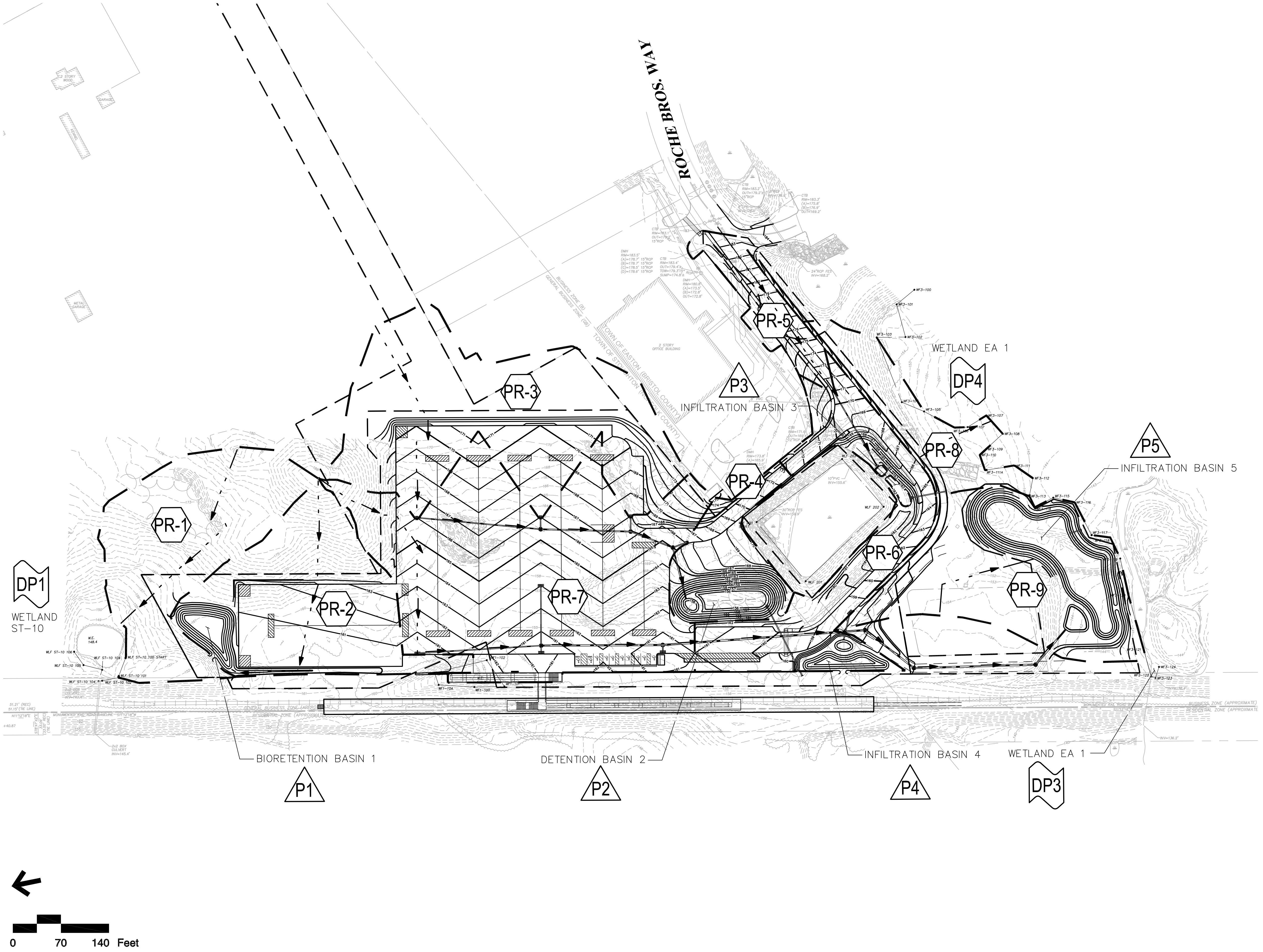
NRCS SOIL CLASSIFICATIONS (HSG)

10	SCARBORO AND BIRDSALL SOIL (D)
73A	WHITMAN FINE SANDY LOAM (D)
245C	HINCKLEY SANDY LOAM (A)
254B	MERRIMAC FINE SANDY LOAM (A)
306C	PAXTON FINE SANDY LOAM (C)
310B	WOODBRIDGE FINE SANDY LOAM (C)
311B	WOODBRIDGE FINE SANDY LOAM (C)

Vanasse Hangen Brustlin, Inc.

Figure 3 May 2012

Existing Conditions Drainage Areas
South Coast Rail
North Easton Station
Stoughton/Easton, Massachusetts



LEGEND

1	SUBCATCHMENT DRAINAGE AREA DESIGNATION
1	POND
1	DESIGN POINT
▬ ▬ ▬	DRAINAGE AREA BOUNDARY
- · - · →	TIME OF CONCENTRATION FLOW LINE
— —	LIMIT OF ACQUISITION
— —	LIMIT OF WORK

Vanasse Hangen Brustlin, Inc.

Figure 4 May 2012

Proposed Conditions Drainage Areas
South Coast Rail
North Easton Station
Stoughton/Easton, Massachusetts

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards at 310 CMR 10.05.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

All proposed Project stormwater outlets and conveyances have been designed to not cause erosion or scour to wetlands or receiving waters. Outlets from closed drainage systems have been designed with flared end sections and stone protection to dissipate discharge velocities. Overflows from BMP's that impound stormwater have been designed with stone to protect down gradient areas from erosion.

Computations and supporting information for the sizing and selection of materials used to protect from scour and erosion are included in Appendix A.

Standard 2: Peak Rate Attenuation

The Project has been designed to fully comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, and 100-years. The results of the analysis, as summarized in Table 4 below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions.

Computations and supporting information regarding the hydrologic modeling are included in Appendix B.

Table 4:
Peak Discharge Rates (cfs*)

Design Point	*2-year*	*10-year*	*100-year*
Design Point 1: Wetland ST-10			
Existing	1.14	2.60	5.48
Proposed	1.03	2.16	4.34
Design Point 3: Wetland EA1			
Existing	1.17	3.28	8.97
Proposed	0.76	2.77	7.78
Design Point 4: Wetland EA1			
Existing	1.28	2.18	3.75
Proposed	1.03	1.76	3.01

* cubic feet per second

Standard 3: Stormwater Recharge

The Project has been designed to fully comply with Standard 3.

In accordance with the Stormwater Handbook, the Required Recharge Volume for the Project is 6,926 cubic feet.

Recharge of stormwater has been provided through the use of infiltration basins which have been sized using the static method. Each infiltration BMP has been designed to drain completely within 72 hours. Table 5 below provides a summary of the proposed infiltration BMPs utilized for the Project.

Table 5
Summary of Recharge Calculations

Infiltration BMP	*Provided Recharge Volume (cubic feet)*
Bioretention Basin 1	7,829
Infiltration Basin 3	947
Infiltration Basin 4	5,356
Infiltration Basin 5	10,896
Total Provided Recharge	25,028
Total Required Recharge	6,926

A Geotechnical Report that describes subsurface soil conditions is included as an appendix to this report.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum of 80% TSS removal for stormwater runoff from all proposed impervious surfaces as well as 44% pretreatment prior to infiltration BMPs.

Computations and supporting information are included in Appendix D.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is considered a LUHPPL as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is a parking lot with a high-intensity use (1,000 vehicle trips per day or more). Therefore has been designed with suitable BMPs sized to treat the 1-inch Water Quality Volume and provide the pretreatment requirement of 44% TSS removal prior to infiltration. Proposed source controls and pollution prevention measures will be identified in the Long-Term Pollution Prevention Plan.

For computations and supporting information regarding the sizing of BMPs suitable for treatment of runoff from LUHPPLs, see Appendix D.

Standard 6: Critical Areas

The Project will not discharge stormwater near or to a critical area.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is a redevelopment, but has still been designed to fully comply with all ten of the Stormwater Management Standards.

Refer directly to each Standard for applicable computations and supporting information demonstrating compliance with each.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Controls

The Project would disturb approximately 9.0 acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) would be developed and a Notice of Intent for the CGP would be submitted by the contractor and owner at least 14 days before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls were discussed in the DEIR/S. Appropriate controls will be prepared and implemented by the contractor and MassDOT (MBTA) during construction in accordance with the final design and NPDES SWPPP.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan will be developed by the MBTA during final design for the Project.

Standard 10: Prohibition of Illicit Discharges

The site was previously undeveloped and no sanitary sewer or storm drainage infrastructure is known to exist on the site. The design plans submitted with this report have been designed in full compliance with current standards. The Long-Term Pollution Prevention Plan will include measures to prevent illicit discharges.

Appendix A
Standard 1 Computations and Supporting Information

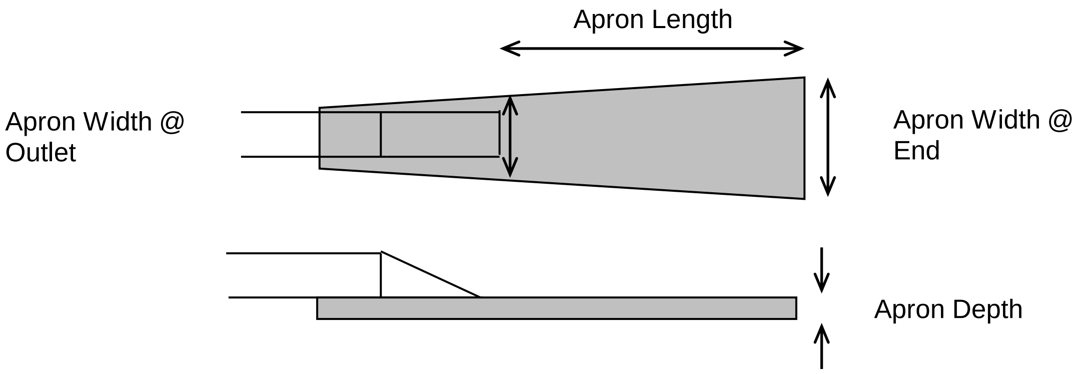
Stone Outlet Protection

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources:
Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

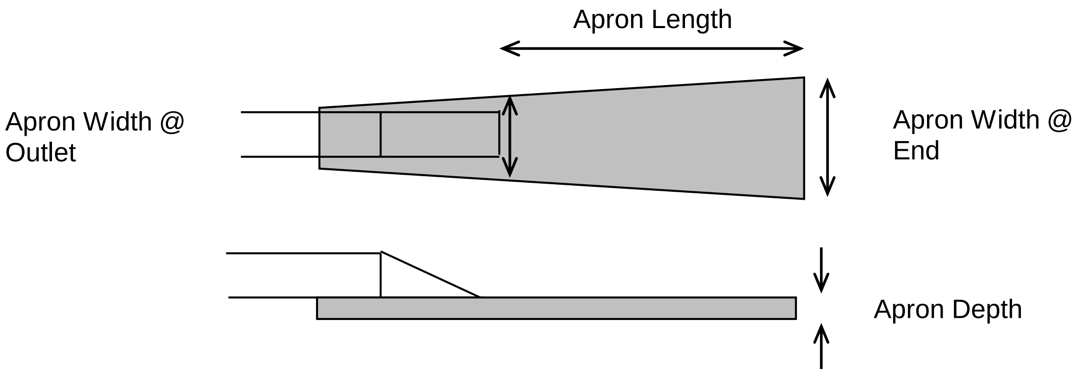
	Outlet Description
Design Element	FES A2
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	12
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	1.3
Apron Width (outlet), ft	3
Apron Length, ft	10
Apron Width (end), ft	11
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources:
Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

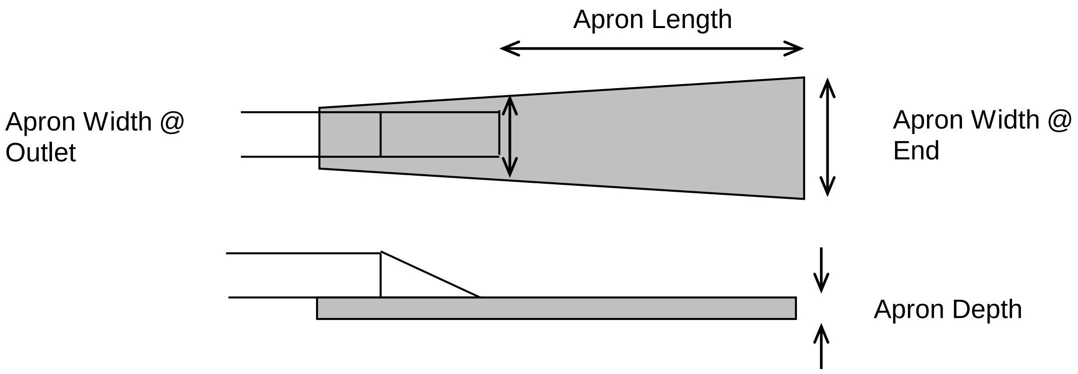
Design Element	Outlet Description FES B8
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	15
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	5.8
Apron Width (outlet), ft	4
Apron Length, ft	10
Apron Width (end), ft	11
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet: Width = 3 x pipe dia. (or width of channel)
Apron Length: Length = From Virginia DCR Handbook - Plate 3.18-3 if Tw depth is < 1/2 dia.
Length = From Virginia DCR Handbook - Plate 3.18-4 if Tw dwpth is >= 1/2 dia.
Apron Width at End: Width = dia. + apron length if Tw depth is < 1/2 dia.
Width = dia. + 0.4 x apron length if Tw dwpth is >= 1/2 dia.
or apron width = channel width if a well defined channel exists
Rock Riprap: Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4
Largest stone dia = 1.5 x d_{50}
Apron Depth: 6" or 1.5 x largest stone dia

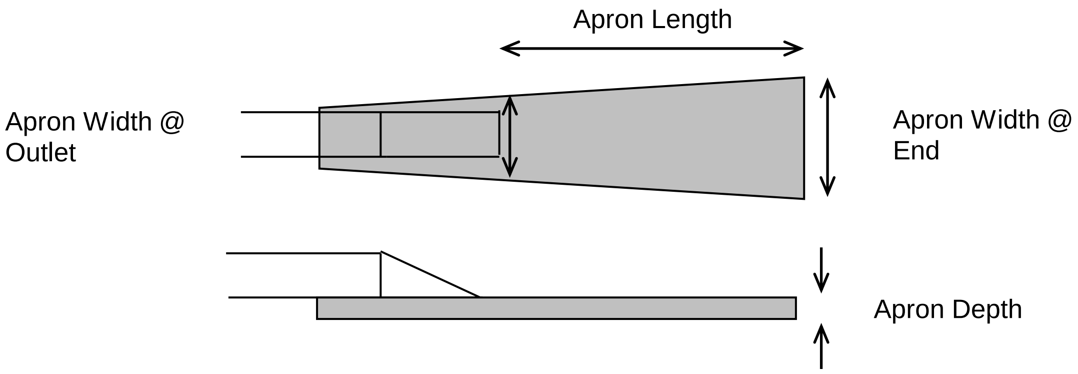
	Outlet Description
Design Element	FES C10
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	21
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	11.7
Apron Width (outlet), ft	5
Apron Length, ft	10
Apron Width (end), ft	12
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

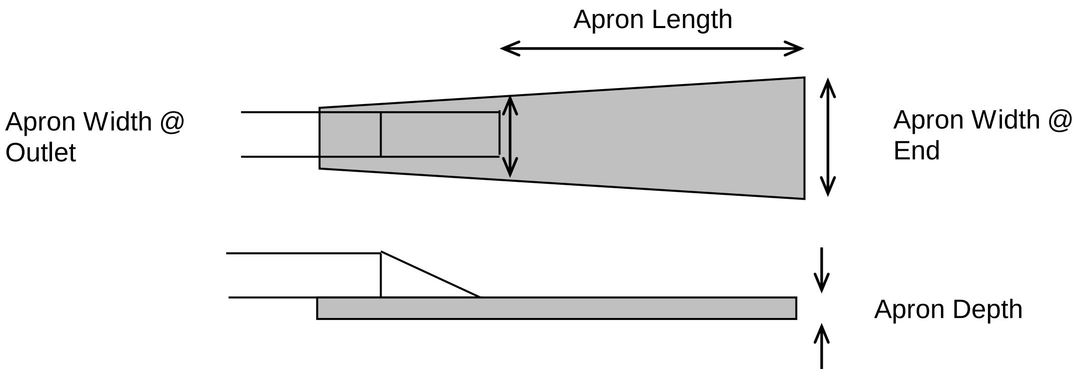
	Outlet Description
Design Element	FES D2
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	12
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	3.7
Apron Width (outlet), ft	3
Apron Length, ft	10
Apron Width (end), ft	11
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet: Width = 3 x pipe dia. (or width of channel)
Apron Length: Length = From Virginia DCR Handbook - Plate 3.18-3 if Tw depth is < 1/2 dia.
Length = From Virginia DCR Handbook - Plate 3.18-4 if Tw dwpth is >= 1/2 dia.
Apron Width at End: Width = dia. + apron length if Tw depth is < 1/2 dia.
Width = dia. + 0.4 x apron length if Tw dwpth is >= 1/2 dia.
or apron width = channel width if a well defined channel exists
Rock Riprap: Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4
Largest stone dia = 1.5 x d_{50}
Apron Depth: 6" or 1.5 x largest stone dia

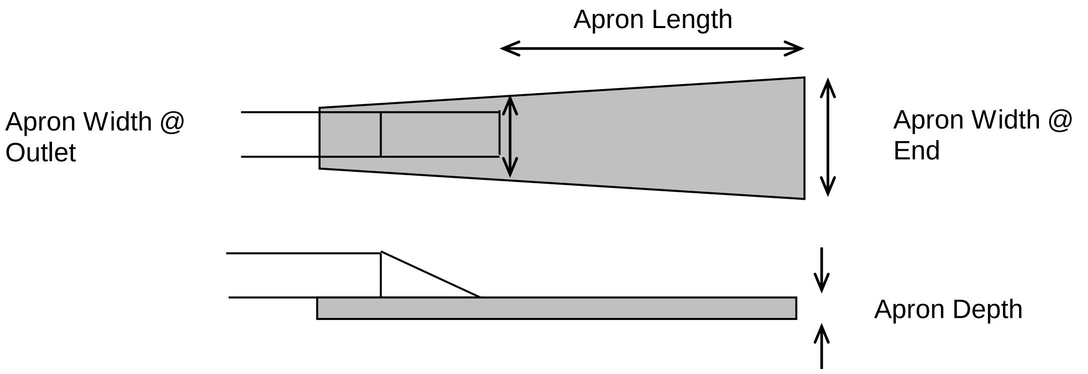
Design Element	Outlet Description FES E2
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	12
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	0.7
Apron Width (outlet), ft	3
Apron Length, ft	10
Apron Width (end), ft	11
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111
Project: North Easton Station - SCR
Location: Stoughton, MA
Calculated by: CWF Date: April 23, 2012
Checked by: VHB Date:
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

Design Element	Outlet Description FES F2
Design Storm (yr):	25
Defined Channel (yes/no)	no
Pipe Dia (D), in	12
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	1.5
Apron Width (outlet), ft	3
Apron Length, ft	10
Apron Width (end), ft	11
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Pipe Calculations

Vanasse Hangen Brustlin, Inc.
Transportation
Land Development
Environmental Services
101 Walnut St., Watertown, MA 02471
(617) 924-1770

Storm Drainage Computations

Name: MBTA SOUTH COAST RAIL STATION DESIGN
Easton, MA
Client: MBTA

Proj. No.: **10111.00**
Date: **2/21/2012**
Computed by: **ZZY**
Checked by: **VHB**

Design Parameters:
25 **Year Storm** Boston, MA **IDF Curve**

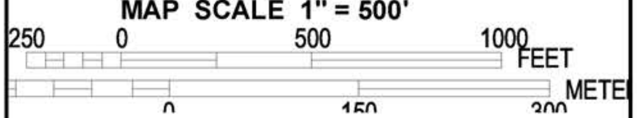
k_e= **0.5**

DESCRIPTION	**LOCATION**		AREA	C	C x A	SUM	**FLOW TIME (MIN)**		i*	**DESIGN**					**CAPACITY**		**PROFILE**						
	FROM	TO	(AC.)			C x A	PIPE	CONC TIME		Q cfs	V fps	n	PIPE SIZE	SLOPE	Q full ft^3/s	V full ft/s	LENGTH ft	FALL ft	RIM	INV UPPER	INV LOWER	W.S.E. ft	Freeboard ft
	CB A1	FES A2	0.30	0.71	0.21	0.21	0.40	5.0	6.0	1.3	5.3	0.013	12	0.0317	6.3	8.1	126	4.00	171.0	167.0	163.0	166.7	4.3
	CB B1	DMH B5	1.00	0.36	0.36	0.36	0.74	5.0	6.0	2.2	4.1	0.013	12	0.0105	3.7	4.6	181	1.90	166.0	162.0	160.1	161.8	4.2
	CB B2	DMH B5	0.72	0.49	0.36	0.36	0.66	5.0	6.0	2.1	4.2	0.013	12	0.0114	3.8	4.9	166	1.90	166.0	162.0	160.1	161.8	4.2
	DMH B5	DMH B6	---	---	---	0.72	0.45	5.0	6.0	4.3	4.9	0.013	15	0.0103	6.6	5.3	131	1.35	165.5	159.85	158.5	159.6	5.9
	CB B3	DMH B6	0.40	0.42	0.17	0.17	0.05	5.0	6.0	1.0	7.9	0.013	12	0.1556	14.1	17.9	23	3.50	167.0	163.0	159.5	162.2	4.8
	DMH B6	DMH B7	---	---	---	0.89	0.22	5.0	6.0	5.3	5.1	0.013	15	0.0091	6.2	5.0	66	0.60	166.3	158.4	157.8	158.1	8.2
	CB B4	DMH B7	0.13	0.66	0.08	0.08	0.14	5.0	6.0	0.5	2.6	0.013	12	0.0095	3.5	4.4	21	0.20	166.0	158.0	157.8	157.9	8.1
	DMH B7	FES B8	---	---	---	0.97	0.25	5.0	6.0	5.8	5.2	0.013	15	0.0091	6.2	5.0	77	0.70	164.0	157.7	157.0	157.4	6.6
	CB C1	DMH C5	0.86	0.76	0.66	0.66	0.54	5.0	6.0	3.9	5.6	0.013	12	0.0139	4.2	5.3	180	2.50	160.0	156.0	153.5	155.6	4.4
	CB C2	DMH C5	0.83	0.90	0.75	0.75	0.03	5.0	6.0	4.5	6.5	0.013	12	0.0200	5.0	6.4	10	0.20	160.0	156.00	155.8	155.5	4.5
	CB 2A	DMH C5	0.40	0.90	0.36	0.36	0.22	5.0	6.0	2.2	6.5	0.013	12	0.0368	6.8	8.7	87	3.20	163.0	159.0	155.8	158.5	4.5
	DMH C5	DMH C6	---	---	---	1.40	0.61	5.0	6.0	8.4	4.8	0.013	21	0.0065	12.8	5.3	177	1.15	160.4	152.75	151.6	152.5	7.9
	CB C3	DMH C6	0.69	0.79	0.55	0.55	0.03	5.0	6.0	3.3	5.8	0.013	12	0.0200	5.0	6.4	10	0.20	160.1	153.8	153.6	153.4	6.7
	DMH C6	DMH C7	---	---	---	1.95	0.85	5.0	6.0	11.7	5.9	0.013	21	0.0083	14.5	6.0	300	2.50	160.4	151.5	149.0	151.1	9.3
	DMH C7	DMH C8	---	---	---	1.95	0.23	5.0	6.0	11.7	5.9	0.013	21	0.0084	14.6	6.0	83	0.70	154.0	148.9	148.2	148.5	5.5
	DMH C8	DMH C9	---	---	---	1.95	0.53	5.0	6.0	11.7	5.5	0.013	21	0.0068	13.0	5.4	177	1.20	153.0	148.1	146.9	147.7	5.3
	DMH C9	FES C10	---	---	---	1.95	0.19	5.0	6.0	11.7	5.7	0.013	21	0.0076	13.8	5.7	66	0.50	150.0	146.8	146.3	146.4	3.6
	CB D1	FES D2	0.90	0.68	0.61	0.61	0.10	5.0	6.0	3.7	7.4	0.013	12	0.0364	6.8	8.7	44	1.60	158.0	155.6	154.0	154.9	3.1
	CB E1	HW E2			0.00	0.00	0.19	5.0	6.0	0.7	3.8	0.013	12	0.0227	5.4	6.8	44	1.00	162.4	155.0	154.0	154.8	7.6
	CB F1	FES F2			0.00	0.00	0.15	5.0	6.0	1.5	4.7	0.013	12	0.0205	5.1	6.5	44	0.90	160.9	153.4	152.5	153.1	7.8

Appendix B
Standard 2 Computations and Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Norfolk County. Runoff coefficients for the existing and proposed conditions, as previously shown in Tables 1 and 2 respectively, were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

FEMA Flood Maps



NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0053F

FIRM
FLOOD INSURANCE RATE MAP
BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 53 OF 550

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
EASTON, TOWN OF	250053	0053	F

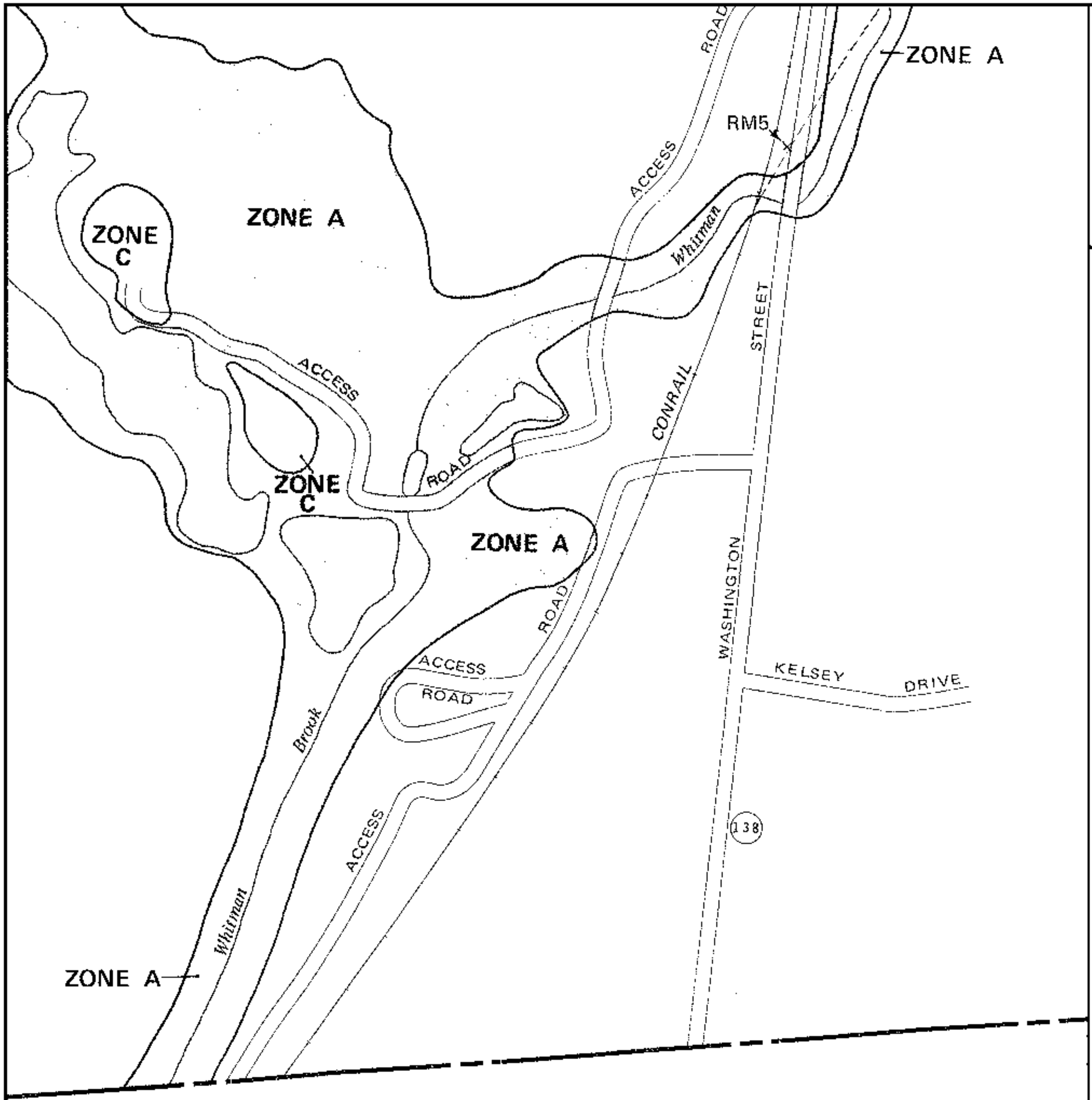
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

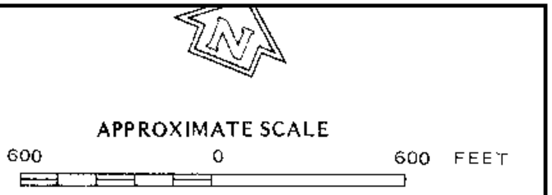
MAP NUMBER
25005C0053F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov





NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
STOUGHTON,
MASSACHUSETTS
NORFOLK COUNTY

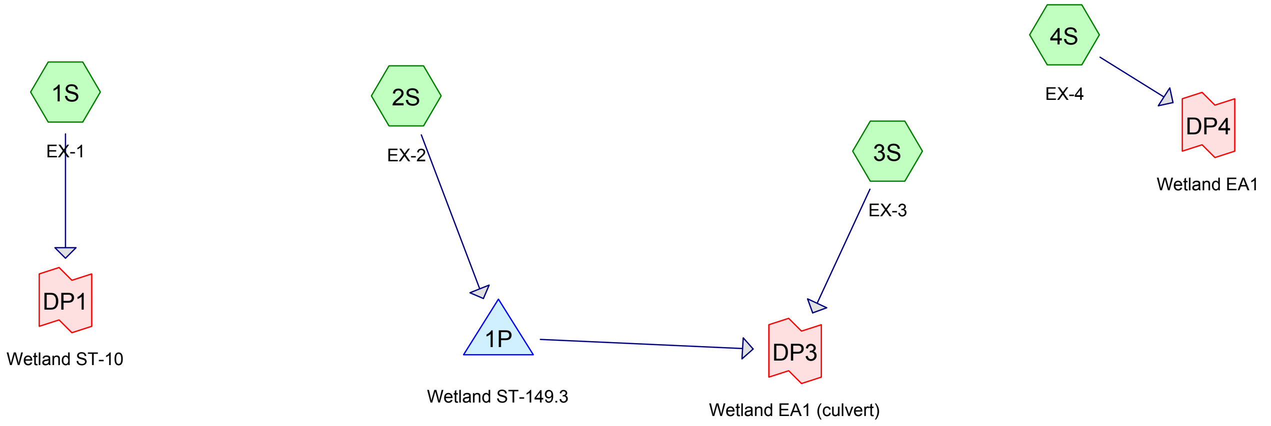
PANEL 4 OF 4
(SEE MAP INDEX FOR PANELS NOT PRINTED)

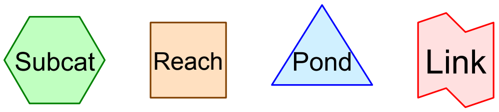
COMMUNITY-PANEL NUMBER
250253 0004 B

EFFECTIVE DATE:
JUNE 1, 1982

Federal Emergency Management Agency

HydroCAD Analysis: Existing Conditions





Routing Diagram for North Easton-EX
Prepared by VHB, Printed 6/4/2012
HydroCAD® 10.00 s/n 01234 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.050	36	Woods, Fair, HSG A (1S, 2S, 3S)
0.780	49	50-75% Grass cover, Fair, HSG A (3S)
0.160	68	<50% Grass cover, Poor, HSG A (2S)
0.370	72	Dirt roads, HSG A (2S)
1.491	73	Woods, Fair, HSG C (1S, 2S, 3S, 4S)
1.097	79	50-75% Grass cover, Fair, HSG C (3S, 4S)
1.143	79	Woods, Fair, HSG D (1S, 2S, 3S, 4S)
0.359	84	50-75% Grass cover, Fair, HSG D (3S, 4S)
0.320	86	<50% Grass cover, Poor, HSG C (2S)
0.880	87	Dirt roads, HSG C (2S)
0.160	89	Dirt roads, HSG D (1S)
0.070	89	Gravel roads, HSG C (3S)
0.050	91	Gravel roads, HSG D (3S)
1.010	98	Paved parking, HSG A (2S)
1.730	98	Paved parking, HSG C (2S)
12.670	**71**	**TOTAL AREA**

2-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EX-1 Runoff Area=1.550 ac 0.00% Impervious Runoff Depth>0.79"
Flow Length=350' Tc=8.5 min CN=67 Runoff=1.14 cfs 0.102 af

Subcatchment2S: EX-2 Runoff Area=7.280 ac 37.64% Impervious Runoff Depth>1.23"
Flow Length=514' Tc=9.2 min CN=75 Runoff=9.07 cfs 0.745 af

Subcatchment3S: EX-3 Runoff Area=3.190 ac 0.00% Impervious Runoff Depth>0.57"
Flow Length=885' Tc=14.8 min CN=62 Runoff=1.17 cfs 0.151 af

Subcatchment4S: EX-4 Runoff Area=0.650 ac 0.00% Impervious Runoff Depth>1.63"
Tc=5.0 min CN=81 Runoff=1.28 cfs 0.088 af

Pond 1P: Wetland ST-149.3 Peak Elev=155.62' Storage=32,467 cf Inflow=9.07 cfs 0.745 af
Outflow=0.00 cfs 0.000 af

Link DP1: Wetland ST-10 Inflow=1.14 cfs 0.102 af
Primary=1.14 cfs 0.102 af

Link DP3: Wetland EA1 (culvert) Inflow=1.17 cfs 0.151 af
Primary=1.17 cfs 0.151 af

Link DP4: Wetland EA1 Inflow=1.28 cfs 0.088 af
Primary=1.28 cfs 0.088 af

Total Runoff Area = 12.670 ac Runoff Volume = 1.086 af Average Runoff Depth = 1.03"
78.37% Pervious = 9.930 ac 21.63% Impervious = 2.740 ac

Summary for Subcatchment 1S: EX-1

```
Runoff      =         1.14 cfs @   12.14 hrs,  Volume=           0.102 af,  Depth>  0.79"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.410	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.660	79	Woods, Fair, HSG D
0.160	89	Dirt roads, HSG D
1.550	67	Weighted Average
1.550		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.1600	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
3.2	300	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.5	350	Total			

Summary for Subcatchment 2S: EX-2

Runoff = 9.07 cfs @ 12.14 hrs, Volume= 0.745 af, Depth> 1.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
1.920	36	Woods, Fair, HSG A
0.820	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
1.010	98	Paved parking, HSG A
1.730	98	Paved parking, HSG C
0.160	68	<50% Grass cover, Poor, HSG A
0.320	86	<50% Grass cover, Poor, HSG C
0.370	72	Dirt roads, HSG A
0.880	87	Dirt roads, HSG C
7.280	75	Weighted Average
4.540		62.36% Pervious Area
2.740		37.64% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	37	0.0600	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.5	14	0.0600	0.43		**Sheet Flow,** Fallow n= 0.050 P2= 3.28"
0.4	60	0.0600	2.45		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.4	105	0.0600	4.97		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.5	139	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	92	0.0400	4.06		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	67	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.2	514	Total			

Summary for Subcatchment 3S: EX-3

Runoff = 1.17 cfs @ 12.26 hrs, Volume= 0.151 af, Depth> 0.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.780	49	50-75% Grass cover, Fair, HSG A
0.990	79	50-75% Grass cover, Fair, HSG C
0.160	84	50-75% Grass cover, Fair, HSG D
0.720	36	Woods, Fair, HSG A
0.350	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
0.070	89	Gravel roads, HSG C
0.050	91	Gravel roads, HSG D
3.190	62	Weighted Average
3.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	35	0.0700	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.1	16	0.1250	2.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
1.6	443	0.0540	4.72		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	36	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.4	100	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	22	0.4500	4.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	93	0.0540	1.63		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.9	140	0.0360	0.47		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.8	885	Total			

Summary for Subcatchment 4S: EX-4

Runoff = 1.28 cfs @ 12.08 hrs, Volume= 0.088 af, Depth> 1.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.107	79	50-75% Grass cover, Fair, HSG C
0.199	84	50-75% Grass cover, Fair, HSG D
0.001	73	Woods, Fair, HSG C
0.343	79	Woods, Fair, HSG D
0.650	81	Weighted Average
0.650		100.00% Pervious Area

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

Summary for Pond 1P: Wetland ST-149.3

Inflow Area = 7.280 ac, 37.64% Impervious, Inflow Depth > 1.23" for 2-Year event
Inflow = 9.07 cfs @ 12.14 hrs, Volume= 0.745 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 155.62' @ 24.00 hrs Surf.Area= 21,770 sf Storage= 32,467 cf

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	151.00'	62,400 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
151.00	1,145	145.0	0	0	1,145
152.00	1,956	207.0	1,533	1,533	2,891
153.00	3,501	290.0	2,691	4,224	6,183
154.00	6,555	401.0	4,949	9,173	12,296
155.00	16,956	686.0	11,351	20,524	36,955
156.00	25,041	784.0	20,868	41,391	48,442
156.40	30,828	976.0	11,154	52,545	75,335
156.70	34,911	1,014.0	9,855	62,400	81,360

Device	Routing	Invert	Outlet Devices
#1	Primary	156.20'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=151.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link DP1: Wetland ST-10

```
Inflow Area =          1.550 ac,    0.00% Impervious,  Inflow Depth >   0.79"    for  2-Year event
Inflow       =         1.14 cfs @   12.14 hrs,  Volume=            0.102 af
Primary      =         1.14 cfs @   12.14 hrs,  Volume=            0.102 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =         10.470 ac,  26.17% Impervious,  Inflow Depth >   0.17"    for  2-Year event
Inflow       =          1.17 cfs @   12.26 hrs,  Volume=            0.151 af
Primary     =          1.17 cfs @   12.26 hrs,  Volume=            0.151 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA1

```
Inflow Area =          0.650 ac,    0.00% Impervious,  Inflow Depth >   1.63"    for  2-Year event
Inflow       =          1.28 cfs @   12.08 hrs,  Volume=            0.088 af
Primary     =          1.28 cfs @   12.08 hrs,  Volume=            0.088 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

10-Year Storm Event - Existing

```
                     Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
                          Runoff by SCS TR-20 method, UH=SCS
          Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment1S: EX-1                   Runoff Area=1.550 ac   0.00% Impervious   Runoff Depth>1.63"
                                     Flow Length=350'   Tc=8.5 min   CN=67   Runoff=2.60 cfs  0.210 af

Subcatchment2S: EX-2                  Runoff Area=7.280 ac   37.64% Impervious   Runoff Depth>2.24"
                                    Flow Length=514'   Tc=9.2 min   CN=75   Runoff=17.10 cfs  1.361 af

Subcatchment3S: EX-3                   Runoff Area=3.190 ac   0.00% Impervious   Runoff Depth>1.28"
                                    Flow Length=885'   Tc=14.8 min   CN=62   Runoff=3.28 cfs  0.341 af

Subcatchment4S: EX-4                   Runoff Area=0.650 ac   0.00% Impervious   Runoff Depth>2.76"
                                                    Tc=5.0 min   CN=81   Runoff=2.18 cfs  0.150 af

Pond 1P: Wetland ST-149.3            Peak Elev=156.28'  Storage=48,827 cf   Inflow=17.10 cfs  1.361 af
                                                                         Outflow=0.51 cfs  0.257 af

Link DP1: Wetland ST-10                                                   Inflow=2.60 cfs  0.210 af
                                                                         Primary=2.60 cfs  0.210 af

Link DP3: Wetland EA1 (culvert)                                           Inflow=3.28 cfs  0.598 af
                                                                         Primary=3.28 cfs  0.598 af

Link DP4: Wetland EA1                                                     Inflow=2.18 cfs  0.150 af
                                                                         Primary=2.18 cfs  0.150 af

          Total Runoff Area = 12.670 ac   Runoff Volume = 2.062 af   Average Runoff Depth = 1.95"
                                   78.37% Pervious = 9.930 ac     21.63% Impervious = 2.740 ac
```

Summary for Subcatchment 1S: EX-1

Runoff = 2.60 cfs @ 12.13 hrs, Volume= 0.210 af, Depth> 1.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.410	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.660	79	Woods, Fair, HSG D
0.160	89	Dirt roads, HSG D
1.550	67	Weighted Average
1.550		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.1600	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
3.2	300	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.5	350	Total			

Summary for Subcatchment 2S: EX-2

Runoff = 17.10 cfs @ 12.13 hrs, Volume= 1.361 af, Depth> 2.24"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
1.920	36	Woods, Fair, HSG A
0.820	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
1.010	98	Paved parking, HSG A
1.730	98	Paved parking, HSG C
0.160	68	<50% Grass cover, Poor, HSG A
0.320	86	<50% Grass cover, Poor, HSG C
0.370	72	Dirt roads, HSG A
0.880	87	Dirt roads, HSG C
7.280	75	Weighted Average
4.540		62.36% Pervious Area
2.740		37.64% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	37	0.0600	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.5	14	0.0600	0.43		**Sheet Flow,** Fallow n= 0.050 P2= 3.28"
0.4	60	0.0600	2.45		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.4	105	0.0600	4.97		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.5	139	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	92	0.0400	4.06		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	67	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.2	514	Total			

Summary for Subcatchment 3S: EX-3

Runoff = 3.28 cfs @ 12.22 hrs, Volume= 0.341 af, Depth> 1.28"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.780	49	50-75% Grass cover, Fair, HSG A
0.990	79	50-75% Grass cover, Fair, HSG C
0.160	84	50-75% Grass cover, Fair, HSG D
0.720	36	Woods, Fair, HSG A
0.350	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
0.070	89	Gravel roads, HSG C
0.050	91	Gravel roads, HSG D
3.190	62	Weighted Average
3.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	35	0.0700	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.1	16	0.1250	2.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
1.6	443	0.0540	4.72		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	36	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.4	100	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	22	0.4500	4.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	93	0.0540	1.63		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.9	140	0.0360	0.47		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.8	885	Total			

Summary for Subcatchment 4S: EX-4

```
Runoff      =        2.18 cfs @   12.07 hrs,  Volume=          0.150 af,  Depth>  2.76"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.107	79	50-75% Grass cover, Fair, HSG C
0.199	84	50-75% Grass cover, Fair, HSG D
0.001	73	Woods, Fair, HSG C
0.343	79	Woods, Fair, HSG D
0.650	81	Weighted Average
0.650		100.00% Pervious Area

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

Summary for Pond 1P: Wetland ST-149.3

```
Inflow Area =        7.280 ac, 37.64% Impervious, Inflow Depth >  2.24"   for 10-Year event
Inflow      =      17.10 cfs @  12.13 hrs, Volume=          1.361 af
Outflow     =       0.51 cfs @  17.55 hrs, Volume=          0.257 af, Atten= 97%, Lag= 324.8 min
Primary     =       0.51 cfs @  17.55 hrs, Volume=          0.257 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 156.28' @ 17.55 hrs Surf.Area= 28,964 sf Storage= 48,827 cf

Plug-Flow detention time= 481.8 min calculated for 0.257 af (19% of inflow)
Center-of-Mass det. time= 339.3 min (1,178.4 - 839.1)

Volume	Invert	Avail.Storage	Storage Description
#1	151.00'	62,400 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
151.00	1,145	145.0	0	0	1,145
152.00	1,956	207.0	1,533	1,533	2,891
153.00	3,501	290.0	2,691	4,224	6,183
154.00	6,555	401.0	4,949	9,173	12,296
155.00	16,956	686.0	11,351	20,524	36,955
156.00	25,041	784.0	20,868	41,391	48,442
156.40	30,828	976.0	11,154	52,545	75,335
156.70	34,911	1,014.0	9,855	62,400	81,360

Device	Routing	Invert	Outlet Devices
#1	Primary	156.20'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=0.49 cfs @ 17.55 hrs HW=156.28' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir**(Weir Controls 0.49 cfs @ 0.64 fps)

Summary for Link DP1: Wetland ST-10

```
Inflow Area =        1.550 ac,   0.00% Impervious,  Inflow Depth >   1.63"    for  10-Year event
Inflow      =       2.60 cfs @   12.13 hrs,  Volume=          0.210 af
Primary     =       2.60 cfs @   12.13 hrs,  Volume=          0.210 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =        10.470 ac,  26.17% Impervious,  Inflow Depth >   0.69"    for  10-Year event
Inflow       =         3.28 cfs @   12.22 hrs,  Volume=            0.598 af
Primary      =         3.28 cfs @   12.22 hrs,  Volume=            0.598 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA1

```
Inflow Area =        0.650 ac,    0.00% Impervious,  Inflow Depth >   2.76"    for  10-Year event
Inflow      =        2.18 cfs @   12.07 hrs,  Volume=          0.150 af
Primary     =        2.18 cfs @   12.07 hrs,  Volume=          0.150 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

100-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EX-1 Runoff Area=1.550 ac 0.00% Impervious Runoff Depth>3.30"
Flow Length=350' Tc=8.5 min CN=67 Runoff=5.48 cfs 0.426 af

Subcatchment2S: EX-2 Runoff Area=7.280 ac 37.64% Impervious Runoff Depth>4.14"
Flow Length=514' Tc=9.2 min CN=75 Runoff=31.74 cfs 2.513 af

Subcatchment3S: EX-3 Runoff Area=3.190 ac 0.00% Impervious Runoff Depth>2.79"
Flow Length=885' Tc=14.8 min CN=62 Runoff=7.77 cfs 0.742 af

Subcatchment4S: EX-4 Runoff Area=0.650 ac 0.00% Impervious Runoff Depth>4.80"
Tc=5.0 min CN=81 Runoff=3.75 cfs 0.260 af

Pond 1P: Wetland ST-149.3 Peak Elev=156.57' Storage=57,956 cf Inflow=31.74 cfs 2.513 af
Outflow=5.57 cfs 1.397 af

Link DP1: Wetland ST-10 Inflow=5.48 cfs 0.426 af
Primary=5.48 cfs 0.426 af

Link DP3: Wetland EA1 (culvert) Inflow=8.97 cfs 2.139 af
Primary=8.97 cfs 2.139 af

Link DP4: Wetland EA1 Inflow=3.75 cfs 0.260 af
Primary=3.75 cfs 0.260 af

Total Runoff Area = 12.670 ac Runoff Volume = 3.941 af Average Runoff Depth = 3.73"
78.37% Pervious = 9.930 ac 21.63% Impervious = 2.740 ac

Summary for Subcatchment 1S: EX-1

Runoff = 5.48 cfs @ 12.12 hrs, Volume= 0.426 af, Depth> 3.30"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.410	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.660	79	Woods, Fair, HSG D
0.160	89	Dirt roads, HSG D
1.550	67	Weighted Average
1.550		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.1600	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
3.2	300	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.5	350	Total			

Summary for Subcatchment 2S: EX-2

Runoff = 31.74 cfs @ 12.13 hrs, Volume= 2.513 af, Depth> 4.14"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
1.920	36	Woods, Fair, HSG A
0.820	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
1.010	98	Paved parking, HSG A
1.730	98	Paved parking, HSG C
0.160	68	<50% Grass cover, Poor, HSG A
0.320	86	<50% Grass cover, Poor, HSG C
0.370	72	Dirt roads, HSG A
0.880	87	Dirt roads, HSG C
7.280	75	Weighted Average
4.540		62.36% Pervious Area
2.740		37.64% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	37	0.0600	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.5	14	0.0600	0.43		**Sheet Flow,** Fallow n= 0.050 P2= 3.28"
0.4	60	0.0600	2.45		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.4	105	0.0600	4.97		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.5	139	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	92	0.0400	4.06		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	67	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.2	514	Total			

Summary for Subcatchment 3S: EX-3

Runoff = 7.77 cfs @ 12.21 hrs, Volume= 0.742 af, Depth> 2.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.780	49	50-75% Grass cover, Fair, HSG A
0.990	79	50-75% Grass cover, Fair, HSG C
0.160	84	50-75% Grass cover, Fair, HSG D
0.720	36	Woods, Fair, HSG A
0.350	73	Woods, Fair, HSG C
0.070	79	Woods, Fair, HSG D
0.070	89	Gravel roads, HSG C
0.050	91	Gravel roads, HSG D
3.190	62	Weighted Average
3.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	35	0.0700	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.1	16	0.1250	2.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
1.6	443	0.0540	4.72		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	36	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.4	100	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	22	0.4500	4.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	93	0.0540	1.63		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.9	140	0.0360	0.47		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.8	885	Total			

Summary for Subcatchment 4S: EX-4

Runoff = 3.75 cfs @ 12.07 hrs, Volume= 0.260 af, Depth> 4.80"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.107	79	50-75% Grass cover, Fair, HSG C
0.199	84	50-75% Grass cover, Fair, HSG D
0.001	73	Woods, Fair, HSG C
0.343	79	Woods, Fair, HSG D
0.650	81	Weighted Average
0.650		100.00% Pervious Area

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

Summary for Pond 1P: Wetland ST-149.3

```
Inflow Area =        7.280 ac, 37.64% Impervious, Inflow Depth >  4.14"   for 100-Year event
Inflow      =       31.74 cfs @  12.13 hrs, Volume=          2.513 af
Outflow     =        5.57 cfs @  12.65 hrs, Volume=          1.397 af, Atten= 82%, Lag= 31.5 min
Primary     =        5.57 cfs @  12.65 hrs, Volume=          1.397 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 156.57' @ 12.65 hrs   Surf.Area= 33,101 sf   Storage= 57,956 cf

Plug-Flow detention time= 229.6 min calculated for 1.397 af (56% of inflow)
Center-of-Mass det. time= 120.3 min ( 941.8 - 821.6 )

Volume      Invert    Avail.Storage   Storage Description
   #1      151.00'       62,400 cf    Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation      Surf.Area    Perim.        Inc.Store       Cum.Store         Wet.Area
    (feet)         (sq-ft)    (feet)     (cubic-feet)    (cubic-feet)           (sq-ft)
    151.00           1,145     145.0                0               0             1,145
    152.00           1,956     207.0            1,533           1,533             2,891
    153.00           3,501     290.0            2,691           4,224             6,183
    154.00           6,555     401.0            4,949           9,173            12,296
    155.00          16,956     686.0           11,351          20,524            36,955
    156.00          25,041     784.0           20,868          41,391            48,442
    156.40          30,828     976.0           11,154          52,545            75,335
    156.70          34,911   1,014.0            9,855          62,400            81,360

Device   Routing          Invert   Outlet Devices
   #1    Primary         156.20'   10.0' long  x 5.0' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                   2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                   Coef. (English)  2.34  2.50  2.70  2.68  2.68  2.66  2.65  2.65  2.65
                                   2.65  2.67  2.66  2.68  2.70  2.74  2.79  2.88

Primary OutFlow Max=5.56 cfs @ 12.65 hrs  HW=156.57'   (Free Discharge)
└─1=Broad-Crested Rectangular Weir(Weir Controls 5.56 cfs @ 1.50 fps)
```

Summary for Link DP1: Wetland ST-10

```
Inflow Area =        1.550 ac,    0.00% Impervious,  Inflow Depth >   3.30"    for  100-Year event
Inflow      =        5.48 cfs @   12.12 hrs,  Volume=          0.426 af
Primary     =        5.48 cfs @   12.12 hrs,  Volume=          0.426 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
```

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =        10.470 ac,  26.17% Impervious,  Inflow Depth >   2.45"    for  100-Year event
Inflow       =         8.97 cfs @   12.52 hrs,  Volume=             2.139 af
Primary      =         8.97 cfs @   12.52 hrs,  Volume=             2.139 af,  Atten= 0%,  Lag= 0.0 min
```

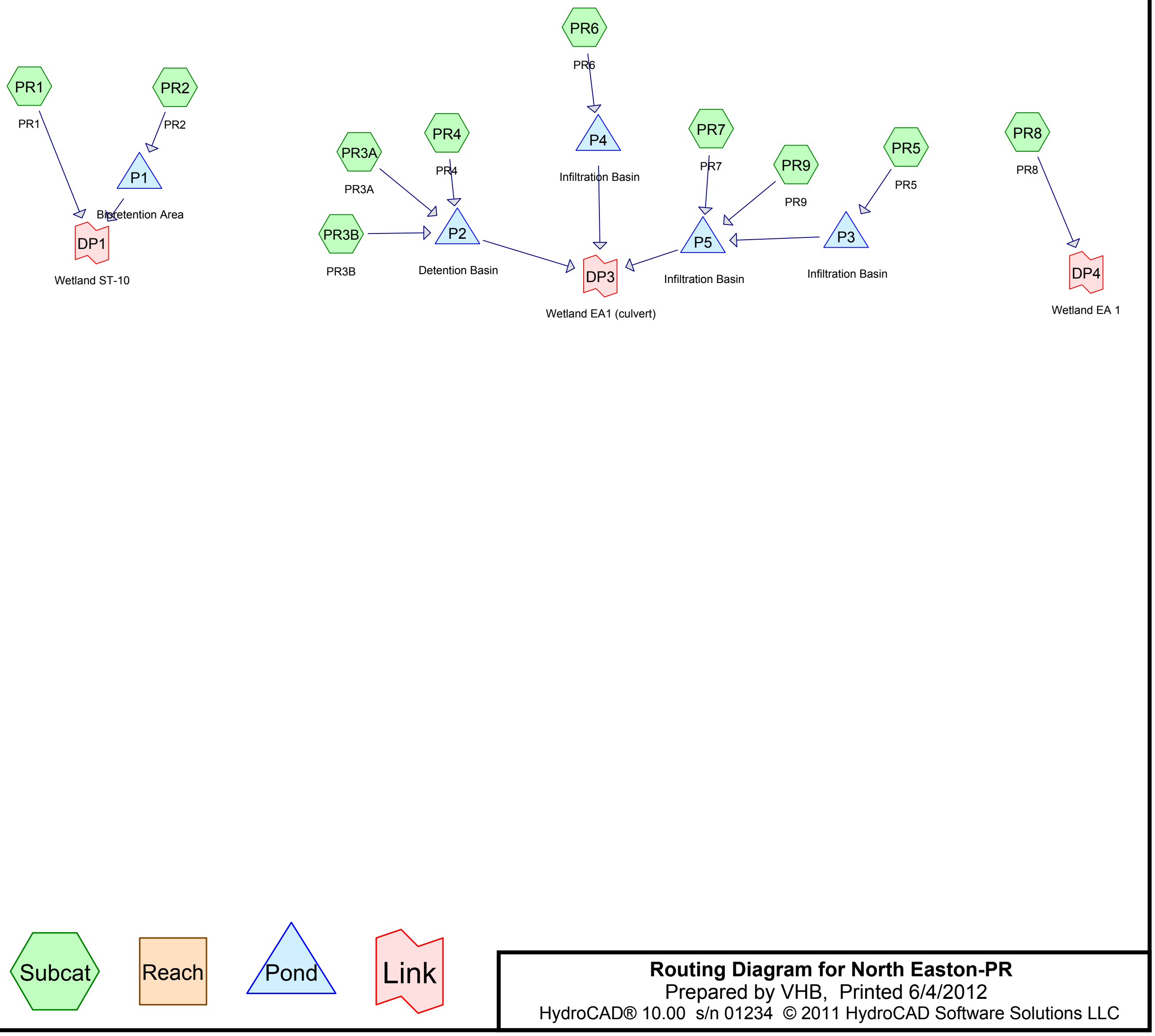
Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA1

```
Inflow Area =        0.650 ac,    0.00% Impervious,  Inflow Depth >   4.80"    for  100-Year event
Inflow      =        3.75 cfs @   12.07 hrs,  Volume=          0.260 af
Primary     =        3.75 cfs @   12.07 hrs,  Volume=          0.260 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

HydroCAD Analysis: Proposed Conditions



Routing Diagram for North Easton-PR
Prepared by VHB, Printed 6/4/2012
HydroCAD® 10.00 s/n 01234 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.367	36	Woods, Fair, HSG A (PR1, PR2, PR7)
1.511	49	50-75% Grass cover, Fair, HSG A (PR2, PR4, PR6, PR7, PR9)
0.922	73	Woods, Fair, HSG C (PR1, PR2, PR3A, PR7)
0.036	76	Gravel roads, HSG A (PR9)
2.416	79	50-75% Grass cover, Fair, HSG C (PR3A, PR4, PR5, PR6, PR7, PR8, PR9)
0.914	79	Woods, Fair, HSG D (PR1, PR2, PR8)
0.534	84	50-75% Grass cover, Fair, HSG D (PR2, PR6, PR8, PR9)
0.157	89	Dirt roads, HSG D (PR1)
0.010	89	Gravel roads, HSG C (PR9)
2.348	98	Paved parking, HSG A (PR2, PR6, PR7)
2.084	98	Paved parking, HSG C (PR3B, PR4, PR5, PR6, PR7)
0.100	98	Paved parking, HSG D (PR6)
11.399	**81**	**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	PR3A	0.00	0.00	181.0	0.0100	0.011	12.0	0.0	0.0
2	PR3A	0.00	0.00	131.0	0.0100	0.011	15.0	0.0	0.0
3	PR3A	0.00	0.00	66.0	0.0091	0.011	15.0	0.0	0.0
4	PR3A	0.00	0.00	75.0	0.0092	0.011	15.0	0.0	0.0
5	PR7	0.00	0.00	180.0	0.0139	0.013	12.0	0.0	0.0
6	PR7	0.00	0.00	177.0	0.0650	0.013	21.0	0.0	0.0
7	PR7	0.00	0.00	295.0	0.0102	0.013	21.0	0.0	0.0
8	PR7	0.00	0.00	90.0	0.0100	0.013	21.0	0.0	0.0
9	PR7	0.00	0.00	177.0	0.0136	0.013	21.0	0.0	0.0
10	PR7	0.00	0.00	66.0	0.0136	0.013	21.0	0.0	0.0
11	P2	153.40	152.50	112.0	0.0080	0.013	12.0	0.0	0.0
12	P3	155.00	154.00	49.0	0.0204	0.013	12.0	0.0	0.0
13	P5	144.00	143.50	50.0	0.0100	0.013	12.0	0.0	0.0

2-Year Storm Event - Proposed

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentPR1: PR1 Runoff Area=1.341 ac 0.00% Impervious Runoff Depth>0.94"
Flow Length=410' Tc=14.6 min CN=70 Runoff=1.03 cfs 0.105 af

SubcatchmentPR2: PR2 Runoff Area=1.420 ac 42.25% Impervious Runoff Depth>1.23"
Flow Length=455' Tc=15.0 min CN=75 Runoff=1.49 cfs 0.145 af

SubcatchmentPR3A: PR3A Runoff Area=1.500 ac 0.00% Impervious Runoff Depth>1.42"
Flow Length=757' Tc=16.8 min CN=78 Runoff=1.78 cfs 0.177 af

SubcatchmentPR3B: PR3B Runoff Area=0.600 ac 100.00% Impervious Runoff Depth>3.16"
Tc=5.0 min CN=98 Runoff=2.05 cfs 0.158 af

SubcatchmentPR4: PR4 Runoff Area=0.128 ac 62.50% Impervious Runoff Depth>1.70"
Tc=5.0 min CN=82 Runoff=0.26 cfs 0.018 af

SubcatchmentPR5: PR5 Runoff Area=0.300 ac 66.67% Impervious Runoff Depth>2.54"
Tc=5.0 min CN=92 Runoff=0.90 cfs 0.063 af

SubcatchmentPR6: PR6 Runoff Area=1.260 ac 43.65% Impervious Runoff Depth>1.36"
Tc=5.0 min CN=77 Runoff=2.04 cfs 0.142 af

SubcatchmentPR7: PR7 Runoff Area=2.800 ac 89.36% Impervious Runoff Depth>2.84"
Flow Length=1,318' Tc=5.0 min CN=95 Runoff=9.10 cfs 0.662 af

SubcatchmentPR8: PR8 Runoff Area=0.555 ac 0.00% Impervious Runoff Depth>1.63"
Flow Length=117' Tc=6.7 min CN=81 Runoff=1.03 cfs 0.075 af

SubcatchmentPR9: PR9 Runoff Area=1.495 ac 0.00% Impervious Runoff Depth>0.84"
Flow Length=175' Tc=7.3 min CN=68 Runoff=1.24 cfs 0.105 af

Pond P1: Bioretention Area Peak Elev=156.43' Storage=2,897 cf Inflow=1.49 cfs 0.145 af
Discarded=0.14 cfs 0.129 af Primary=0.00 cfs 0.000 af Outflow=0.14 cfs 0.129 af

Pond P2: Detention Basin Peak Elev=158.37' Storage=8,278 cf Inflow=3.30 cfs 0.353 af
Outflow=0.46 cfs 0.275 af

Pond P3: Infiltration Basin Peak Elev=162.50' Storage=872 cf Inflow=0.90 cfs 0.063 af
Discarded=0.01 cfs 0.009 af Primary=0.82 cfs 0.037 af Outflow=0.83 cfs 0.046 af

Pond P4: Infiltration Basin Peak Elev=153.25' Storage=3,053 cf Inflow=2.04 cfs 0.142 af
Discarded=0.13 cfs 0.115 af Primary=0.00 cfs 0.000 af Outflow=0.13 cfs 0.115 af

Pond P5: Infiltration Basin Peak Elev=144.29' Storage=14,390 cf Inflow=10.92 cfs 0.804 af
Discarded=0.70 cfs 0.750 af Primary=0.30 cfs 0.052 af Outflow=1.00 cfs 0.803 af

Link DP1: Wetland ST-10 Inflow=1.03 cfs 0.105 af
Primary=1.03 cfs 0.105 af

Link DP3: Wetland EA1 (culvert) Inflow=0.76 cfs 0.328 af
Primary=0.76 cfs 0.328 af

Link DP4: Wetland EA 1 Inflow=1.03 cfs 0.075 af
Primary=1.03 cfs 0.075 af

Total Runoff Area = 11.399 ac Runoff Volume = 1.652 af Average Runoff Depth = 1.74"
60.24% Pervious = 6.867 ac 39.76% Impervious = 4.532 ac

Summary for Subcatchment PR1: PR1

Runoff = 1.03 cfs @ 12.22 hrs, Volume= 0.105 af, Depth> 0.94"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.278	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.586	79	Woods, Fair, HSG D
0.157	89	Dirt roads, HSG D
1.341	70	Weighted Average
1.341		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	50	0.1600	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
3.7	190	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.3	34	0.1700	2.06		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.4	136	0.1100	1.66		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.6	410	Total			

Summary for Subcatchment PR2: PR2

Runoff = 1.49 cfs @ 12.22 hrs, Volume= 0.145 af, Depth> 1.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.080	36	Woods, Fair, HSG A
0.200	73	Woods, Fair, HSG C
0.100	79	Woods, Fair, HSG D
0.600	98	Paved parking, HSG A
0.400	49	50-75% Grass cover, Fair, HSG A
0.040	84	50-75% Grass cover, Fair, HSG D
1.420	75	Weighted Average
0.820		57.75% Pervious Area
0.600		42.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	50	0.0800	0.07		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
0.5	79	0.2400	2.45		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	20	0.1500	2.71		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.4	205	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	101	0.0190	2.07		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
15.0	455	Total			

Summary for Subcatchment PR3A: PR3A

Runoff = 1.78 cfs @ 12.23 hrs, Volume= 0.177 af, Depth> 1.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.300	73	Woods, Fair, HSG C
1.200	79	50-75% Grass cover, Fair, HSG C
1.500	78	Weighted Average
1.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0650	0.06		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
1.4	104	0.0650	1.27		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	12	0.3300	2.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.7	138	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	181	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.4	131	0.0100	6.22	7.63	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	66	0.0091	5.93	7.28	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	75	0.0092	5.97	7.32	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
16.8	757	Total			

Summary for Subcatchment PR3B: PR3B

```
Runoff      =          2.05 cfs @   12.07 hrs,  Volume=           0.158 af,  Depth>  3.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr  2-Year Rainfall=3.40"

   Area (ac)    CN   Description
 -------------------------------------------------------------------------------
       0.600    98   Paved parking, HSG C
 -------------------------------------------------------------------------------
       0.600         100.00% Impervious Area

     Tc   Length     Slope   Velocity   Capacity   Description
   (min)    (feet)    (ft/ft)   (ft/sec)      (cfs)
 -------------------------------------------------------------------------------
     5.0                                               Direct Entry,
```

Summary for Subcatchment PR4: PR4

Runoff = 0.26 cfs @ 12.08 hrs, Volume= 0.018 af, Depth> 1.70"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.011	79	50-75% Grass cover, Fair, HSG C
0.037	49	50-75% Grass cover, Fair, HSG A
0.080	98	Paved parking, HSG C
0.128	82	Weighted Average
0.048		37.50% Pervious Area
0.080		62.50% Impervious Area

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

Summary for Subcatchment PR5: PR5

Runoff = 0.90 cfs @ 12.07 hrs, Volume= 0.063 af, Depth> 2.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.100	79	50-75% Grass cover, Fair, HSG C
0.200	98	Paved parking, HSG C
0.300	92	Weighted Average
0.100		33.33% Pervious Area
0.200		66.67% Impervious Area

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

Summary for Subcatchment PR6: PR6

Runoff = 2.04 cfs @ 12.08 hrs, Volume= 0.142 af, Depth> 1.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.450	49	50-75% Grass cover, Fair, HSG A
0.200	79	50-75% Grass cover, Fair, HSG C
0.060	84	50-75% Grass cover, Fair, HSG D
0.300	98	Paved parking, HSG A
0.150	98	Paved parking, HSG C
0.100	98	Paved parking, HSG D
1.260	77	Weighted Average
0.710		56.35% Pervious Area
0.550		43.65% Impervious Area

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

Summary for Subcatchment PR7: PR7

Runoff = 9.10 cfs @ 12.07 hrs, Volume= 0.662 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.102	73	Woods, Fair, HSG C
0.009	36	Woods, Fair, HSG A
0.034	49	50-75% Grass cover, Fair, HSG A
0.153	79	50-75% Grass cover, Fair, HSG C
1.448	98	Paved parking, HSG A
1.054	98	Paved parking, HSG C
2.800	95	Weighted Average
0.298		10.64% Pervious Area
2.502		89.36% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0350	1.52		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
0.4	53	0.2000	2.24		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	21	0.2200	3.28		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	209	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	180	0.0139	5.35	4.20	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, straight & clean
0.2	177	0.0650	16.80	40.40	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.7	295	0.0102	6.65	16.00	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.2	90	0.0100	6.59	15.85	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.4	177	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.8					**Direct Entry,**
0.1	66	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
5.0	1,318	Total			

Summary for Subcatchment PR8: PR8

```
Runoff      =        1.03 cfs @   12.10 hrs,  Volume=          0.075 af,  Depth>  1.63"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.125	79	50-75% Grass cover, Fair, HSG C
0.202	84	50-75% Grass cover, Fair, HSG D
0.228	79	Woods, Fair, HSG D
0.555	81	Weighted Average
0.555		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	50	0.1300	0.14		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.9	67	0.0600	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.7	117	Total			

Summary for Subcatchment PR9: PR9

Runoff = 1.24 cfs @ 12.12 hrs, Volume= 0.105 af, Depth> 0.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.590	49	50-75% Grass cover, Fair, HSG A
0.627	79	50-75% Grass cover, Fair, HSG C
0.232	84	50-75% Grass cover, Fair, HSG D
0.036	76	Gravel roads, HSG A
0.010	89	Gravel roads, HSG C
1.495	68	Weighted Average
1.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.28"
1.7	125	0.0320	1.25		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
7.3	175	Total			

Summary for Pond P1: Bioretention Area

Inflow Area = 1.420 ac, 42.25% Impervious, Inflow Depth > 1.23" for 2-Year event
Inflow = 1.49 cfs @ 12.22 hrs, Volume= 0.145 af
Outflow = 0.14 cfs @ 14.50 hrs, Volume= 0.129 af, Atten= 91%, Lag= 137.0 min
Discarded = 0.14 cfs @ 14.50 hrs, Volume= 0.129 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 156.43' @ 14.50 hrs Surf.Area= 2,518 sf Storage= 2,897 cf

Plug-Flow detention time= 240.7 min calculated for 0.129 af (89% of inflow)
Center-of-Mass det. time= 189.7 min (1,051.0 - 861.3)

Volume	Invert	Avail.Storage	Storage Description
#1	155.00'	11,957 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
155.00	1,579	188.0	0	0	1,579
156.00	2,217	223.0	1,889	1,889	2,742
157.00	2,953	252.0	2,576	4,465	3,864
158.00	3,738	271.0	3,338	7,803	4,697
158.50	4,153	280.0	1,972	9,775	5,114
159.00	4,581	290.0	2,183	11,957	5,590

Device	Routing	Invert	Outlet Devices
#1	Primary	158.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 5.00 6.00
#2	Discarded	155.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.14 cfs @ 14.50 hrs HW=156.43' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=155.00' (Free Discharge)
↑—**1=Custom Weir/Orifice** (Controls 0.00 cfs)

Summary for Pond P2: Detention Basin

```
Inflow Area =       2.228 ac, 30.52% Impervious, Inflow Depth >  1.90"   for 2-Year event
Inflow      =      3.30 cfs @  12.09 hrs, Volume=        0.353 af
Outflow     =      0.46 cfs @  13.12 hrs, Volume=        0.275 af, Atten= 86%, Lag= 62.1 min
Primary     =      0.46 cfs @  13.12 hrs, Volume=        0.275 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 158.37' @ 13.12 hrs  Surf.Area= 4,672 sf  Storage= 8,278 cf

Plug-Flow detention time= 261.0 min calculated for 0.275 af (78% of inflow)
Center-of-Mass det. time= 177.1 min ( 984.9 - 807.8 )

Volume      Invert    Avail.Storage  Storage Description
  #1        156.00'       27,737 cf  Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation      Surf.Area    Perim.        Inc.Store       Cum.Store         Wet.Area
    (feet)         (sq-ft)    (feet)     (cubic-feet)     (cubic-feet)          (sq-ft)
    156.00          2,331     275.0               0                0            2,331
    157.00          3,258     321.0           2,782            2,782            4,533
    157.50          3,896     289.0           1,786            4,568            6,094
    158.00          4,338     299.0           2,058            6,625            6,584
    159.00          5,276     318.0           4,799           11,425            7,567
    160.00          6,256     337.0           5,759           17,184            8,610
    161.00          7,298     356.0           6,770           23,954            9,714
    161.50          7,839     365.0           3,783           27,737           10,260

Device  Routing        Invert  Outlet Devices
   #1   Primary       153.40'  12.0"  Round Culvert
                               L= 112.0'  RCP, sq.cut end projecting, Ke= 0.500
                               Inlet / Outlet Invert= 153.40' / 152.50'  S= 0.0080 '/'  Cc= 0.900
                               n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
   #2   Device 1      157.00'  4.0" Vert. Orifice/Grate  C= 0.600
   #3   Device 1      160.90'  4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns
                               X 4 rows C= 0.600 in 24.0" x 24.0" Grate
                               Limited to weir flow at low heads

Primary OutFlow Max=0.46 cfs @ 13.12 hrs  HW=158.37'  (Free Discharge)
└─1=Culvert (Passes 0.46 cfs of 6.21 cfs potential flow)
   ├─2=Orifice/Grate (Orifice Controls 0.46 cfs @ 5.28 fps)
   └─3=Orifice/Grate ( Controls 0.00 cfs)
```

Summary for Pond P3: Infiltration Basin

```
Inflow Area =        0.300 ac, 66.67% Impervious,  Inflow Depth >  2.54"    for  2-Year event
Inflow      =       0.90 cfs @  12.07 hrs,  Volume=           0.063 af
Outflow     =       0.83 cfs @  12.11 hrs,  Volume=           0.046 af,  Atten= 8%,  Lag= 2.0 min
Discarded   =       0.01 cfs @  12.11 hrs,  Volume=           0.009 af
Primary     =       0.82 cfs @  12.11 hrs,  Volume=           0.037 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 162.50' @ 12.11 hrs Surf.Area= 1,201 sf Storage= 872 cf

Plug-Flow detention time= 140.3 min calculated for 0.046 af (73% of inflow)
Center-of-Mass det. time= 52.2 min (846.4 - 794.2)

Volume	Invert	Avail.Storage	Storage Description
#1	161.50'	1,389 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
161.50	552	116.0	0	0	552
162.00	879	170.0	355	355	1,783
162.50	1,202	174.0	518	873	1,922
162.90	1,379	179.0	516	1,389	2,080

Device	Routing	Invert	Outlet Devices
#1	Primary	155.00'	**12.0" Round Culvert** L= 49.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 155.00' / 154.00' S= 0.0204 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Device 1	162.40'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 4 rows C= 0.600 in 24.0" x 24.0" Grate Limited to weir flow at low heads
#3	Discarded	161.50'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.01 cfs @ 12.11 hrs HW=162.50' (Free Discharge)
↑—**3=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.82 cfs @ 12.11 hrs HW=162.50' (Free Discharge)
↑—**1=Culvert** (Passes 0.82 cfs of 9.90 cfs potential flow)
  ↑—**2=Orifice/Grate** (Weir Controls 0.82 cfs @ 1.03 fps)

Summary for Pond P4: Infiltration Basin

```
Inflow Area =      1.260 ac,  43.65% Impervious,  Inflow Depth >   1.36"    for  2-Year event
Inflow      =      2.04 cfs @   12.08 hrs,  Volume=          0.142 af
Outflow     =      0.13 cfs @   14.41 hrs,  Volume=          0.115 af,  Atten= 94%,  Lag= 139.7 min
Discarded  =       0.13 cfs @   14.41 hrs,  Volume=          0.115 af
Primary     =      0.00 cfs @    0.00 hrs,  Volume=          0.000 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 153.25' @ 14.41 hrs Surf.Area= 2,345 sf Storage= 3,053 cf

Plug-Flow detention time= 270.1 min calculated for 0.115 af (81% of inflow)
Center-of-Mass det. time= 192.5 min (1,039.9 - 847.4)

Volume	Invert	Avail.Storage	Storage Description
#1	151.00'	6,847 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
151.00	545	185.0	0	0	545
152.00	1,210	238.0	856	856	2,342
153.00	2,120	306.0	1,644	2,500	5,298
154.00	3,095	343.0	2,592	5,092	7,236
154.50	3,945	293.0	1,756	6,847	9,772

Device	Routing	Invert	Outlet Devices
#1	Primary	154.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 5.00 6.00
#2	Discarded	151.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.13 cfs @ 14.41 hrs HW=153.25' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.13 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=151.00' (Free Discharge)
↑—**1=Custom Weir/Orifice** (Controls 0.00 cfs)

Summary for Pond P5: Infiltration Basin

Inflow Area =	4.595 ac, 58.80% Impervious, Inflow Depth > 2.10" for 2-Year event			
Inflow =	10.92 cfs @	12.08 hrs,	Volume=	0.804 af
Outflow =	1.00 cfs @	13.00 hrs,	Volume=	0.803 af, Atten= 91%, Lag= 55.5 min
Discarded =	0.70 cfs @	13.00 hrs,	Volume=	0.750 af
Primary =	0.30 cfs @	13.00 hrs,	Volume=	0.052 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 144.29' @ 13.00 hrs Surf.Area= 12,548 sf Storage= 14,390 cf

Plug-Flow detention time= 170.6 min calculated for 0.802 af (100% of inflow)
Center-of-Mass det. time= 169.1 min (961.8 - 792.7)

Volume	Invert	Avail.Storage	Storage Description
#1	143.00'	48,482 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
143.00	9,980	601.0	0	0	9,980
144.00	11,812	620.0	10,883	10,883	11,924
145.00	14,463	744.0	13,115	23,998	25,401
146.00	16,751	782.0	15,593	39,591	30,078
146.50	18,831	695.0	8,890	48,482	40,311

Device	Routing	Invert	Outlet Devices
#1	Primary	144.00'	**12.0" Round Culvert** L= 50.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 144.00' / 143.50' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Primary	146.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 6.00 7.00
#3	Discarded	143.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.70 cfs @ 13.00 hrs HW=144.29' (Free Discharge)
└─**3=Exfiltration** (Exfiltration Controls 0.70 cfs)

Primary OutFlow Max=0.30 cfs @ 13.00 hrs HW=144.29' (Free Discharge)
├─**1=Culvert** (Inlet Controls 0.30 cfs @ 1.61 fps)
└─**2=Custom Weir/Orifice** (Controls 0.00 cfs)

Summary for Link DP1: Wetland ST-10

```
Inflow Area =         2.761 ac, 21.73% Impervious, Inflow Depth >  0.46"   for 2-Year event
Inflow      =        1.03 cfs @  12.22 hrs, Volume=          0.105 af
Primary     =        1.03 cfs @  12.22 hrs, Volume=          0.105 af, Atten= 0%, Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =         8.083 ac,  48.65% Impervious,  Inflow Depth >   0.49"    for  2-Year event
Inflow       =        0.76 cfs @   13.02 hrs,  Volume=           0.328 af
Primary     =        0.76 cfs @   13.02 hrs,  Volume=           0.328 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA 1

```
Inflow Area =          0.555 ac,    0.00% Impervious,  Inflow Depth >   1.63"    for  2-Year event
Inflow       =          1.03 cfs @   12.10 hrs,  Volume=             0.075 af
Primary     =          1.03 cfs @   12.10 hrs,  Volume=             0.075 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

10-Year Storm Event- Proposed

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentPR1: PR1 Runoff Area=1.341 ac 0.00% Impervious Runoff Depth>1.85"
Flow Length=410' Tc=14.6 min CN=70 Runoff=2.16 cfs 0.206 af

SubcatchmentPR2: PR2 Runoff Area=1.420 ac 42.25% Impervious Runoff Depth>2.24"
Flow Length=455' Tc=15.0 min CN=75 Runoff=2.81 cfs 0.265 af

SubcatchmentPR3A: PR3A Runoff Area=1.500 ac 0.00% Impervious Runoff Depth>2.49"
Flow Length=757' Tc=16.8 min CN=78 Runoff=3.18 cfs 0.312 af

SubcatchmentPR3B: PR3B Runoff Area=0.600 ac 100.00% Impervious Runoff Depth>4.51"
Tc=5.0 min CN=98 Runoff=2.89 cfs 0.226 af

SubcatchmentPR4: PR4 Runoff Area=0.128 ac 62.50% Impervious Runoff Depth>2.85"
Tc=5.0 min CN=82 Runoff=0.44 cfs 0.030 af

SubcatchmentPR5: PR5 Runoff Area=0.300 ac 66.67% Impervious Runoff Depth>3.84"
Tc=5.0 min CN=92 Runoff=1.33 cfs 0.096 af

SubcatchmentPR6: PR6 Runoff Area=1.260 ac 43.65% Impervious Runoff Depth>2.41"
Tc=5.0 min CN=77 Runoff=3.70 cfs 0.253 af

SubcatchmentPR7: PR7 Runoff Area=2.800 ac 89.36% Impervious Runoff Depth>4.17"
Flow Length=1,318' Tc=5.0 min CN=95 Runoff=13.07 cfs 0.973 af

SubcatchmentPR8: PR8 Runoff Area=0.555 ac 0.00% Impervious Runoff Depth>2.76"
Flow Length=117' Tc=6.7 min CN=81 Runoff=1.76 cfs 0.128 af

SubcatchmentPR9: PR9 Runoff Area=1.495 ac 0.00% Impervious Runoff Depth>1.70"
Flow Length=175' Tc=7.3 min CN=68 Runoff=2.75 cfs 0.212 af

Pond P1: Bioretention Area Peak Elev=157.56' Storage=6,224 cf Inflow=2.81 cfs 0.265 af
Discarded=0.19 cfs 0.185 af Primary=0.00 cfs 0.000 af Outflow=0.19 cfs 0.185 af

Pond P2: Detention Basin Peak Elev=159.41' Storage=13,693 cf Inflow=5.23 cfs 0.567 af
Outflow=0.63 cfs 0.472 af

Pond P3: Infiltration Basin Peak Elev=162.53' Storage=913 cf Inflow=1.33 cfs 0.096 af
Discarded=0.01 cfs 0.010 af Primary=1.27 cfs 0.069 af Outflow=1.28 cfs 0.079 af

Pond P4: Infiltration Basin Peak Elev=154.06' Storage=5,288 cf Inflow=3.70 cfs 0.253 af
Discarded=0.18 cfs 0.165 af Primary=0.27 cfs 0.025 af Outflow=0.44 cfs 0.190 af

Pond P5: Infiltration Basin Peak Elev=144.84' Storage=21,778 cf Inflow=16.79 cfs 1.254 af
Discarded=0.78 cfs 0.859 af Primary=1.95 cfs 0.330 af Outflow=2.73 cfs 1.190 af

Link DP1: Wetland ST-10 Inflow=2.16 cfs 0.206 af
Primary=2.16 cfs 0.206 af

Link DP3: Wetland EA1 (culvert)	Inflow=2.77 cfs 0.827 af Primary=2.77 cfs 0.827 af
Link DP4: Wetland EA 1	Inflow=1.76 cfs 0.128 af Primary=1.76 cfs 0.128 af

Total Runoff Area = 11.399 ac Runoff Volume = 2.701 af Average Runoff Depth = 2.84"
60.24% Pervious = 6.867 ac 39.76% Impervious = 4.532 ac

Summary for Subcatchment PR1: PR1

```
Runoff      =       2.16 cfs @   12.21 hrs,  Volume=          0.206 af,  Depth>  1.85"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.278	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.586	79	Woods, Fair, HSG D
0.157	89	Dirt roads, HSG D
1.341	70	Weighted Average
1.341		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	50	0.1600	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
3.7	190	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.3	34	0.1700	2.06		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.4	136	0.1100	1.66		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.6	410	Total			

Summary for Subcatchment PR2: PR2

```
Runoff      =         2.81 cfs @   12.21 hrs,  Volume=           0.265 af,  Depth>  2.24"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.080	36	Woods, Fair, HSG A
0.200	73	Woods, Fair, HSG C
0.100	79	Woods, Fair, HSG D
0.600	98	Paved parking, HSG A
0.400	49	50-75% Grass cover, Fair, HSG A
0.040	84	50-75% Grass cover, Fair, HSG D
1.420	75	Weighted Average
0.820		57.75% Pervious Area
0.600		42.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	50	0.0800	0.07		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
0.5	79	0.2400	2.45		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	20	0.1500	2.71		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.4	205	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	101	0.0190	2.07		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
15.0	455	Total			

Summary for Subcatchment PR3A: PR3A

Runoff = 3.18 cfs @ 12.23 hrs, Volume= 0.312 af, Depth> 2.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.300	73	Woods, Fair, HSG C
1.200	79	50-75% Grass cover, Fair, HSG C
1.500	78	Weighted Average
1.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0650	0.06		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
1.4	104	0.0650	1.27		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	12	0.3300	2.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.7	138	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	181	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.4	131	0.0100	6.22	7.63	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	66	0.0091	5.93	7.28	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	75	0.0092	5.97	7.32	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
16.8	757	Total			

Summary for Subcatchment PR3B: PR3B

```
Runoff      =        2.89 cfs @   12.07 hrs,  Volume=          0.226 af,  Depth>  4.51"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.600	98	Paved parking, HSG C
0.600		100.00% Impervious Area

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

Summary for Subcatchment PR4: PR4

Runoff = 0.44 cfs @ 12.07 hrs, Volume= 0.030 af, Depth> 2.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.011	79	50-75% Grass cover, Fair, HSG C
0.037	49	50-75% Grass cover, Fair, HSG A
0.080	98	Paved parking, HSG C
0.128	82	Weighted Average
0.048		37.50% Pervious Area
0.080		62.50% Impervious Area

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

Summary for Subcatchment PR5: PR5

```
Runoff      =        1.33 cfs @   12.07 hrs,  Volume=          0.096 af,  Depth>  3.84"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.100	79	50-75% Grass cover, Fair, HSG C
0.200	98	Paved parking, HSG C
0.300	92	Weighted Average
0.100		33.33% Pervious Area
0.200		66.67% Impervious Area

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

Summary for Subcatchment PR6: PR6

Runoff = 3.70 cfs @ 12.08 hrs, Volume= 0.253 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.450	49	50-75% Grass cover, Fair, HSG A
0.200	79	50-75% Grass cover, Fair, HSG C
0.060	84	50-75% Grass cover, Fair, HSG D
0.300	98	Paved parking, HSG A
0.150	98	Paved parking, HSG C
0.100	98	Paved parking, HSG D
1.260	77	Weighted Average
0.710		56.35% Pervious Area
0.550		43.65% Impervious Area

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

Summary for Subcatchment PR7: PR7

Runoff = 13.07 cfs @ 12.07 hrs, Volume= 0.973 af, Depth> 4.17"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.102	73	Woods, Fair, HSG C
0.009	36	Woods, Fair, HSG A
0.034	49	50-75% Grass cover, Fair, HSG A
0.153	79	50-75% Grass cover, Fair, HSG C
1.448	98	Paved parking, HSG A
1.054	98	Paved parking, HSG C
2.800	95	Weighted Average
0.298		10.64% Pervious Area
2.502		89.36% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0350	1.52		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
0.4	53	0.2000	2.24		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	21	0.2200	3.28		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	209	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	180	0.0139	5.35	4.20	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, straight & clean
0.2	177	0.0650	16.80	40.40	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.7	295	0.0102	6.65	16.00	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.2	90	0.0100	6.59	15.85	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.4	177	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.8					**Direct Entry,**
0.1	66	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
5.0	1,318	Total			

Summary for Subcatchment PR8: PR8

Runoff = 1.76 cfs @ 12.10 hrs, Volume= 0.128 af, Depth> 2.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.125	79	50-75% Grass cover, Fair, HSG C
0.202	84	50-75% Grass cover, Fair, HSG D
0.228	79	Woods, Fair, HSG D
0.555	81	Weighted Average
0.555		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	50	0.1300	0.14		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.28"
0.9	67	0.0600	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.7	117	Total			

Summary for Subcatchment PR9: PR9

Runoff = 2.75 cfs @ 12.11 hrs, Volume= 0.212 af, Depth> 1.70"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.75"

Area (ac)	CN	Description
0.590	49	50-75% Grass cover, Fair, HSG A
0.627	79	50-75% Grass cover, Fair, HSG C
0.232	84	50-75% Grass cover, Fair, HSG D
0.036	76	Gravel roads, HSG A
0.010	89	Gravel roads, HSG C
1.495	68	Weighted Average
1.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.28"
1.7	125	0.0320	1.25		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
7.3	175	Total			

Summary for Pond P1: Bioretention Area

```
Inflow Area =      1.420 ac, 42.25% Impervious, Inflow Depth >  2.24"   for 10-Year event
Inflow      =      2.81 cfs @  12.21 hrs, Volume=        0.265 af
Outflow     =      0.19 cfs @  15.30 hrs, Volume=        0.185 af, Atten= 93%, Lag= 185.3 min
Discarded   =      0.19 cfs @  15.30 hrs, Volume=        0.185 af
Primary     =      0.00 cfs @   0.00 hrs, Volume=        0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 157.56' @ 15.30 hrs   Surf.Area= 3,378 sf   Storage= 6,224 cf

Plug-Flow detention time= 299.2 min calculated for 0.184 af (70% of inflow)
Center-of-Mass det. time= 201.5 min ( 1,045.2 - 843.7 )

Volume      Invert    Avail.Storage  Storage Description
  #1        155.00'       11,957 cf  Custom Stage Data (Irregular)Listed below (Recalc)

Elevation      Surf.Area    Perim.       Inc.Store       Cum.Store        Wet.Area
   (feet)        (sq-ft)    (feet)    (cubic-feet)    (cubic-feet)          (sq-ft)
   155.00          1,579     188.0               0               0            1,579
   156.00          2,217     223.0           1,889           1,889            2,742
   157.00          2,953     252.0           2,576           4,465            3,864
   158.00          3,738     271.0           3,338           7,803            4,697
   158.50          4,153     280.0           1,972           9,775            5,114
   159.00          4,581     290.0           2,183          11,957            5,590

Device   Routing        Invert   Outlet Devices
  #1     Primary       158.00'   Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
                                 Head (feet)  0.00  0.50
                                 Width (feet)  5.00  6.00
  #2     Discarded     155.00'   2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.19 cfs @ 15.30 hrs  HW=157.56'   (Free Discharge)
└─2=Exfiltration  (Exfiltration Controls 0.19 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs  HW=155.00'   (Free Discharge)
└─1=Custom Weir/Orifice ( Controls 0.00 cfs)
```

Summary for Pond P2: Detention Basin

Inflow Area = 2.228 ac, 30.52% Impervious, Inflow Depth > 3.06" for 10-Year event
Inflow = 5.23 cfs @ 12.09 hrs, Volume= 0.567 af
Outflow = 0.63 cfs @ 13.32 hrs, Volume= 0.472 af, Atten= 88%, Lag= 73.8 min
Primary = 0.63 cfs @ 13.32 hrs, Volume= 0.472 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 159.41' @ 13.32 hrs Surf.Area= 5,672 sf Storage= 13,693 cf

Plug-Flow detention time= 288.5 min calculated for 0.472 af (83% of inflow)
Center-of-Mass det. time= 218.3 min (1,018.9 - 800.5)

Volume	Invert	Avail.Storage	Storage Description
#1	156.00'	27,737 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
156.00	2,331	275.0	0	0	2,331
157.00	3,258	321.0	2,782	2,782	4,533
157.50	3,896	289.0	1,786	4,568	6,094
158.00	4,338	299.0	2,058	6,625	6,584
159.00	5,276	318.0	4,799	11,425	7,567
160.00	6,256	337.0	5,759	17,184	8,610
161.00	7,298	356.0	6,770	23,954	9,714
161.50	7,839	365.0	3,783	27,737	10,260

Device	Routing	Invert	Outlet Devices
#1	Primary	153.40'	**12.0" Round Culvert** L= 112.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 153.40' / 152.50' S= 0.0080 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	157.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	160.90'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 4 rows C= 0.600 in 24.0" x 24.0" Grate Limited to weir flow at low heads

Primary OutFlow Max=0.63 cfs @ 13.32 hrs HW=159.41' (Free Discharge)
↑—**1=Culvert** (Passes 0.63 cfs of 6.84 cfs potential flow)
  ↑—**2=Orifice/Grate** (Orifice Controls 0.63 cfs @ 7.22 fps)
  └—**3=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond P3: Infiltration Basin

Inflow Area = 0.300 ac, 66.67% Impervious, Inflow Depth > 3.84" for 10-Year event
Inflow = 1.33 cfs @ 12.07 hrs, Volume= 0.096 af
Outflow = 1.28 cfs @ 12.09 hrs, Volume= 0.079 af, Atten= 4%, Lag= 1.4 min
Discarded = 0.01 cfs @ 12.09 hrs, Volume= 0.010 af
Primary = 1.27 cfs @ 12.09 hrs, Volume= 0.069 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 162.53' @ 12.09 hrs Surf.Area= 1,216 sf Storage= 913 cf

Plug-Flow detention time= 112.1 min calculated for 0.079 af (82% of inflow)
Center-of-Mass det. time= 41.3 min (824.3 - 782.9)

Volume	Invert	Avail.Storage	Storage Description
#1	161.50'	1,389 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
161.50	552	116.0	0	0	552
162.00	879	170.0	355	355	1,783
162.50	1,202	174.0	518	873	1,922
162.90	1,379	179.0	516	1,389	2,080

Device	Routing	Invert	Outlet Devices
#1	Primary	155.00'	**12.0" Round Culvert** L= 49.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 155.00' / 154.00' S= 0.0204 '/' Cc= 0.900 n= 0.013 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Device 1	162.40'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 4 rows C= 0.600 in 24.0" x 24.0" Grate Limited to weir flow at low heads
#3	Discarded	161.50'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=162.53' (Free Discharge)
└─**3=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=1.27 cfs @ 12.09 hrs HW=162.53' (Free Discharge)
└─**1=Culvert** (Passes 1.27 cfs of 9.92 cfs potential flow)
  └─**2=Orifice/Grate** (Weir Controls 1.27 cfs @ 1.19 fps)

Summary for Pond P4: Infiltration Basin

Inflow Area = 1.260 ac, 43.65% Impervious, Inflow Depth > 2.41" for 10-Year event
Inflow = 3.70 cfs @ 12.08 hrs, Volume= 0.253 af
Outflow = 0.44 cfs @ 12.79 hrs, Volume= 0.190 af, Atten= 88%, Lag= 42.7 min
Discarded = 0.18 cfs @ 12.79 hrs, Volume= 0.165 af
Primary = 0.27 cfs @ 12.79 hrs, Volume= 0.025 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 154.06' @ 12.79 hrs Surf.Area= 3,195 sf Storage= 5,288 cf

Plug-Flow detention time= 265.0 min calculated for 0.190 af (75% of inflow)
Center-of-Mass det. time= 176.5 min (1,007.1 - 830.6)

Volume	Invert	Avail.Storage	Storage Description
#1	151.00'	6,847 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
151.00	545	185.0	0	0	545
152.00	1,210	238.0	856	856	2,342
153.00	2,120	306.0	1,644	2,500	5,298
154.00	3,095	343.0	2,592	5,092	7,236
154.50	3,945	293.0	1,756	6,847	9,772

Device	Routing	Invert	Outlet Devices
#1	Primary	154.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 5.00 6.00
#2	Discarded	151.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.18 cfs @ 12.79 hrs HW=154.06' (Free Discharge)
⮤**2=Exfiltration** (Exfiltration Controls 0.18 cfs)

Primary OutFlow Max=0.26 cfs @ 12.79 hrs HW=154.06' (Free Discharge)
⮤**1=Custom Weir/Orifice** (Weir Controls 0.26 cfs @ 0.82 fps)

Summary for Pond P5: Infiltration Basin

```
Inflow Area =        4.595 ac, 58.80% Impervious, Inflow Depth >  3.27"   for 10-Year event
Inflow      =      16.79 cfs @  12.08 hrs, Volume=          1.254 af
Outflow     =       2.73 cfs @  12.56 hrs, Volume=          1.190 af, Atten= 84%, Lag= 28.9 min
Discarded   =       0.78 cfs @  12.56 hrs, Volume=          0.859 af
Primary     =       1.95 cfs @  12.56 hrs, Volume=          0.330 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 144.84' @ 12.56 hrs   Surf.Area= 14,032 sf   Storage= 21,778 cf

Plug-Flow detention time= 157.6 min calculated for 1.189 af (95% of inflow)
Center-of-Mass det. time= 129.0 min ( 914.3 - 785.3 )

Volume     Invert    Avail.Storage   Storage Description
   #1      143.00'       48,482 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation       Surf.Area    Perim.       Inc.Store       Cum.Store        Wet.Area
    (feet)         (sq-ft)    (feet)    (cubic-feet)    (cubic-feet)         (sq-ft)
    143.00           9,980     601.0               0               0           9,980
    144.00          11,812     620.0          10,883          10,883          11,924
    145.00          14,463     744.0          13,115          23,998          25,401
    146.00          16,751     782.0          15,593          39,591          30,078
    146.50          18,831     695.0           8,890          48,482          40,311

Device   Routing          Invert   Outlet Devices
   #1    Primary         144.00'   12.0"  Round Culvert
                                   L= 50.0'   RCP, mitered to conform to fill,  Ke= 0.700
                                   Inlet / Outlet Invert= 144.00' / 143.50'   S= 0.0100 '/'   Cc= 0.900
                                   n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
   #2    Primary         146.00'   Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
                                   Head (feet)  0.00  0.50
                                   Width (feet)  6.00  7.00
   #3    Discarded       143.00'   2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.78 cfs @ 12.56 hrs  HW=144.84'   (Free Discharge)
↑—3=Exfiltration  (Exfiltration Controls 0.78 cfs)

Primary OutFlow Max=1.95 cfs @ 12.56 hrs  HW=144.84'   (Free Discharge)
↑—1=Culvert  (Inlet Controls 1.95 cfs @ 2.76 fps)
└—2=Custom Weir/Orifice ( Controls 0.00 cfs)
```

Summary for Link DP1: Wetland ST-10

```
Inflow Area =         2.761 ac,  21.73% Impervious,  Inflow Depth >   0.90"    for  10-Year event
Inflow       =        2.16 cfs @   12.21 hrs,  Volume=            0.206 af
Primary      =        2.16 cfs @   12.21 hrs,  Volume=            0.206 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
```

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =         8.083 ac,  48.65% Impervious,  Inflow Depth >   1.23"    for  10-Year event
Inflow      =         2.77 cfs @   12.68 hrs,  Volume=           0.827 af
Primary     =         2.77 cfs @   12.68 hrs,  Volume=           0.827 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA 1

```
Inflow Area =       0.555 ac,    0.00% Impervious,  Inflow Depth >   2.76"    for  10-Year event
Inflow      =        1.76 cfs @   12.10 hrs,  Volume=            0.128 af
Primary     =        1.76 cfs @   12.10 hrs,  Volume=            0.128 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

100-Year Storm Event – Proposed

```
                 Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
                         Runoff by SCS TR-20 method, UH=SCS
         Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentPR1: PR1                  Runoff Area=1.341 ac   0.00% Impervious   Runoff Depth>3.61"
                                  Flow Length=410'   Tc=14.6 min   CN=70   Runoff=4.34 cfs  0.403 af

SubcatchmentPR2: PR2                 Runoff Area=1.420 ac   42.25% Impervious   Runoff Depth>4.14"
                                  Flow Length=455'   Tc=15.0 min   CN=75   Runoff=5.22 cfs  0.490 af

SubcatchmentPR3A: PR3A                Runoff Area=1.500 ac   0.00% Impervious   Runoff Depth>4.46"
                                  Flow Length=757'   Tc=16.8 min   CN=78   Runoff=5.69 cfs  0.558 af

SubcatchmentPR3B: PR3B              Runoff Area=0.600 ac   100.00% Impervious   Runoff Depth>6.76"
                                                Tc=5.0 min   CN=98   Runoff=4.27 cfs  0.338 af

SubcatchmentPR4: PR4                 Runoff Area=0.128 ac   62.50% Impervious   Runoff Depth>4.91"
                                                Tc=5.0 min   CN=82   Runoff=0.75 cfs  0.052 af

SubcatchmentPR5: PR5                 Runoff Area=0.300 ac   66.67% Impervious   Runoff Depth>6.05"
                                                Tc=5.0 min   CN=92   Runoff=2.05 cfs  0.151 af

SubcatchmentPR6: PR6                 Runoff Area=1.260 ac   43.65% Impervious   Runoff Depth>4.36"
                                                Tc=5.0 min   CN=77   Runoff=6.66 cfs  0.458 af

SubcatchmentPR7: PR7                 Runoff Area=2.800 ac   89.36% Impervious   Runoff Depth>6.40"
                                Flow Length=1,318'   Tc=5.0 min   CN=95   Runoff=19.62 cfs  1.494 af

SubcatchmentPR8: PR8                  Runoff Area=0.555 ac   0.00% Impervious   Runoff Depth>4.80"
                                   Flow Length=117'   Tc=6.7 min   CN=81   Runoff=3.01 cfs  0.222 af

SubcatchmentPR9: PR9                  Runoff Area=1.495 ac   0.00% Impervious   Runoff Depth>3.40"
                                   Flow Length=175'   Tc=7.3 min   CN=68   Runoff=5.69 cfs  0.424 af

Pond P1: BioretentionArea             Peak Elev=158.24'  Storage=8,736 cf   Inflow=5.22 cfs  0.490 af
                    Discarded=0.22 cfs  0.225 af  Primary=2.04 cfs  0.132 af  Outflow=2.26 cfs  0.357 af

Pond P2: DetentionBasin              Peak Elev=160.93'  Storage=23,425 cf   Inflow=8.60 cfs  0.948 af
                                                                            Outflow=0.97 cfs  0.742 af

Pond P3: InfiltrationBasin              Peak Elev=162.58'  Storage=968 cf   Inflow=2.05 cfs  0.151 af
                    Discarded=0.01 cfs  0.011 af  Primary=1.97 cfs  0.123 af  Outflow=1.98 cfs  0.134 af

Pond P4: InfiltrationBasin            Peak Elev=154.37'  Storage=6,367 cf   Inflow=6.66 cfs  0.458 af
                    Discarded=0.21 cfs  0.186 af  Primary=3.99 cfs  0.188 af  Outflow=4.19 cfs  0.374 af

Pond P5: InfiltrationBasin          Peak Elev=145.82'  Storage=36,694 cf   Inflow=26.82 cfs  2.041 af
                    Discarded=0.91 cfs  0.982 af  Primary=3.84 cfs  0.907 af  Outflow=4.75 cfs  1.889 af

Link DP1: WetlandST-10                                                       Inflow=4.34 cfs  0.535 af
                                                                            Primary=4.34 cfs  0.535 af
```

Link DP3: Wetland EA1 (culvert)	Inflow=7.78 cfs 1.837 af Primary=7.78 cfs 1.837 af
Link DP4: Wetland EA 1	Inflow=3.01 cfs 0.222 af Primary=3.01 cfs 0.222 af

Total Runoff Area = 11.399 ac Runoff Volume = 4.590 af Average Runoff Depth = 4.83"
60.24% Pervious = 6.867 ac 39.76% Impervious = 4.532 ac

Summary for Subcatchment PR1: PR1

Runoff = 4.34 cfs @ 12.20 hrs, Volume= 0.403 af, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.278	36	Woods, Fair, HSG A
0.320	73	Woods, Fair, HSG C
0.586	79	Woods, Fair, HSG D
0.157	89	Dirt roads, HSG D
1.341	70	Weighted Average
1.341		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	50	0.1600	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
3.7	190	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.3	34	0.1700	2.06		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.4	136	0.1100	1.66		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.6	410	Total			

Summary for Subcatchment PR2: PR2

Runoff = 5.22 cfs @ 12.21 hrs, Volume= 0.490 af, Depth> 4.14"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.080	36	Woods, Fair, HSG A
0.200	73	Woods, Fair, HSG C
0.100	79	Woods, Fair, HSG D
0.600	98	Paved parking, HSG A
0.400	49	50-75% Grass cover, Fair, HSG A
0.040	84	50-75% Grass cover, Fair, HSG D
1.420	75	Weighted Average
0.820		57.75% Pervious Area
0.600		42.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	50	0.0800	0.07		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
0.5	79	0.2400	2.45		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	20	0.1500	2.71		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.4	205	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	101	0.0190	2.07		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
15.0	455	Total			

Summary for Subcatchment PR3A: PR3A

Runoff = 5.69 cfs @ 12.23 hrs, Volume= 0.558 af, Depth> 4.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.300	73	Woods, Fair, HSG C
1.200	79	50-75% Grass cover, Fair, HSG C
1.500	78	Weighted Average
1.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.2	50	0.0650	0.06		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.28"
1.4	104	0.0650	1.27		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	12	0.3300	2.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.7	138	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	181	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.4	131	0.0100	6.22	7.63	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	66	0.0091	5.93	7.28	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
0.2	75	0.0092	5.97	7.32	**Pipe Channel, RCP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.011 Concrete pipe, straight & clean
16.8	757	Total			

Summary for Subcatchment PR3B: PR3B

```
Runoff      =        4.27 cfs @   12.07 hrs,  Volume=          0.338 af,  Depth>  6.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr  100-Year Rainfall=7.00"

   Area (ac)   CN   Description
      0.600    98   Paved parking, HSG C
      0.600         100.00% Impervious Area

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

Summary for Subcatchment PR4: PR4

```
Runoff      =         0.75 cfs @   12.07 hrs,  Volume=           0.052 af,  Depth>  4.91"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.011	79	50-75% Grass cover, Fair, HSG C
0.037	49	50-75% Grass cover, Fair, HSG A
0.080	98	Paved parking, HSG C
0.128	82	Weighted Average
0.048		37.50% Pervious Area
0.080		62.50% Impervious Area

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

Summary for Subcatchment PR5: PR5

Runoff = 2.05 cfs @ 12.07 hrs, Volume= 0.151 af, Depth> 6.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.100	79	50-75% Grass cover, Fair, HSG C
0.200	98	Paved parking, HSG C
0.300	92	Weighted Average
0.100		33.33% Pervious Area
0.200		66.67% Impervious Area

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

Summary for Subcatchment PR6: PR6

```
Runoff      =        6.66 cfs @   12.07 hrs,  Volume=           0.458 af,  Depth>  4.36"
```

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.450	49	50-75% Grass cover, Fair, HSG A
0.200	79	50-75% Grass cover, Fair, HSG C
0.060	84	50-75% Grass cover, Fair, HSG D
0.300	98	Paved parking, HSG A
0.150	98	Paved parking, HSG C
0.100	98	Paved parking, HSG D
1.260	77	Weighted Average
0.710		56.35% Pervious Area
0.550		43.65% Impervious Area

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

Summary for Subcatchment PR7: PR7

Runoff = 19.62 cfs @ 12.07 hrs, Volume= 1.494 af, Depth> 6.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.102	73	Woods, Fair, HSG C
0.009	36	Woods, Fair, HSG A
0.034	49	50-75% Grass cover, Fair, HSG A
0.153	79	50-75% Grass cover, Fair, HSG C
1.448	98	Paved parking, HSG A
1.054	98	Paved parking, HSG C
2.800	95	Weighted Average
0.298		10.64% Pervious Area
2.502		89.36% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0350	1.52		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.28"
0.4	53	0.2000	2.24		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	21	0.2200	3.28		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	209	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	180	0.0139	5.35	4.20	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, straight & clean
0.2	177	0.0650	16.80	40.40	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.7	295	0.0102	6.65	16.00	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.2	90	0.0100	6.59	15.85	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.4	177	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
0.8					**Direct Entry,**
0.1	66	0.0136	7.68	18.48	**Pipe Channel,** 21.0" Round Area= 2.4 sf Perim= 5.5' r= 0.44' n= 0.013 Concrete pipe, straight & clean
5.0	1,318	Total			

```
                         Summary for Subcatchment PR8: PR8

Runoff      =        3.01 cfs @   12.10 hrs,  Volume=          0.222 af,  Depth>  4.80"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr  100-Year Rainfall=7.00"

  Area (ac)   CN   Description
------------------------------------------------------------------------
      0.125   79   50-75% Grass cover, Fair, HSG C
      0.202   84   50-75% Grass cover, Fair, HSG D
      0.228   79   Woods, Fair, HSG D
------------------------------------------------------------------------
      0.555   81   Weighted Average
      0.555        100.00% Pervious Area

   Tc  Length   Slope  Velocity  Capacity  Description
 (min)  (feet)  (ft/ft)  (ft/sec)     (cfs)
------------------------------------------------------------------------
   5.8      50  0.1300      0.14            Sheet Flow,
                                            Woods: Light underbrush   n= 0.400   P2= 3.28"
   0.9      67  0.0600      1.22            Shallow Concentrated Flow,
                                            Woodland   Kv= 5.0 fps
------------------------------------------------------------------------
   6.7     117  Total
```

Summary for Subcatchment PR9: PR9

Runoff = 5.69 cfs @ 12.11 hrs, Volume= 0.424 af, Depth> 3.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.590	49	50-75% Grass cover, Fair, HSG A
0.627	79	50-75% Grass cover, Fair, HSG C
0.232	84	50-75% Grass cover, Fair, HSG D
0.036	76	Gravel roads, HSG A
0.010	89	Gravel roads, HSG C
1.495	68	Weighted Average
1.495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.28"
1.7	125	0.0320	1.25		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
7.3	175	Total			

Summary for Pond P1: Bioretention Area

Inflow Area = 1.420 ac, 42.25% Impervious, Inflow Depth > 4.14" for 100-Year event
Inflow = 5.22 cfs @ 12.21 hrs, Volume= 0.490 af
Outflow = 2.26 cfs @ 12.55 hrs, Volume= 0.357 af, Atten= 57%, Lag= 20.7 min
Discarded = 0.22 cfs @ 12.55 hrs, Volume= 0.225 af
Primary = 2.04 cfs @ 12.55 hrs, Volume= 0.132 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 158.24' @ 12.55 hrs Surf.Area= 3,937 sf Storage= 8,736 cf

Plug-Flow detention time= 204.7 min calculated for 0.357 af (73% of inflow)
Center-of-Mass det. time= 115.3 min (941.5 - 826.2)

Volume	Invert	Avail.Storage	Storage Description
#1	155.00'	11,957 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
155.00	1,579	188.0	0	0	1,579
156.00	2,217	223.0	1,889	1,889	2,742
157.00	2,953	252.0	2,576	4,465	3,864
158.00	3,738	271.0	3,338	7,803	4,697
158.50	4,153	280.0	1,972	9,775	5,114
159.00	4,581	290.0	2,183	11,957	5,590

Device	Routing	Invert	Outlet Devices
#1	Primary	158.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 5.00 6.00
#2	Discarded	155.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.22 cfs @ 12.55 hrs HW=158.24' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.22 cfs)

Primary OutFlow Max=2.04 cfs @ 12.55 hrs HW=158.24' (Free Discharge)
↑—**1=Custom Weir/Orifice** (Weir Controls 2.04 cfs @ 1.60 fps)

Summary for Pond P2: Detention Basin

Inflow Area = 2.228 ac, 30.52% Impervious, Inflow Depth > 5.10" for 100-Year event
Inflow = 8.60 cfs @ 12.10 hrs, Volume= 0.948 af
Outflow = 0.97 cfs @ 13.40 hrs, Volume= 0.742 af, Atten= 89%, Lag= 77.9 min
Primary = 0.97 cfs @ 13.40 hrs, Volume= 0.742 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 160.93' @ 13.40 hrs Surf.Area= 7,219 sf Storage= 23,425 cf

Plug-Flow detention time= 319.5 min calculated for 0.741 af (78% of inflow)
Center-of-Mass det. time= 239.2 min (1,030.7 - 791.5)

Volume	Invert	Avail.Storage	Storage Description
#1	156.00'	27,737 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
156.00	2,331	275.0	0	0	2,331
157.00	3,258	321.0	2,782	2,782	4,533
157.50	3,896	289.0	1,786	4,568	6,094
158.00	4,338	299.0	2,058	6,625	6,584
159.00	5,276	318.0	4,799	11,425	7,567
160.00	6,256	337.0	5,759	17,184	8,610
161.00	7,298	356.0	6,770	23,954	9,714
161.50	7,839	365.0	3,783	27,737	10,260

Device	Routing	Invert	Outlet Devices
#1	Primary	153.40'	**12.0" Round Culvert** L= 112.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 153.40' / 152.50' S= 0.0080 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	157.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	160.90'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 4 rows C= 0.600 in 24.0" x 24.0" Grate Limited to weir flow at low heads

Primary OutFlow Max=0.93 cfs @ 13.40 hrs HW=160.93' (Free Discharge)
↑—**1=Culvert** (Passes 0.93 cfs of 7.67 cfs potential flow)
  ↑—**2=Orifice/Grate** (Orifice Controls 0.81 cfs @ 9.34 fps)
  └—**3=Orifice/Grate** (Weir Controls 0.12 cfs @ 0.54 fps)

Summary for Pond P3: Infiltration Basin

```
Inflow Area =       0.300 ac, 66.67% Impervious, Inflow Depth >  6.05"   for  100-Year event
Inflow      =      2.05 cfs @  12.07 hrs,  Volume=          0.151 af
Outflow     =      1.98 cfs @  12.09 hrs,  Volume=          0.134 af,  Atten= 3%,  Lag= 1.2 min
Discarded   =      0.01 cfs @  12.09 hrs,  Volume=          0.011 af
Primary     =      1.97 cfs @  12.09 hrs,  Volume=          0.123 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 162.58' @ 12.09 hrs   Surf.Area= 1,236 sf   Storage= 968 cf

Plug-Flow detention time= 88.9 min calculated for 0.134 af (88% of inflow)
Center-of-Mass det. time= 35.2 min ( 806.6 - 771.3 )

Volume       Invert     Avail.Storage   Storage Description
   #1       161.50'          1,389 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation       Surf.Area    Perim.        Inc.Store       Cum.Store       Wet.Area
    (feet)         (sq-ft)    (feet)     (cubic-feet)    (cubic-feet)        (sq-ft)
    161.50             552     116.0                0               0            552
    162.00             879     170.0              355             355          1,783
    162.50           1,202     174.0              518             873          1,922
    162.90           1,379     179.0              516           1,389          2,080

Device   Routing            Invert   Outlet Devices
   #1    Primary           155.00'   12.0"  Round Culvert
                                     L= 49.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                     Inlet / Outlet Invert= 155.00' / 154.00'   S= 0.0204 '/'   Cc= 0.900
                                     n= 0.013  Concrete pipe, straight & clean,  Flow Area= 0.79 sf
   #2    Device 1          162.40'   4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns
                                     X 4 rows C= 0.600 in 24.0" x 24.0" Grate
                                     Limited to weir flow at low heads
   #3    Discarded         161.50'   0.270 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs  HW=162.58'   (Free Discharge)
└─3=Exfiltration  (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=1.97 cfs @ 12.09 hrs  HW=162.58'   (Free Discharge)
└─1=Culvert  (Passes 1.97 cfs of 9.95 cfs potential flow)
   └─2=Orifice/Grate  (Weir Controls 1.97 cfs @ 1.38 fps)
```

Summary for Pond P4: Infiltration Basin

Inflow Area = 1.260 ac, 43.65% Impervious, Inflow Depth > 4.36" for 100-Year event
Inflow = 6.66 cfs @ 12.07 hrs, Volume= 0.458 af
Outflow = 4.19 cfs @ 12.16 hrs, Volume= 0.374 af, Atten= 37%, Lag= 5.4 min
Discarded = 0.21 cfs @ 12.16 hrs, Volume= 0.186 af
Primary = 3.99 cfs @ 12.16 hrs, Volume= 0.188 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 154.37' @ 12.16 hrs Surf.Area= 3,722 sf Storage= 6,367 cf

Plug-Flow detention time= 154.9 min calculated for 0.374 af (82% of inflow)
Center-of-Mass det. time= 82.4 min (896.0 - 813.6)

Volume	Invert	Avail.Storage	Storage Description
#1	151.00'	6,847 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
151.00	545	185.0	0	0	545
152.00	1,210	238.0	856	856	2,342
153.00	2,120	306.0	1,644	2,500	5,298
154.00	3,095	343.0	2,592	5,092	7,236
154.50	3,945	293.0	1,756	6,847	9,772

Device	Routing	Invert	Outlet Devices
#1	Primary	154.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 0.50 Width (feet) 5.00 6.00
#2	Discarded	151.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.21 cfs @ 12.16 hrs HW=154.37' (Free Discharge)
↑**2=Exfiltration** (Exfiltration Controls 0.21 cfs)

Primary OutFlow Max=3.98 cfs @ 12.16 hrs HW=154.37' (Free Discharge)
↑**1=Custom Weir/Orifice** (Weir Controls 3.98 cfs @ 1.98 fps)

Summary for Pond P5: Infiltration Basin

```
Inflow Area =      4.595 ac, 58.80% Impervious, Inflow Depth >  5.33"   for 100-Year event
Inflow      =     26.82 cfs @  12.08 hrs, Volume=          2.041 af
Outflow     =      4.75 cfs @  12.54 hrs, Volume=          1.889 af, Atten= 82%, Lag= 27.6 min
Discarded   =      0.91 cfs @  12.54 hrs, Volume=          0.982 af
Primary     =      3.84 cfs @  12.54 hrs, Volume=          0.907 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 145.82' @ 12.54 hrs   Surf.Area= 16,338 sf   Storage= 36,694 cf

Plug-Flow detention time= 136.9 min calculated for 1.889 af (93% of inflow)
Center-of-Mass det. time= 97.6 min ( 874.7 - 777.1 )

Volume     Invert    Avail.Storage  Storage Description
  #1       143.00'       48,482 cf  Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation     Surf.Area    Perim.      Inc.Store      Cum.Store      Wet.Area
   (feet)        (sq-ft)    (feet)   (cubic-feet)   (cubic-feet)       (sq-ft)
   143.00         9,980     601.0              0              0         9,980
   144.00        11,812     620.0         10,883         10,883        11,924
   145.00        14,463     744.0         13,115         23,998        25,401
   146.00        16,751     782.0         15,593         39,591        30,078
   146.50        18,831     695.0          8,890         48,482        40,311

Device  Routing          Invert  Outlet Devices
  #1    Primary         144.00'  12.0"  Round Culvert
                                 L= 50.0'   RCP, mitered to conform to fill,  Ke= 0.700
                                 Inlet / Outlet Invert= 144.00' / 143.50'   S= 0.0100 '/'   Cc= 0.900
                                 n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
  #2    Primary         146.00'  Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
                                 Head (feet)  0.00  0.50
                                 Width (feet)  6.00  7.00
  #3    Discarded       143.00'  2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.91 cfs @ 12.54 hrs  HW=145.82'   (Free Discharge)
└─3=Exfiltration  (Exfiltration Controls 0.91 cfs)

Primary OutFlow Max=3.84 cfs @ 12.54 hrs  HW=145.82'   (Free Discharge)
├─1=Culvert  (Inlet Controls 3.84 cfs @ 4.89 fps)
└─2=Custom Weir/Orifice ( Controls 0.00 cfs)
```

Summary for Link DP1: Wetland ST-10

```
Inflow Area =          2.761 ac, 21.73% Impervious,  Inflow Depth >  2.33"   for  100-Year event
Inflow      =          4.34 cfs @  12.20 hrs,  Volume=          0.535 af
Primary     =          4.34 cfs @  12.20 hrs,  Volume=          0.535 af,  Atten= 0%,  Lag= 0.0 min
```

```
Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
```

Summary for Link DP3: Wetland EA1 (culvert)

```
Inflow Area =         8.083 ac,  48.65% Impervious,  Inflow Depth >   2.73"    for  100-Year event
Inflow       =         7.78 cfs @   12.18 hrs,  Volume=            1.837 af
Primary     =         7.78 cfs @   12.18 hrs,  Volume=            1.837 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Summary for Link DP4: Wetland EA 1

Inflow Area = 0.555 ac, 0.00% Impervious, Inflow Depth > 4.80" for 100-Year event
Inflow = 3.01 cfs @ 12.10 hrs, Volume= 0.222 af
Primary = 3.01 cfs @ 12.10 hrs, Volume= 0.222 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Appendix C
Standard 3 Computations and Supporting Information

Soil Evaluation and Analysis

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Bristol County, Massachusetts, Northern Part; and Norfolk and Suffolk Counties, Massachusetts

March 27, 2012

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

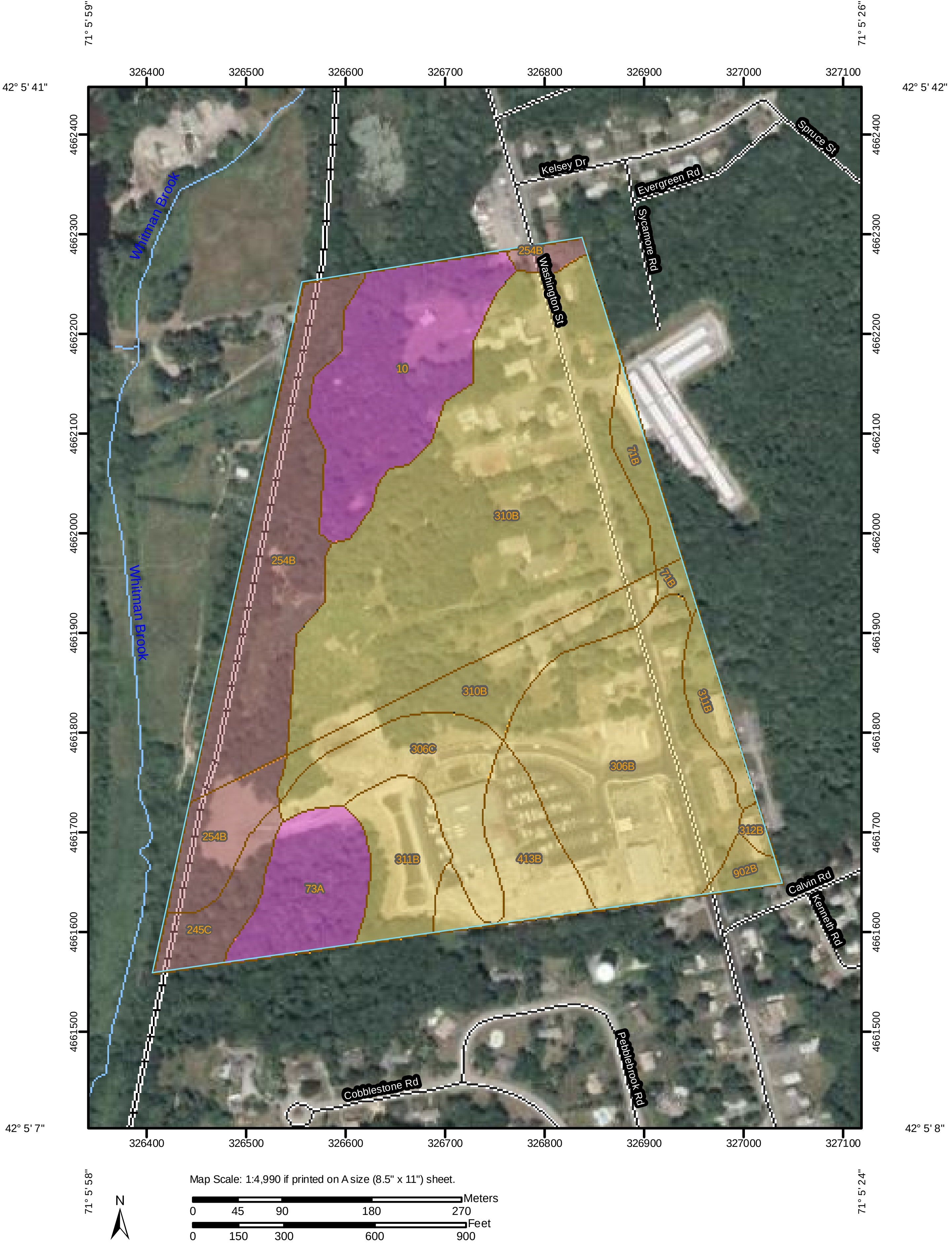
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Custom Soil Resource Report
Map—Hydrologic Soil Group



MAP LEGEND

Area of Interest (AOI)

- ☐ Area of Interest (AOI)

Soils

- ☐ Soil Map Units

Soil Ratings

- ■ A
- ■ A/D
- ■ B
- ■ B/D
- ■ C
- ■ C/D
- ■ D
- ■ Not rated or not available

Political Features

- ● Cities

Water Features

- 〰 Streams and Canals

Transportation

- ╫ Rails
- 〰 Interstate Highways
- 〰 US Routes
- 〰 Major Roads
- 〰 Local Roads

MAP INFORMATION

Map Scale: 1:4,990 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bristol County, Massachusetts, Northern Part
Survey Area Data: Version 5, Jul 27, 2010

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 8, Jul 23, 2010

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 7/10/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Northern Part (MA602)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	C	0.3	0.4%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	3.7	4.9%
245C	Hinckley sandy loam, 8 to 15 percent slopes	A	1.9	2.5%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	2.2	2.9%
306B	Paxton fine sandy loam, 0 to 8 percent slopes, very stony	C	11.5	15.1%
306C	Paxton fine sandy loam, 8 to 15 percent slopes, very stony	C	4.5	5.9%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C	3.6	4.7%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C	4.3	5.6%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	C	0.3	0.4%
413B	Charlton - Paxton fine sandy loams, 0 to 8 percent slopes, very stony	C	3.2	4.2%
902B	Charlton - Paxton fine sandy loams, 0 to 8 percent slopes, extremely stony	C	0.6	0.8%
Subtotals for Soil Survey Area			**36.1**	**47.4%**
Totals for Area of Interest			**76.2**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Norfolk and Suffolk Counties, Massachusetts (MA616)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
10	Scarboro and Birdsall soils, 0 to 3 percent slopes	D	7.8	10.2%
71B	Ridgebury fine sandy loam, 2 to 8 percent slopes, extremely stony	C	1.3	1.7%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	8.6	11.3%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C	22.4	29.4%
Subtotals for Soil Survey Area			**40.1**	**52.6%**
Totals for Area of Interest			**76.2**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Required and Provided Recharge Volumes

Recharge Calculations

Project Name: North Easton
Project Location: Stoughton, MA

Proj. No.: 10111.00
Date: 31-May-12
Calculated by: CWF
Checked by: EJM

Proposed Impervious Surface Summary

Net Proposed Impervious Areas by Hydrologic Soil Group (HSG) in acres

Subcatchment	HSG A	HSG B	HSG C	HSG D	Total Area
1	0.0	0.0	0.0	0.0	0.0
2	0.6	0.0	0.0	0.0	0.6
3	0.0	0.0	0.6	0.0	0.6
4	0.0	0.0	0.1	0.0	0.1
5	0.0	0.0	0.2	0.0	0.2
6	0.3	0.0	0.2	0.1	0.6
7	1.4	0.0	1.0	0.0	2.4
8	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
TOTAL	**2.3**	**0.0**	**2.1**	**0.1**	**4.5**

Required Recharge Volume (Cubic Feet)

HSG	Area (acres)	Recharge Depth * (in.)	Volume (c.f.)
A	2.3	0.60	5,009
B	0.0	0.35	0
C	2.1	0.25	1,880
D	0.1	0.10	36
TOTAL			**6,926**

* Per 2008 Massachusetts DEP Recharge Requirement

Provided Recharge Volume (Cubic Feet)

Infiltration Volumes Provided in Infiltration Basins (below lowest overflow outlet - see attached sheets)

Basin 1	7,829	
Basin 3	947	
Basin 4	5,356	
Basin5	10,896	
Total	**25,028**	c.f.

\\MABOS\projects\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\North Easton\Appendices\Appendix C_Standard 3 Support\Recharge Requirement (MA).xls

72-hour Drawdown Analysis

Drawdown Calculations

Project Name: North Easton Station **Proj. No.:** 10111.00

Date: 5/31/2012

Project Location: Stoughton/Easton, MA **Calculated by:** EJM

Bioretention Basin - 1

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
155.00	1,579	0
156.00	2,217	1,898
157.00	2,953	4,483
158.00	3,738	7,829
TOTAL		**7,829**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 24.7 hours

Infiltration Basin - 3

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
161.50	552	0
162.00	879	358
162.50	1,202	878
TOTAL		**878**

Assumptions:

Recharge Rate: 0.27 in/hr

Drawdown Time: 70.7 hours

Infiltration Basin - 4

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
151.00	545	0
152.00	1,210	878
153.00	2,120	2,543
154.00	3,095	5,150
TOTAL		**5,150**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 47.1 hours

Drawdown Calculations

Project Name:	North Easton Station	**Proj. No.:**	10111.00
		Date:	5/31/2012
Project Location:	Stoughton/Easton, MA	**Calculated by:**	EJM

Infiltration Basin - 5

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
143.00	9,980	0
144.00	11,812	10,896
TOTAL		**10,896**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 5.4 hours

Appendix D
Standard 4 Computations and Supporting Information

Water Quality Volume Calculations

VHB

Water Quality Volume Calculations

Project Name: **North Easton Stati** **Proj. No.:** 10111.00
Project Location: **Easton, MA** **Date:** 5/31/2012
Calculated by: CWF
Checked by: EJM

Bioretention Basin P1
(runoff from Area PR2)

Total Impervious Area = 0.60 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Water Quality Volume	1	2,178

Provided:

Infiltration Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	155.0	1,579	0
	156.0	2,217	1,898
	157.0	2,953	4,483
	158.0	3,738	7,829

Infiltration Basin P2
(runoff from Area PR3, PR4)

Total Impervious Area = 0.68 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	247
Water Quality Volume	1	2,468

Provided:

	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
Sediment Forebay	156.0	186	0
	157.0	364	275
Infiltration Basin	156.0	2,331	0
	157.0	3,258	2,795

Infiltration Basin P3
(runoff from Area PR5)

Total Impervious Area = 0.20 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	73
Water Quality Volume	1	726

Provided:

	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
Sediment Forebay	161.5	0	0
	162.0	146	37
	162.5	220	128
Infiltration Basin	161.25	0	0
	161.5	552	69
	162.0	879	427
	162.5	1,202	947

VHB

Water Quality Volume Calculations

Project Name: **North Easton Stati** **Proj. No.:** 10111.00
Project Location: **Easton, MA** **Date:** 5/31/2012
Calculated by: CWF

Infiltration Basin P4
(runoff from Area PR6)

Total Impervious Area = 0.55 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	200
Water Quality Volume	1	1,997

Provided:

	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
Sediment Forebay	153.0	168	0
	154.0	346	257
Infiltration Basin	150.5	280	0
	151.0	545	206
	152.0	1,210	1,084
	153.0	2,120	2,749
	154.0	3,095	5,356

Infiltration Basin P5
(runoff from Area PR7)

Total Impervious Area = 2.50 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	908
Water Quality Volume	1	9,075

Provided:

	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
Sediment Forebay	145.0	761	0
	146.0	1104	933
Infiltration Basin	143.0	9,980	0
	144.0	11,812	10,896

\\MABOS\projects\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\North Easton\Appendices\Appendix D_Standard 4 Support\Water Quality Volume Analysis.xls

TSS Removal Worksheets

TSS Removal Calculation Worksheet

***Vanasse Hangen Brustlin, Inc*.**
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **North Easton Station**
Project Number: **10111.00**
Location: **Stoughton, MA**
Discharge Point: **DP-1**
Drainage Area(s): **PR1, PR2**

Sheet: **1 of 3**
Date: **11-Apr-2012**
Computed by: **CWF**
Checked by: **VHB**

1. Pre-Treatment prior to Infiltration

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area	**90%**	**100%**	**90%**	**10%**
	0%	**10%**	**0%**	**10%**
	0%	**10%**	**0%**	**10%**

Pre-Treatment TSS Removal = **90%**

2. Total TSS Removal including Pretreatment 1.

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area	**90%**	**100%**	**90%**	**10%**
	0%	**10%**	**0%**	**10%**
	0%	**10%**	**0%**	**10%**
	0%	**10%**	**0%**	**10%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
** Equals remaining load from previous BMP (E)

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **North Easton Station**
Project Number: **10111.00**
Location: **Stoughton, MA**
Discharge Point: **DP-3**
Drainage Area(s): **PR 4, 5, 6, 8, 9**

Sheet: **2 of 3**
Date: **11-Apr-2012**
Computed by: **CWF**
Checked by: **VHB**

1. Pre-Treatment prior to Infiltration

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Sediment Forebay	**25%**	**75%**	**19%**	**56%**
	0%	**56%**	**0%**	**56%**

Pre-Treatment TSS Removal = **44%**

2. Total TSS Removal including Pretreatment 1.

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Infiltration Basin	**80%**	**75%**	**60%**	**15%**
	0%	**15%**	**0%**	**15%**
	0%	**15%**	**0%**	**15%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
** Equals remaining load from previous BMP (E)

TSS Removal Calculation Worksheet

***Vanasse Hangen Brustlin, Inc*.**
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **North Easton Station**
Project Number: **10111.00**
Location: **Stoughton, MA**
Discharge Point: **DP-3**
Drainage Area(s): **PR 3, 7**

Sheet: **3 of 3**
Date: **11-Apr-2012**
Computed by: **CWF**
Checked by: **VHB**

1. Pre-Treatment prior to Infiltration

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Sediment Forebay	**25%**	**75%**	**19%**	**56%**
	0%	**56%**	**0%**	**56%**

Pre-Treatment TSS Removal = **44%**

2. Total TSS Removal including Pretreatment 1.

BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**100%**	**25%**	**75%**
Oil Grit Separator	**25%**	**75%**	**19%**	**56%**
Infiltration Basin	**80%**	**56%**	**45%**	**11%**
	0%	**11%**	**0%**	**11%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
** Equals remaining load from previous BMP (E)

Appendix E
Geotechnical Report

343 Congress Street
Boston, MA 02210

Design Memorandum

Date	January 23, 2012
To	Rick Carey, Natasha Velickovic - VHB
From	Paul Murphy, Da Ha, Peter Chou - Jacobs
Cc	
Subject	MBTA South Coast Rail (New Bedford/Fall River Commuter Rail Extension) North Easton Station Geotechnical Design Memorandum Easton, MA
Project No.	E2347101

INTRODUCTION

The South Coast Rail project will restore passenger rail transportation from South Station in Boston to the cities of Fall River and New Bedford along an existing rail freight corridor running south from Taunton to Fall River and New Bedford. The project will include the construction of several existing and new passenger stations and two terminal layover facilities. This geotechnical design memorandum presents the foundation design considerations for the new station platform at the proposed North Easton Station in Easton, Massachusetts. The design recommendations presented in this report are based on the results of subsurface investigation performed by Jacobs in 2010.

Existing Conditions

The proposed North Easton Station is off Route 138 in Easton, behind the Roche Brothers Shopping Plaza (Figure 1). The station site is undeveloped and entirely vegetated, but has evidence of earthwork, most likely as a result of the construction of the shopping plaza. In addition to the shopping plaza to the east, the site is adjacent to forested land to the west and south. The shopping plaza contains six buildings in good condition as all are relatively new. A medical office building adjacent to the proposed station site is the newest building. Existing grades at the platform location range from elevations 160 to 154 feet (NGVD29 Datum), generally sloping downward from north to south.

Proposed Construction

A commuter parking lot, drop-off ramps and platform are currently proposed at this site. Current station plans are to construct a new parking area and a new drop-off area, and add an 800 foot long, 12 foot wide high level center platform adjacent to the existing tracks with some track relocation required, as well as the addition of a second track. Access to the platform will be from a new ramp/stair structure along the east side of the tracks with a bridge over the track to the platform. Approximately 375 feet of the platform will be under a new station canopy. The details of new track layout (including grading), associated sidewalks and ramps of the proposed station are still under development at the time of this report preparation. This report focuses on the foundations for the platform only.

SCOPE OF WORK

This memorandum was prepared by Jacobs Engineering Group (Jacobs) in accordance with the scope of work under the contract between Jacobs and VHB for work on the New Bedford/Fall River Commuter Rail Line Extension Project for Massachusetts Bay Transportation Authority (MBTA). The geotechnical work included the following tasks:

- Perform a geotechnical exploration and laboratory testing program;
- Report and interpret the results of the exploration and laboratory testing program; and
- Provide geotechnical recommendations for design and construction of the platform foundations.

The Jacobs scope of work did not include environmental analyses to assess the potential presence of any hazardous materials at the project site or potential impacts to adjacent structures during construction.

LOCAL GEOLOGY

The soils at the site are underlain by the Dedham Granite. The Dedham Granite is Proterozoic in age, medium grained, and light gray, pinkish gray and greenish gray in color. The intact strength of the rock averages about 35,000 psi. The rock mass is sparsely fractured. The top of rock was encountered as shallow as five feet in some of the borings but extended deeper than 16 feet in others. The top of rock was typically sharp, with little or no residual soil. In some borings, there appeared to be a layer of granite, followed by a zone of soil, followed by granite. The intervening layer of soil was typically not sampled and described simply as material not recovered by rock coring. The most likely explanation is that exfoliation has caused large slabs of rock to pop off the top of the main body of rock. If this explanation is correct, then these slabs could extend laterally for tens of feet and could have open voids beneath them. Another possible explanation is that these layers are localized boulders in the glacial deposits overlying the rock. The similarity between the upper layer the underlying rock suggests that the first explanation is more likely. Heavily loaded foundations will need to pass through the upper slab and into the underlying, competent rock.

GEOTECHNICAL EXPLORATIONS

Jacobs Engineering Group planned the subsurface exploration program and retained the drilling contractor to perform the explorations. The geotechnical data reports were submitted in 2010. Five borings (NES-1, NES-2, NES-2A, NES-3 and NES-4) were conducted along the proposed station platform and eighteen borings (NES-6 to NES-9, NES-11, NES-11A, NES-12 to NES-17, NES-19, NES-19A and NES-20 to NES-23) were drilled in the general vicinity of the proposed parking lot and its driveways for the 2010 explorations. Boring locations are shown on the Subsurface Exploration Plan (Figure 2).

The 2010 borings were drilled by New Hampshire Boring of Brockton, Massachusetts using either a CME-550 or D-50 ATV mounted drill rig, a D-90 or D-120 track mounted drill rig, or a CME-75 truck mounted drill rig. The borings were advanced through the soil by wash boring methods using a 4-inch casing and roller bit with water. Standard penetration tests (SPT), consisting of a 140-pound hammer dropping 30 inches on a standard 2-inch-diameter (OD) split-spoon sampler, were performed with a safety hammer or automatic hammer to establish the consistency of the subsurface soils. The SPT's were typically performed at five foot intervals of depth. The obtained samples were sealed in glass jars to retain their natural moisture. Bedrock was not encountered during the explorations.

The borings were observed by a representative from Jacobs. The soil samples were classified in the field in accordance with ASTM D-2488, Standard Practice for Description and Identification of Soils (Visual-Manual

Procedure) by Jacobs' representative, and appropriate stratum breaks were interpolated from drilling and sampling observations. The boring logs were prepared by Jacobs based on the field classifications and laboratory testing, and are presented in Appendix A.

LABORATORY TESTING

The results of the laboratory testing were previously submitted to VHB in a report entitled "South Coast Rail, Jacobs Geotechnical Data Report", dated November 2010.

Grain size distribution analyses were performed to evaluate the gradation of the natural granular soils for potential reuse as backfill, if needed, and to confirm sample classifications. The analyses are summarized in Table 1 below and are presented in Appendix B.

Table 1: Laboratory Soil Classification Summary

BORING NO.	SAMPLE NO.	ELEVATION (FEET)	USCS SOIL CLASSIFICATION	W (%)	GRAVEL (%)	SAND (%)	FINES (%)
NES-4	S4	144.0	Silty Clay (CL)	23.6	0.0	1.9	98.1
NES-5	S2	154.0	Silty Sand (SM)	1.1	13.3	68.3	18.4
NES-14	S2	162.0	Silty Sand w/ Gavel (SM)	NT	32.7	51.3	16.0
NES-21	S2	158.0	Gravel w/ Silt + Sand (GW-GM)	NT	56.9	34.1	9.0

Where: w = natural moisture content, NT = Not Tested.

SUBSURFACE CONDITIONS

The subsurface conditions at the site were inferred from the boring data collected for the South Coast Rail project, with some interpretations. The subsurface conditions encountered at the station platform area during our 2010 explorations generally consist of a layer of granular fill with thickness of about 4 to 9 feet, underlain by a sand and gravel layer with thickness ranging from 0 to 26 feet overlying bedrock. A 10 feet thick hard silty clay layer was encountered within the sand and gravel layer from about 14 to 24 feet below ground surface in boring NES-4. Boulders were encountered at borings NES-2, NES-3 and NES-5 within the upper 5 to 10 feet of the borings. Bedrock was encountered at a depth of about 5 to 35 feet in the platform area, corresponding to approximately elevations 123 to 151.5 feet.

Fill materials with thicknesses varying from 0 to 8 feet were also encountered in the vicinity of the proposed parking lot area. Bedrock was encountered at a depth about 4 to 18 feet (corresponding to elevations 133 to 169.5 feet) with generally shallower bedrock found on the south side of the parking lot and in the area of the proposed infiltration basin.

Subsurface soil conditions are summarized in Table 2 below.

Table 2: Summary of Subsurface Conditions at Available Borings

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Platform Borings							
NES - 2	154.0	0.5 (Top Soil)	153.5	153.5	153.5	NR	Obstruction encountered.
NES - 2A	154.0	4.0	150.0	148.5	146.0	NR	Offset ~5 ft from NES - 2.
NES - 3	156.0	0.3 (Top Soil)	155.7	144.0	138.5	NR	
NES - 4	158.0	9.0	149.0	123.0	122.0	148.0	
NES - 5 OW	158.0	4.0	154.0	141.0	131.0	140.5	
NES - 7	158.0	6.5	151.5	151.5	149.0	NR	
NES - 8	154.0	4.0	150.0	NE	138.0	150.5	Boring offset ~12 ft SE from staked location.
NES - 9	159.0	0	159.0	NE	143.0	154.0	
Site Borings							
NES - 1 OW	151.0	8.0	143.0	133.0	127.5	135.5	Well screened from 18 to 23 ft.
NES - 6	163.0	0	163.0	157.5	152.5	159.5	
NES - 11	165.0	0	165.0	160.0	153.0	NR	
NES - 11A	162.0	0	162.0	156.5	142.0	NR	Boring offset ~25 ft W of NES-11, ~3 ft less elevation.
NES - 12	166.0	4.0	162.0	160.5	158.0	NR	
NES - 13	159.0	4.0	155.0	NE	143.0	NR	
NES - 14	166.0	0	166.0	151.0	150.0	NR	
NES - 15	173.0	0	173.0	169.0	169.0	NR	
NES - 16	160.0	4.0	156.0	NE	144.0	NR	
NES - 17	175.0	0	175.0	168.0	166.0	NR	
NES - 19	175.0	0	175.0	168.0	168.0	NR	Refusal at 7 ft, relocated boring.
NES - 19A	175.0	0	175.0	168.5	161.0	172.0	
NES - 20	175.0	0	175.0	169.5	165.0	NR	
NES - 21	162.0	0	162.0	NE	146.0	NR	
NES - 22	144.0	0.3 (Top Soil)	143.7	139.0	129.0	141.0	
NES - 23	162.0	8.0	154.0	153.0	145.0	NR	Boulder at 1 ft, relocated boring 5 ft south.

NE: Not encountered at the boring during drilling. NR: Not recorded.

Fill: The fill layer typically consists of mostly granular, loose to very dense sand with up to about 15% silt and 15% gravel. The fill layer is generally about 0 to 4 feet thick but may be as thick as 9 feet in the area of the platform.

Natural Granular Deposits: In the platform area, the natural soil deposits below the fill generally consist of predominantly sand with up to about 30% gravel and 20% silt. These deposits are loose to very dense with Standard Penetration Test (SPT) N-values ranging between 9 and in excess of 50 blows per foot (bpf). The numerous high N-values encountered may be caused by the presence of large pieces of gravel and cobbles or even boulders, which are common within this type of deposit.

An approximately 10 feet thick hard silty clay layer was encountered in boring NES-4 from about 14 to 24 feet below ground surface, corresponding to elevations 134 to 144 feet.

Bedrock: Granite bedrock was encountered in the platform area at depth of about 5 to 35 feet below existing ground surface, corresponding to approximately elevations 123 to 151.5 feet. The bedrock was generally hard, fresh to slightly weathered GRANITE.

Bedrock was encountered at elevations ranging from about 133 to 169.5 feet in other site areas. In the vicinity of borings NES-11 and NES-15, bedrock was encountered above the proposed grades at the site.

Groundwater: Groundwater levels were measured in the test borings using a weighted tape during and at completion of drilling. The data indicated the groundwater level ranged from approximate elevations 140.5 to 154.0 feet in the general area of the platform, and from elevations 135.5 to 172 feet in the general site area. The use of wash boring techniques for all soil borings may have artificially increased the water level readings due to the addition of water to the borings. Trapped/perched water is also commonly seen at a higher elevation within existing fill or silty materials. The longer term water level readings taken at Boring NES–1 OW on July 9, 2010 indicated the ground water level at a depth of about 17.0 feet (Elevation 134.0 feet). The longer term water level readings taken at Boring NES–5 OW on July 9, 2010 and September 12, 2011 indicated the water at a depth of about 17.5 feet (Elevation 140.5 feet) and 15.5 feet (Elevation 142.5 feet), respectively.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. Local and periodic variations of ground water elevations may also be influenced by local subsurface drainage and, leaking water or sewer pipes. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. However, based upon these short-term observations and readings from the observation well at Boring NES–1 OW and NES-5 OW, it is anticipated that the groundwater could be at within 15 to 18 feet below existing grade at both the platform and the parking lot areas.

GEOTECHNICAL RECOMMENDATIONS

Based on our review of available subsurface information, the proposed station platforms can be supported on spread footings bearing directly within either competent natural soil or structural fill placed above suitable natural soils. Final platform and canopy design loads were not available at the time of this report preparation. However, it is anticipated that the station platform will be lightly (axially) loaded with limited horizontal forces from wind and seismic loads.

The following paragraphs provide project specific geotechnical recommendations for foundation soil preparation, structural fill/backfill placement, and design and construction of spread footings.

Platform Foundation- Spread Footings

Spread footings are recommended for the platform foundations, bearing on compacted structure fill or natural granular deposits. The bottom of footing elevation should be at least 4 feet below final grades for frost protection. The existing fill is not suitable for support of the spread footings and should be removed within the zone of influence of the footing, defined by a line extending one foot horizontally from the bottom edge of footing and then down and away at a 1H:1V slope until natural granular soils are encountered.

The recommended allowable design bearing capacity for spread footings bearing on structural fill or natural sand and gravel deposits is 5 ksf, provided that subgrades are prepared as described herein. This provides an adequate factor of safety against bearing failure and limits the total estimated settlement to less than one inch and the differential settlement to less than ½ inch. All footings should be at least 4 feet wide.

The structural fill material, if needed, should be free from organics and other deleterious substances and should conform to the requirements listed in the MBTA Standard Specification Section 02200 - Earthwork for Type B Gravel Borrow. The structural fill should be compacted to 95% of the maximum dry density as determined by the Modified Proctor compaction test (ASTM D1557).

All temporary open cuts required for footing construction should be in accordance with the related OSHA regulations and should have side slopes of no steeper than 1.5H:1V.

Seismic Consideration

The seismic design should comply with the requirements of the most current Massachusetts State Building Code 780 CMR and other relevant project design codes such as AREMA and AASHTO. Modification of the peak acceleration by the soils overlying bedrock depends upon the type of soil at the site. For the subsurface conditions encountered, the station site is classified as Seismic Site Class C soil profile in accordance with 780 CMR Chapter 1614.0 Section 9.4 Site Ground Motion. The structure could be designed for the total lateral seismic force using the equations specified in the code, or by the response spectrum method using the design spectra presented in the code. The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods (Ss) and at 1-sec (S_1) obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4.

For Site Class C Soils at the location of this station:

S_{MS} = 0.300 and S_{M1} = 0.109

S_{DS} = 0.200 and S_{D1} = 0.073

where:

- S_{MS} is the maximum consider earthquake spectral response acceleration for short periods adjusted for site class
- S_{M1} is the maximum consider earthquake spectral response acceleration at 1-sec adjusted for site class
- S_{DS} is the design earthquake spectral response acceleration for short periods adjusted for site class

- S_{D1} is the design earthquake spectral response acceleration
  at 1-sec adjusted for site class

The building code also requires that the soil be evaluated for the following potential hazards: slope instability, soil liquefaction, or surface rupture due to faulting or lateral spreading. The proposed grading is relatively flat and we are not aware of any pre-existing slope instability in this area. The existing overburden soils do not appear to be subject to surface rupture due to faulting or lateral spreading.

Liquefaction

Based on the observed subsurface conditions, recorded water levels, percentage of fine contents and sample relative densities (high SPT N-values), the existing soils underlying the site are judged not susceptible to liquefaction.

CONSTRUCTION CONSIDERATIONS

Foundation Installation - Spread Footings

Following excavation to the base of the spread footing subgrade or to the bottom of existing fill layer, whichever is deeper, the exposed surface should be observed by an on-site representative of the project geotechnical engineer and proof-compacted with at least 10 passes of a large vibratory drum roller. Any yielding areas should be observed by geotechnical personnel to assess if additional localized undercutting is necessary. Footing inspections should include hand auger probes by the geotechnical personnel to identify soft/weak zones. The need for undercutting and backfilling with structural fill should be closely evaluated in the field based on encountered conditions.

If bedrock is encountered at the proposed bottom of footing elevation, the footing should either bear entirely on bedrock or entirely on soil. Where partial bedrock subgrade is encountered at the bottom of footing elevation, the bedrock should be over-excavated to a depth of at least 10 inches below the bottom of footing elevation and replaced with compacted Gravel Borrow to provide a uniform bearing surface.

In areas where seepage is encountered within footing excavations, the need for placing a 3" thick lean concrete mud mat or a layer of ¾-inch crushed stone to protect the bearing surface should be evaluated in the field. Crushed stone thicker than 4 inches shall be wrapped by non-woven filter fabric.

Following observation of the bearing soils by geotechnical personnel, reinforcing steel and concrete can be placed in the excavation. It is recommended that footing reinforcing steel and concrete be placed the same day as the footing excavation is made, where possible, to avoid significant moisture content changes in the bearing soils. No water should be allowed to pond within excavations and drainage should be maintained away from foundations both during and after construction. The footing excavation should be free of loose debris at the time of footing concrete placement.

Subgrade Preparation

Prior to performing any required grading operations and excavations in the proposed structure footprints, walkway and paved areas, these areas should be stripped of topsoil, vegetation, and existing pavement, if present. The topsoil should be placed in a designated area for reuse during final grading. Following site clearing and stripping, the exposed subgrade should be proof compacted with 10 passes of a large vibratory drum roller. Any pockets of excessively soft, wet or disturbed soil or unsuitable soils should be removed and replaced with properly compacted fill materials.

If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches but not exceeding eighteen inches, aerated, re-compacted, and retested to provide uniform compaction. Following satisfactory compaction of the subgrade, controlled compacted fill material should be placed to bring the site to the required grade.

Fill should not be placed over frozen soil. Soil subgrades should be protected against frost both during and after construction.

Proper drainage of construction areas should be provided to protect the subgrades from the detrimental effects of weather conditions. Excavations should be made with as few passes of the backhoe bucket as possible to reduce disturbance of the subgrade. Also if possible, a backhoe bucket fitted with a smooth blade should be used during the final subgrade preparation, where necessary. The exposed base should be kept free of standing water at all times. The site should be graded to carry any surface runoff away from the work areas. Construction traffic should be controlled to prevent excessive stresses and disturbance to the subgrade.

If pavements are not constructed immediately after grading, the subgrade should be shaped so as to prevent ponding. If there is a substantial lapse in time between grading and paving, or if the subgrade is disturbed, it should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during proof-rolling or initial construction should be removed and replaced with compacted granular fill.

Within the proposed paved areas, and extending a distance of five feet beyond the edge on all sides, excavate existing granular fill soils to a depth of two feet below existing site grades. It may be possible to reuse the existing granular fill, depending on the suitability of the material, as described herein.

Fill Placement and Compaction

Fill materials most likely will be obtained by importing granular fill materials from off-site borrow sources. However, it may be possible to reuse existing site granular fill material provided that it can be properly placed and compacted. The gradation shall be in accordance with MBTA Standard Specification Section 02200-Earthwork for Type B Gravel Borrow.

All structural fill should be free of organics, demolition debris or other deleterious substances. The fill material should have a plasticity index (PI) less than 4 and a liquid limit (LL) less than 10, and contain fragments less than 4 inches in maximum dimension. Each lift should be compacted to the specified density prior to placing any subsequent lift. All materials to be used as structural fill should be tested in the laboratory to determine their project suitability and compaction characteristics.

The fill should be systematically compacted to the following percentages of the maximum dry density:

Table 3: Fill Compaction Requirements

DESCRIPTION	MINIMUM PERCENT COMPACTION (ASTM D-1557)
General Site Fills, Structural Fill (Below Footings and Slabs)	95
Behind Retaining Walls	92
Landscape Area	90

Soils which exhibit a well-defined moisture content–dry density relationship should be compacted to within plus or minus two percentage points of the optimum moisture content as determined by the Modified Proctor test (ASTM D-1557).

Where fill materials are placed against an existing embankment slope, the slope should be benched as the fill is brought up in layers. Benching should be of a sufficient width to permit placing and compaction of fill material upon the existing embankment materials. Typically, benches are between four to eight feet wide. Each bench cut should begin at the intersection of the existing embankment and the vertical side of the previous bench. Trench backfills over pipelines or utility structures should be performed so as not to adversely impact the underlying utilities. In fill areas, the backfill material, compaction method, and degree of compaction requirements should be similar to that for the fill adjacent to the trench.

Construction Dewatering

All excavations should be performed in the dry condition. Discharge of pumped water should be performed in accordance with all federal, state and/or local regulations which may require a discharge permit and possible filtration and chemical testing of the water prior to discharge.

Permanent Slopes

Permanent slopes with loamed and seeded surfaces should not be steeper than 2-1/2 horizontal to 1 vertical (2-1/2H:1V) without slope protection to limit erosion and surficial sloughing of the slope. Additional analyses may be required to assess the stability of slopes steeper than 2-1/2H:1V as the station design is finalized.

Excavation Slopes and Shoring

The slopes of open cuts should be no steeper than 1-1/2H:1V. Open cuts should not be used below the water table because of the likelihood of soil sloughing into the excavation.

The temporary excavation support system, if needed, should be selected by the Contractor and designed by an experienced registered Professional Engineer in the Commonwealth of Massachusetts and retained by the Contractor. Where excavation sides can be sloped back, they should be performed in accordance with the Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

Protection of Existing Facilities

It is recommended that a geotechnical instrumentation and monitoring program be performed during construction of the project to evaluate impacts on adjacent structures. It is recommended that the program be developed to provide data for the following considerations:

- To monitor ground movements and vibration levels during construction.
- To provide early warning of potentially adverse trends by presenting sufficient data to determine the source of unanticipated ground movements, if present.
- If necessary, to plan remedial measures to limit damage to embankments and structures and to provide early warning when alternative means of protection are necessary.
- To document impacts of construction on adjacent facilities.
- To evaluate the performance and structural integrity of the constructed facilities.

We recommend the following instrumentation program to measure:

- Ground surface settlement and lateral movement adjacent to proposed construction.
- Horizontal and vertical movement of any excavation support system, and existing structures.
- Vibrations as a result of construction activities.

Vertical and horizontal survey points should be established on the adjacent structures. The monitoring points should be surveyed prior to the start of construction and monitored during construction to detect movement.

Vibration monitoring shall be conducted within 100 feet of existing structures during construction activities.

We recommend conducting a pre-construction survey of structures and utilities within 100 feet of the site to document existing conditions prior to construction. Documentation should include photographs, video, sketches, and/or written comments.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

CLOSING

This report and the recommendations contained herein have been prepared for the exclusive use of MBTA and VHB and their representatives for specific application to the design and construction of the proposed North Easton Station in Easton, Massachusetts.

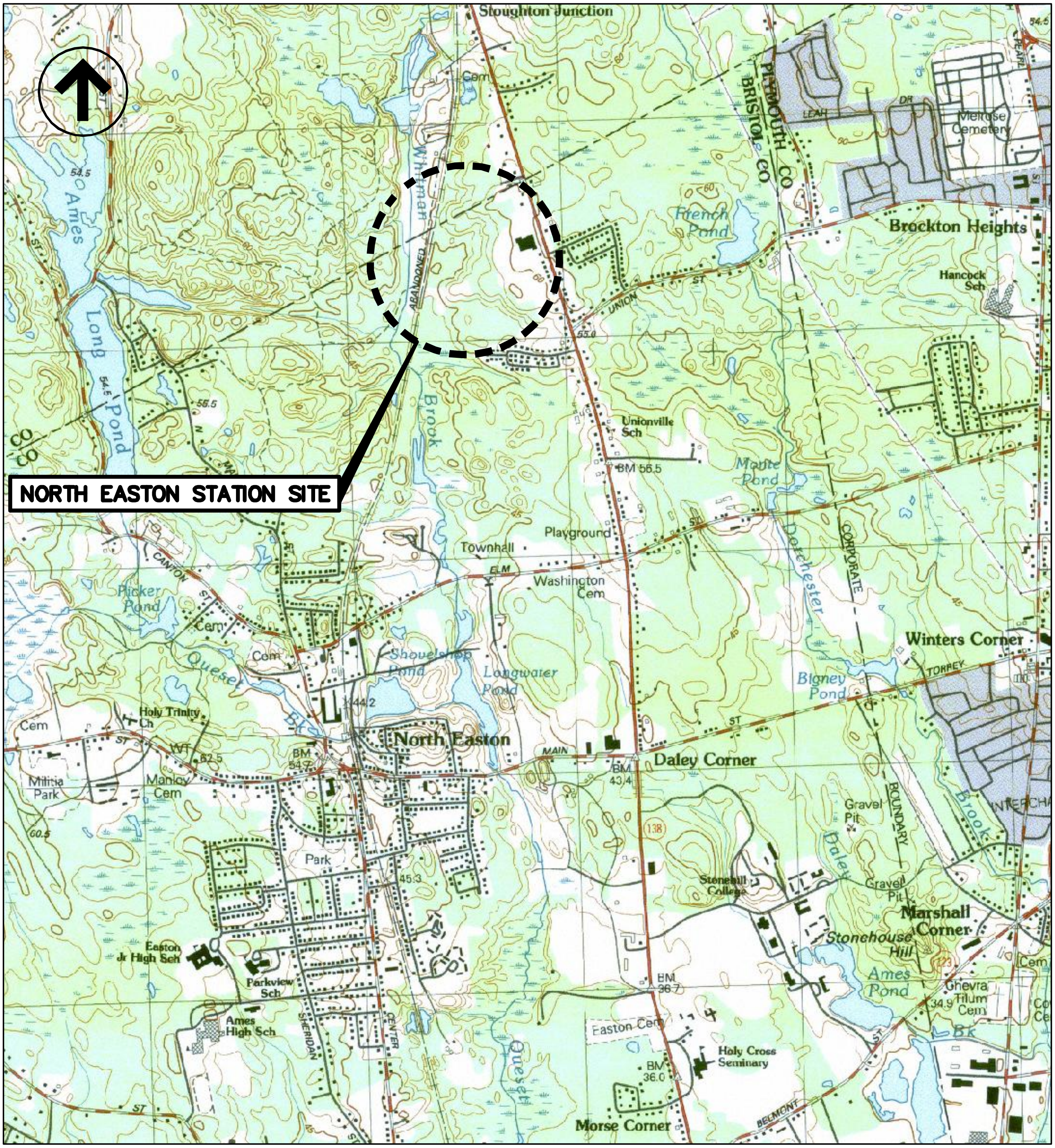
This report was prepared in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations then appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

ATTACHMENTS

FIGURE 1 – SITE LOCATION PLAN
FIGURE 2 – SUBSURFACE EXPLORATION PLAN
FIGURE 3 – SUBSURFACE SOIL PROFILES
APPENDIX A – EXPLORATION LOGS
APPENDIX B – LABORATORY DATA
APPENDIX C – GEOTECHNICAL CALCULATIONS

F:\Proj\013471\600 Discipline Files\610 Studies and Reports\2011 GIR\07 - North Easton Station\North Easton Station.doc

FIGURES



NORTH EASTON STATION
PROJECT LOCUS PLAN

NOT TO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

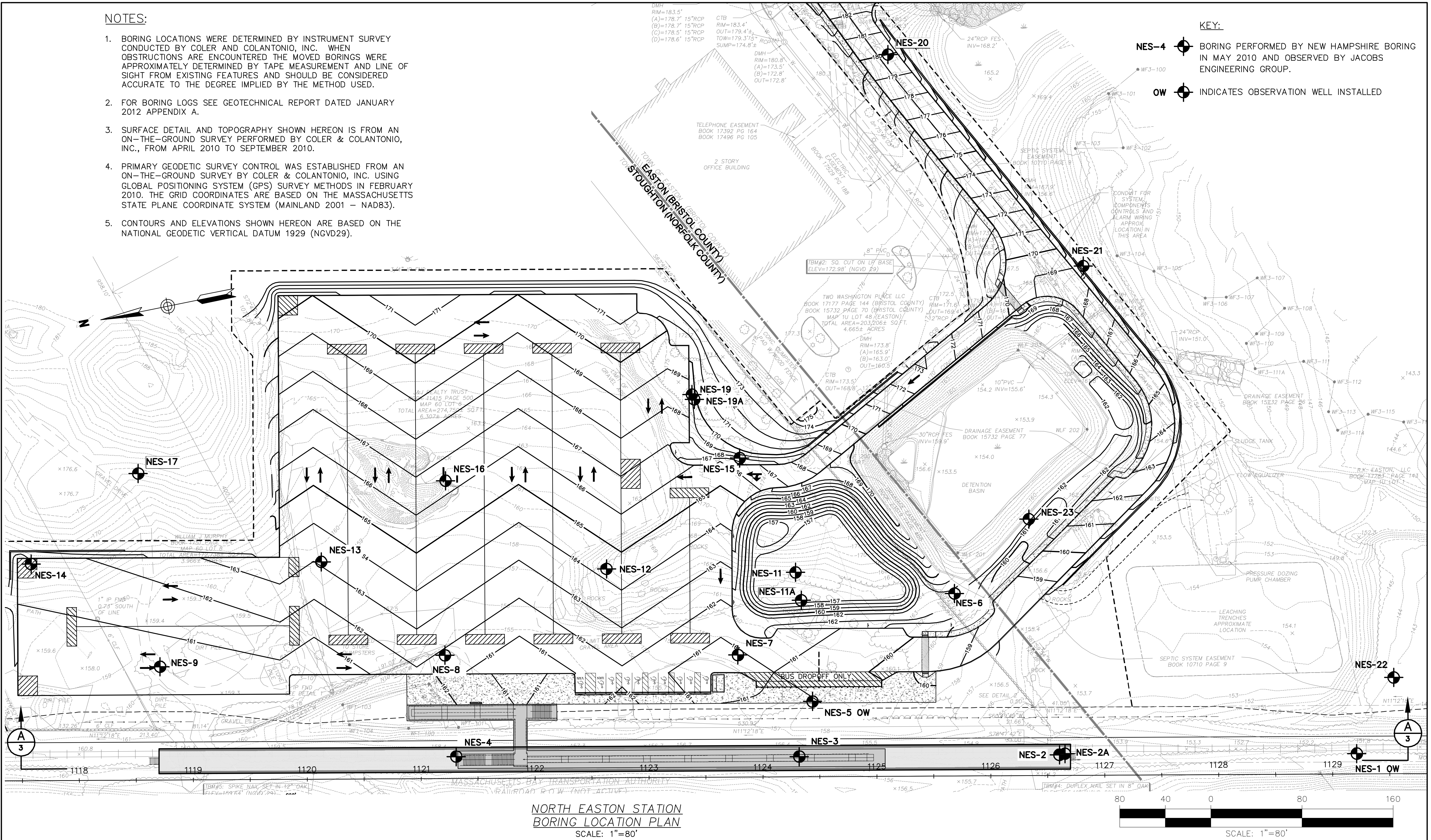
NORTH EASTON STATION
EASTON, MASSACHUSETTS
FIGURE 1

NOTES:

1. BORING LOCATIONS WERE DETERMINED BY INSTRUMENT SURVEY CONDUCTED BY COLER AND COLANTONIO, INC. WHEN OBSTRUCTIONS ARE ENCOUNTERED THE MOVED BORINGS WERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENT AND LINE OF SIGHT FROM EXISTING FEATURES AND SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.
2. FOR BORING LOGS SEE GEOTECHNICAL REPORT DATED JANUARY 2012 APPENDIX A.
3. SURFACE DETAIL AND TOPOGRAPHY SHOWN HEREON IS FROM AN ON–THE–GROUND SURVEY PERFORMED BY COLER & COLANTONIO, INC., FROM APRIL 2010 TO SEPTEMBER 2010.
4. PRIMARY GEODETIC SURVEY CONTROL WAS ESTABLISHED FROM AN ON–THE–GROUND SURVEY BY COLER & COLANTONIO, INC. USING GLOBAL POSITIONING SYSTEM (GPS) SURVEY METHODS IN FEBRUARY 2010. THE GRID COORDINATES ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (MAINLAND 2001 – NAD83).
5. CONTOURS AND ELEVATIONS SHOWN HEREON ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29).

KEY:

NES-4 ⊕	BORING PERFORMED BY NEW HAMPSHIRE BORING IN MAY 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
OW ⊕	INDICATES OBSERVATION WELL INSTALLED



NORTH EASTON STATION
BORING LOCATION PLAN
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_NoEaston.dwg Jan 24, 2012

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

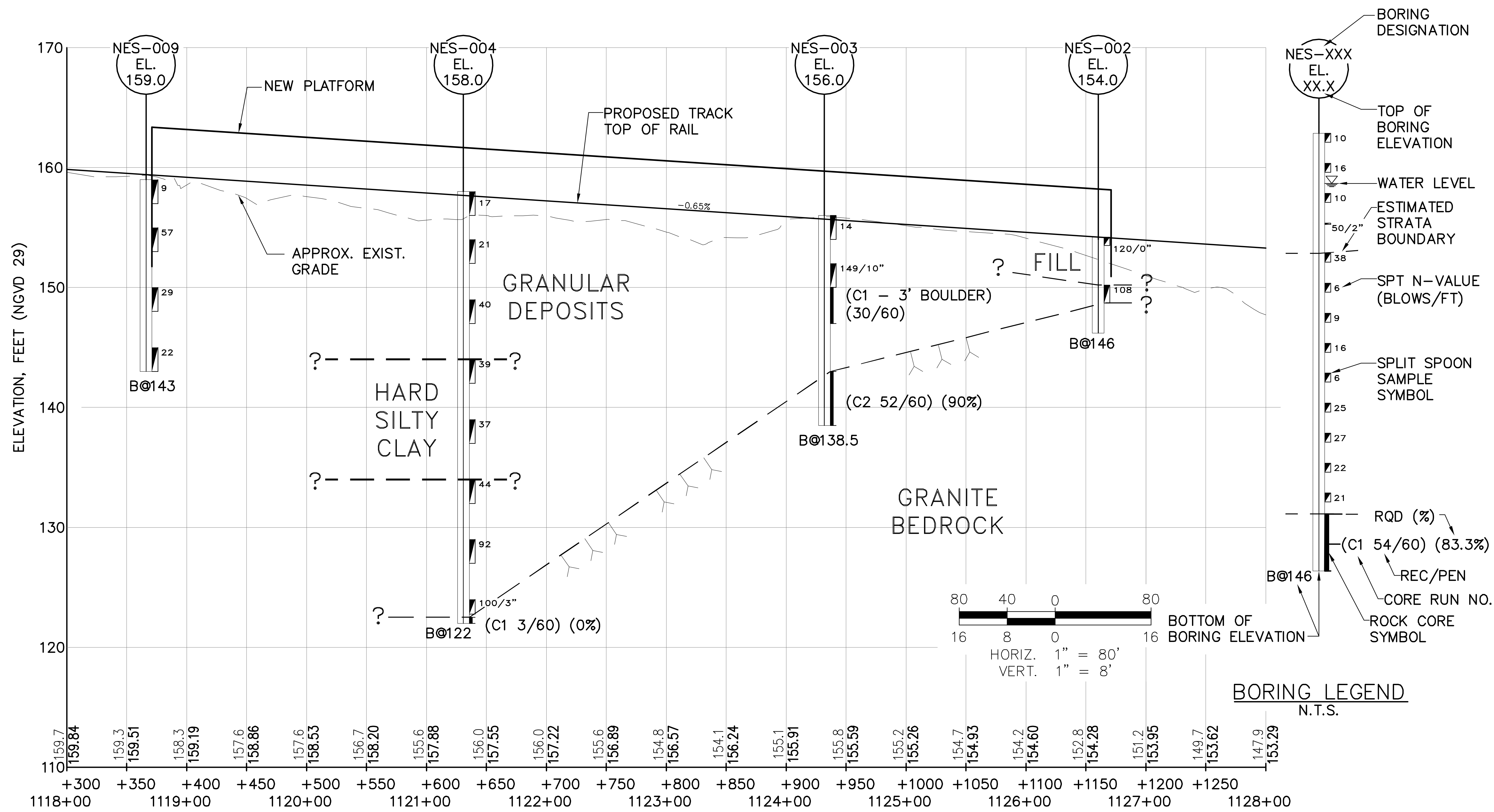
JACOBS

343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

NORTH EASTON STATION
EASTON, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: JANUARY 2012

FIGURE NO: 2



F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_NoEaston-profile.dwg Jan 23, 2012

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

NORTH EASTON STATION
EASTON, MASSACHUSETTS
SUBSURFACE PROFILE A-A

DATE: JANUARY 2012

FIGURE NO: 3

APPENDIX A: EXPLORATION LOGS

NES-1 TO NES-9
NES-11 TO NES-17
NES-19 TO NES-23

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	NES - 001 OW
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION	151
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2857348
18.5	NX Rock Core	5/24/2010	15.5	Monitoring Well Reading			COORD E	765149
23.5	Terminated	7/8/2010	17	Monitoring Well Reading			DATE START	5/19/10
							DATE END	5/24/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		3 4 4 10	S1	0 - 2	5		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brown, moist, FILL.
5		8 7 7 5	S2	3 - 5	6		WELL GRADED SAND (SW); fine to coarse sand, light brown, moist, FILL.
		7 15 22 31	S3	8 - 10	11	143.0	SILT (ML); non-plastic silt, light brown, moist.
10						141.5	(Bottom 1" of S3) SILTY SAND (SM); fine to coarse sand, little non-plastic silt, light brown, moist.
15		24 46 37 30	S4	13 - 15	8	138.0	WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM); fine to coarse sand, little fine gravel, trace non-plastic silt, gray, wet.
20		RQD=100	C1	18.5 - 23.5	60	133.0	GRANITE; very hard, fresh, continuous 5 ft stick with a single mechanical break, high angle fracture (~70 degrees) along a seam at the bottom of the run, gray with black and green.
25 30 35						127.5	Bottom of Hole at 23.5'. Notes: Observation well screened 18 - 23 ft.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 001 OW

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 2/2A
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring			DRILLER	J. Stokes	ELEVATION		154
METHOD OF DRILLING		GROUNDWATER READINGS				DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME		DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2857604
8	Terminated							COORD	E	765200
								DATE START		5/24/10
								DATE END		5/24/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	▨	7 120/0"	S1	0 - 0.5	5		WELL GRADED SAND WITH SILT (SW-SM); fine to coarse sand, trace non-plastic silt, dark brown, moist, FILL. Boulder encountered at 0.5 feet; Boring NES-2 terminated. Offset boring NES-2A 5 ft south.
5	▨	23 31 78 120/0"	S2	4 - 5.5	10	150.0	SILTY SAND WITH GRAVEL (SM); fine to coarse sand, little non-plastic silt, little fine gravel, grayish brown, possible GLACIAL TILL, pieces of granite in tip of spoon.
	▨					148.5	Top of apparent Bedrock at 5.5 ft, roller bit to 8 ft.
						146.0	
10							Bottom of Hole at 8'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 2/2A

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 003
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	S. Hooley	ELEVATION	156
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29

METHOD OF DRILLING		GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS			
	Wash Boring w/Casing			SPT HAMMER 140 lb Safety	GRID	N	2857828
13	NX Rock Core				COORD	E	765244
17.5	Terminated				DATE START		5/10/10
					DATE END		5/11/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		7 6 8 8	S1	0 - 2	12	155.7	Top 3" TOPSOIL. (.25 - 2') POORLY GRADED SAND (SP); mostly fine sand, trace silt, brown, moist.
5		63 49 100/4"	S2	4 - 6	16	152.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some gravel, trace silt, brown, wet.
			C1	6 - 9	30	150.0	GRANITE; loosing water at 8.5 ft, probable sand seams. Probable boulder.
10							Break through at 9 ft, hit rock again at 12 ft.
		RQD=90	C2	13 - 17.5	52	144.0	GRANITE; hard, fresh, joints spaced 4 - 44", joints angled at ~0 degrees, white and black with gray.
15							
						138.5	Bottom of Hole at 17.5'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 003

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 004
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	T. Pentacost	ELEVATION		158
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2858123
35.5	NX Rock Core	5/13/2010	10	Upon Completion (In Casing)			COORD	E	765304
36	Terminated						DATE START		5/13/10
							DATE END		5/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		5 7 10 11	S1	0 - 2	10		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, little fine gravel, brown, moist, FILL.
5		21 11 10 8	S2	4 - 6	17		SIMILAR TO S1.
10		26 19 21 30	S3	9 - 11	15	149.0	POORLY GRADED SAND (SP); mostly medium sand, light brown, moist.
15		23 20 19 27	S4	14 - 16	17	144.0	SILTY CLAY (CL); slightly-plastic clay, some silt, grayish-brown, wet.
20		18 21 16 21	S5	19 - 21	18		SIMILAR TO S4.
25		23 21 23 21	S6	24 - 26	6	134.0	WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM); fine to coarse sand, little fine gravel, trace silt, grayish brown, wet.
							Cobbles/boulders encountered.
30		46 42 50 49	S7	29 - 31	8		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel up to 1.5", gray, wet.
35		11	S8	34 - 35.25	6		WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM); fine to coarse sand,

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO. NES - 004
	LOCATION	North Easton, MA	
	OWNER	Mass.Bay Transportation Authority	
	JOB NUMBER	E2347101	SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		52				123.0	some fine gravel, trace silt, grayish-brown, wet, possible GLACIAL TILL.
		100/3" RQD=0	C1	35.5 - 36	3	122.0	GRANITE; very hard, fresh, single vertical fracture, white and black.
							Bottom of Hole at 36'. Unable to complete the rock core due to a silt blow in and bent casing.
40							
45							
50							
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 004

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	NES - 005 OW
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	S. Hooley	ELEVATION	158
				DRILL RIG	ATV CME - 550	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2857807
						GRID COORD E	765289
						DATE START	5/12/10
						DATE END	5/12/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
	Wash Boring w/Casing			
17	NX Rock Core	7/8/2010	17.5	Monitoring Well Reading
27	Terminated	9/12/2011	15.5	Monitoring Well Reading

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		4 3 2 3	S1	0 - 2	17		SILTY SAND (SM); mostly fine sand, little non-plastic silt, brown, moist, FILL.
		120/4"	S2	4 - 4.33	4	154.0	SILTY SAND (SM); fine to coarse sand, little silt, little gravel, gray, wet.
5							
		120/3"	S3	8 - 8.25	0		NO RECOVERY Boulders/cobbles encountered.
10							
		26 28 25 94	S4	13 - 15	8	145.0	WELL GRADED GRAVEL WITH SAND (GW); fine to coarse gravel up to 2", some fine to coarse sand, grayish brown, wet.
15							
		RQD=56	C1	17 - 22	50	141.0	GRANITE; hard, joints spaced 1 - 14", joints angled at ~0 - 10 degrees, slight weathering, white and black with gray.
20							
		RQD=68	C2	22 - 27	54		SIMILAR TO C1; joints spaced 3 - 35".
25							
						131.0	Bottom of Hole at 27'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 005 OW

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	NES - 006	
LOCATION	North Easton, MA			
OWNER	Mass.Bay Transportation Authority			
JOB NUMBER	E2347101		SHEET 1 OF 1	

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		163
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2857666
5.5	NX Rock Core	5/17/2010	3.5	Upon Completion (Casing pulled)			COORD	E	765357
10.5	Terminated						DATE START		5/17/10
							DATE END		5/17/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 8 13 14	S1	0 - 2	10		SILTY SAND (SM); fine to coarse sand, some non-plastic silt, trace fine gravel, brown, moist.
		7 9 16 45	S2	3 - 5	10	160.0	POORLY GRADED SAND (SP); mostly fine sand, light brown, moist.
5		RQD=78	C1	5.5 - 10.5	60	157.5	GRANITE; hard, joints spaced 2 - 18", joints angled at ~15 - 30 degrees, slight weathering, zone of moderate to severe weathering at 9.5 - 10 ft, vertical fractures, gray with black.
10						152.5	Bottom of Hole at 10.5'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)	█	Rock Core (RC) and RQD (%) REC (%)	◢	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯	Undisturbed (U)-Shelby Tube, (P)-Piston	⧗	Jar Sample (JS)	☒	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 006

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	NES - 007
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	D. Dunklee	ELEVATION	158
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR D-90	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID COORD N 2857863
9	Terminated					GRID COORD E	765342
						DATE START	5/13/10
						DATE END	5/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	▨	12 12 11 10	S1	0 - 2	6		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brown, moist, FILL.
5	▨	8 5 12 22	S2	4 - 6	22		POORLY GRADED SAND (SP); mostly fine sand, trace fine gravel, light brown, moist, possible FILL.
	▧					151.5	Possible bedrock encountered at 6.5 ft, roller bit to 9 ft.
						149.0	
10							Bottom of Hole at 9'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 007

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	NES - 008
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	D. Dunklee	ELEVATION	154
				DRILL RIG	TR D-90	DATUM	NGVD 29
				SPT HAMMER	140 lb Auto	GRID N	2858115
						COORD E	765393
						DATE START	5/13/10
						DATE END	5/13/10

METHOD OF DRILLING		GROUNDWATER READINGS		
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS
16	Terminated	5/13/2010	3.5	Upon Completion (In Casing)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	▨	12 22 27 14	S1	0 - 2	16		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brown, FILL.
5	⁘	9 9 9 11	S2	4 - 6	20	150.0	POORLY GRADED SAND (SP); mostly medium sand, brown, moist.
10	⁘	5 5 4 5	S3	9 - 11	12	145.0	POORLY GRADED SAND (SP); mostly medium sand, trace non-plastic silt, grayish brown, wet.
15	⁘	5 21 23 24	S4	14 - 16	10	140.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel up to 2", gray, wet.
						138.0	Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 008

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 009
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring		DRILLER	J. Stokes	ELEVATION		159
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR D-120	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2858362
16	Terminated	5/28/2010	5	Upon Completion (In Casing)			COORD	E	765433
							DATE START		5/28/10
							DATE END		5/28/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		12 6 3 3	S1	0 - 2	4		SILTY SAND (SM); fine to coarse sand, little silt, dark brown, dry, topsoil.
5		30 27 30 21	S2	4 - 6	5	155.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, trace silt, light brown, wet.
10		12 13 16 21	S3	9 - 11	18	150.0	WELL GRADED SAND (SW); fine to coarse sand, trace silt, light brown, wet.
15		11 11 11 8	S4	14 - 16	16	145.0	POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, trace silt, light brown/gray, wet.
						143.0	Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 009

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 011
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	D. Dunklee	ELEVATION	165
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR D-90	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID N	2857799
7	NX Rock Core						COORD E	765403
12	Terminated						DATE START	5/13/10
							DATE END	5/13/10

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	2 2 3 3	S1	0 - 2	20		POORLY GRADED SAND (SP); mostly fine sand, brown, moist.
4	25 70 120/2"	S2	4 - 5.16	8		POORLY GRADED SAND (SP); mostly medium sand, brown, moist.
5					160.0	Top of bedrock at 5 ft, roller bit to 7 ft.
7	RQD=25	C1	7 - 12	18		
12					153.0	Core Barrel bit and casing break in hole, boring abandoned.
						Bottom of Hole at 12'.

Depth scale: 5, 10, 15, 20, 25, 30, 35

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 011

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail		BORING NO.	NES - 011A	
	LOCATION	North Easton, MA				
	OWNER	Mass.Bay Transportation Authority				
	JOB NUMBER	E2347101			SHEET 1 OF 1	
INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	J. Stokes	ELEVATION 162
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM NGVD 29

	METHOD OF DRILLING	DATE/TIME	DEPTH(ft)	REMARKS		
	Wash Boring w/Casing			SPT HAMMER 140 lb Safety	GRID N	2857799
7	NX Rock Core				COORD E	765403
20	Terminated				DATE START	5/26/10
					DATE END	5/27/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Boring offset from NES - 011 and continued as NES - 011A.
5						156.5	Top of rock at 5.5 ft, roller bit to 7 ft.
			C1	7 - 11	20		Granite Boulder
10							
		120/3"	S1	11 - 11.25	0		NO RECOVERY.
			C2	12 - 13	3		Granite Boulder
		120/1"	S2	13 - 13.08	0		NO RECOVERY; roller bit to 15 ft.
15		RQD=70	C3	15 - 20	48		GRANITE; very hard, joints spaced 2 - 12", joints angled at ~0 - 15 degrees, fresh and smooth joint surfaces, gray with black and white.
20						142.0	
							Bottom of Hole at 20'.
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 011A

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	NES - 012
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	J. Stokes	ELEVATION	166
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR D-120	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft) REMARKS	SPT HAMMER	140 lb Safety	GRID N	2857961
8	Terminated					COORD E	765439
						DATE START	5/27/10
						DATE END	5/27/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 8 100/3"	S1	0.33 - 1.5	7		Top 4" gravel fill. WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, light brown, moist, FILL. Cobbles encountered.
5		28 44 100/3"	S2	4 - 5.25	9	162.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel up to 1.5", grayish-brown, wet, pieces of granite in tip of spoon.
						160.5	Top of apparent bedrock at 5.5 ft, got very hard at 6 ft, roller bit to 8 ft.
						158.0	
10							Bottom of Hole at 8'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 012

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 013
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	J. Stokes
				DRILL RIG	TR CME 75
				SPT HAMMER	140 lb Safety

ELEVATION	159
DATUM	NGVD 29
GRID COORD N	2858205
GRID COORD E	765495
DATE START	5/10/10
DATE END	5/10/10

METHOD OF DRILLING	
	Wash Boring w/Casing
16	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH(ft)	REMARKS

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	42 68 72 81	S1	0 - 2	17		POORLY GRADED SAND WITH GRAVEL (SP); mostly fine sand, some crushed stone, trace silt, brown, moist, FILL.
5	12 19 34 18	S2	4 - 6	22	155.0	POORLY GRADED SAND (SP); mostly fine sand, trace gravel, brown, moist.
10	56 94 100/5"	S3	9 - 10.42	17		POORLY GRADED SAND WITH GRAVEL (SP); mostly fine to medium sand, some gravel, brown, wet.
15	21 23 43 62	S4	14 - 16	13	145.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some gravel, brown, wet.
					143.0	Bottom of Hole at 16'.
20						
25						
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 013

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail		BORING NO.	NES - 014
	LOCATION	North Easton, MA			
	OWNER	Mass.Bay Transportation Authority			
	JOB NUMBER	E2347101			SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	J. Stokes	ELEVATION		166
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID	N	2858455
16	Terminated						COORD	E	765544
							DATE START		5/28/10
							DATE END		5/28/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		3 6 5 4	S1	0 - 2	15		POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM); mostly fine sand, little fine to coarse gravel, trace silt, dry, orange.
5		22 34 42 38	S2	4 - 6	17	162.0	SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some fine to coarse gravel, little silt, gray, dry.
10		19 28 31 33	S3	9 - 11	15		SIMILAR TO S2; moist.
		16 100/3"	S4	14 - 14.75	4		SIMILAR TO S2; wet.
15						151.0	Top of apparent bedrock at 15 ft, roller bit to 16 ft.
						150.0	
							Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2 3 - 4 5 - 8 9 - 15 16 - 30 30 +	VERY SOFT SOFT MEDIUM STIFF STIFF VERY STIFF HARD	0 - 4 5 - 10 11 - 30 31 - 50 51 +	VERY LOOSE LOOSE MEDIUM DENSE DENSE VERY DENSE	< 10% 15 - 25% 30 - 45% 50 - 100%	TRACE LITTLE SOME MOSTLY

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO.	NES - 014

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO. NES - 015
	LOCATION	North Easton, MA	
	OWNER	Mass.Bay Transportation Authority	
	JOB NUMBER	E2347101	SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	T. Pentacost	ELEVATION	173
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER: 140 lb Safety	GRID N	2857827
4	Terminated					COORD E	765511
						DATE START	5/10/10
						DATE END	5/10/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		3 4 4 6	S1	0 - 2	12		SANDY SILT (ML); mostly silt, some sand, trace clay, trace gravel, brown, moist.
		50/1"	S2	4 - 4.08	0	169.0	NO RECOVERY; split-spoon refusal, propable bedrock.
5							Bottom of Hole at 4'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 015

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	NES - 016
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	J. Stokes	ELEVATION	160
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N 2858084
16	Terminated					COORD E	765543
						DATE START	5/10/10
						DATE END	5/10/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		12 19 14 8	S1	0 - 2	16		SILTLY SAND (SM); mostly fine sand, some silt, trace decayed wood pieces, dark brown, moist, FILL.
5		11 12 16 28	S2	4 - 6	24	156.0	POORLY GRADED SAND WITH GRAVEL (SP); mostly fine to medium sand, little fine gravel, brown, moist.
10		47 100/3"	S3	9 - 9.75	7	151.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, gray, wet.
15		28 35 46 52	S4	14 - 16	17		SIMILAR TO S3.
						144.0	Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 016

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 017
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring		DRILLER	J. Stokes	ELEVATION		175
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR D-120	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2858347
9	Terminated						COORD	E	765603
							DATE START		5/28/10
							DATE END		5/28/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		5 10 12 12	S1	0 - 2	7		WELL GRADED SAND (SW); fine to coarse sand, trace silt, roots, orange-brown, dry.
5		41 47 46 51	S2	4 - 6	16	171.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, trace silt, light brown, dry.
						168.0	Top of apparent bedrock at 7 ft, roller bit to 9 ft.
						166.0	
10							Bottom of Hole at 9'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 017

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail		BORING NO.	NES - 019
	LOCATION	North Easton, MA			
	OWNER	Mass.Bay Transportation Authority			
	JOB NUMBER	E2347101			SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring		DRILLER	T. Pentacost	ELEVATION		175
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2857857
7	Terminated						COORD	E	765574
							DATE START		5/10/10
							DATE END		5/10/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		8 4 11 17	S1	0 - 2	10		SANDY SILT (ML); mostly silt, some sand, little gravel, trace clay, brown, moist.
5		38 47 60 120	S2	4 - 6	16	171.0	WELL GRADED SAND WITH GRAVEL (SW); mostly fine to medium sand, some fine to coarse gravel, trace silt, brown, moist.
		120/0"	S3	7 - 7		168.0	Refusal on probable bedrock, offset boring to NES - 019A.
							Bottom of Hole at 7'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 019

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	NES - 019A
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	J. Stokes	ELEVATION	175

METHOD OF DRILLING		GROUNDWATER READINGS								
		DATE/TIME	DEPTH(ft)	REMARKS	DRILL RIG	TR CME 75	DATUM		NGVD 29
	Wash Boring w/Casing				SPT HAMMER	140 lb Safety	GRID COORD	N	2857857
9	NX Rock Core	5/10/2010	3	Upon Completion (In Casing)				E	765574
14	Terminated						DATE START		5/10/10
							DATE END		5/10/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Boring offset from NES - 019, roller bit to 4 ft.
5		29 18 38 100/4"	S1	4 - 5.83	12		POORLY GRADED SAND WITH GRAVEL (SP); mostly fine to medium sand, some fine gravel, trace silt, brown, moist.
						168.5	Top of bedrock at 6.5 ft, roller bit to 9 ft.
10		RQD=65	C1	9 - 14	50		GRANITE; very hard, coarse grained, joints spaced 6 - 24", high angle fracture at 10.5 ft, gray and pink.
						161.0	
15							Bottom of Hole at 14'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 019A

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 020
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	J. Stokes	ELEVATION	175
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2857629
10	Terminated						COORD E	765832
							DATE START	5/25/10
							DATE END	5/25/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		9 12 26 42	S1	0 - 2	17		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brown, moist, FILL.
5		16 59 100/2"	S2	4 - 5.16	6	171.0	SILTY SAND WITH GRAVEL (SM); fine to coarse sand, little non-plastic silt, little fine gravel, brown, wet.
						169.5	Top of apparent bedrock at ~5.5 ft, roller bit to 10 ft.
10						165.0	
							Bottom of Hole at 10'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

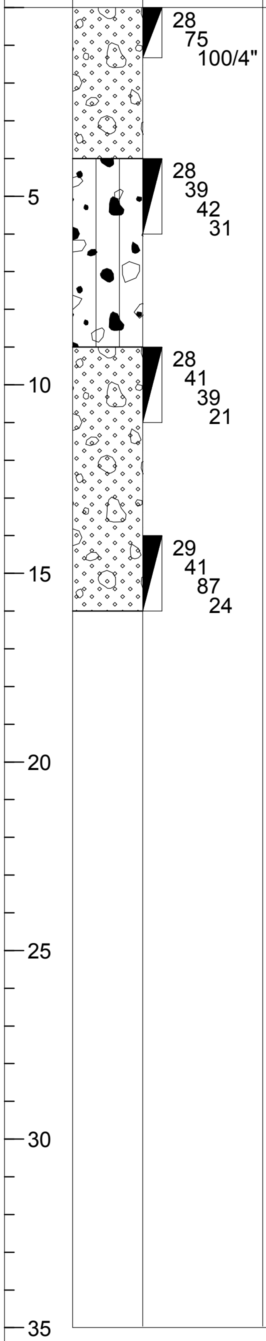
REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 020

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 021	
	LOCATION	North Easton, MA			
	OWNER	Mass.Bay Transportation Authority			
	JOB NUMBER	E2347101		SHEET 1 OF 1	

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	J. Stokes	ELEVATION	162
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2857498
16	Terminated						COORD E	765616
							DATE START	5/25/10
							DATE END	5/25/10



SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
28 75 100/4"	S1	0 - 1.33	14		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to medium gravel, dry, brown.
28 39 42 31	S2	4 - 6	19	158.0	GRAVEL WITH SILT AND SAND (GW - GM); fine to coarse gravel, some fine to coarse sand, trace silt, gray, moist.
28 41 39 21	S3	9 - 11	16	153.0	WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, moist, brown.
29 41 87 24	S4	14 - 16	14		SIMILAR TO S3; wet.
				146.0	Bottom of Hole at 16'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 021

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	NES - 022
LOCATION	North Easton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	144
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID N	2857303
						COORD E	765208
						DATE START	5/19/10
						DATE END	5/19/10

METHOD OF DRILLING	
	Wash Boring w/Casing
5	NX Rock Core
15	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH(ft)	REMARKS
5/19/2010	3	Upon Completion (Casing pulled)

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	3 3 4 6	S1	0.33 - 2.33	16	143.7	Top 4" Topsoil. SILT (ML); non-plastic silt, trace fine to coarse sand, light brown, dry.
	23 65 57 67	S2	3 - 5	9	141.0	SILTY SAND (SM); mostly fine sand, little non-plastic silt, grayish-brown, moist.
5	RQD=25	C1	5 - 10	30	139.0	GRANITE; hard, joints spaced 2 - 9", joints angled at ~10 - 60 degrees, slight to moderate weathering, zones of highly fractured rock, some vertical fractures, sand seams, loss of water, gray with black.
10	RQD=50	C2	10 - 15	42		GRANITE; hard, joints spaced 2 - 23", joints angled at ~ 45 degrees, slight to moderate weathering, zone of highly fractured and weathered rock at 10 ft, vertical fractures, loss of drill water, gray with black.
15					129.0	Bottom of Hole at 15'.
20						
25						
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

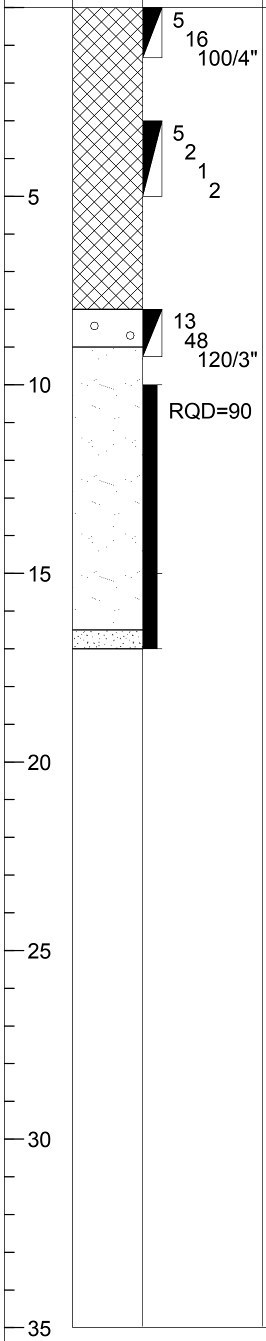
REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 022

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	NES - 023
	LOCATION	North Easton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		162
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2857589
10	NX Rock Core						COORD	E	765408
17	Terminated						DATE START		5/17/10
							DATE END		5/18/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		5 16 100/4"	S1	0 - 1.33	10		SILTY SAND (SM); fine to coarse sand, some non-plastic silt, trace fine gravel, brown, moist, FILL. Boulder encountered at 1.5 ft, move boring 5 ft south.
		5 2 1 2	S2	3 - 5	6		SIMILAR TO S1; wet.
		13 48 120/3"	S3	8 - 9.25	7	154.0 153.0	WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, light brown, moist.
		RQD=90	C1	10 - 15	54		GRANITE; very hard, fresh, one mechanical break, some high angle fractures and intrusions, gray with black and white.
			C2	15 - 17	10	145.5 145.0	(15 - 16.5') GRANITE; very hard, moderate weathering, highly fractured, 6" seam at 15.5 ft, gray with black and white. (16.5 - 17') GABBRO; hard, moderate weathering, highly fractured, black.
							Bottom of Hole at 17'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)
█	Rock Core (RC) and RQD (%) REC (%)
◤	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
▯	Undisturbed (U)-Shelby Tube, (P)-Piston
⧗	Jar Sample (JS)
☒	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NES - 023

APPENDIX B: LABORATORY DATA

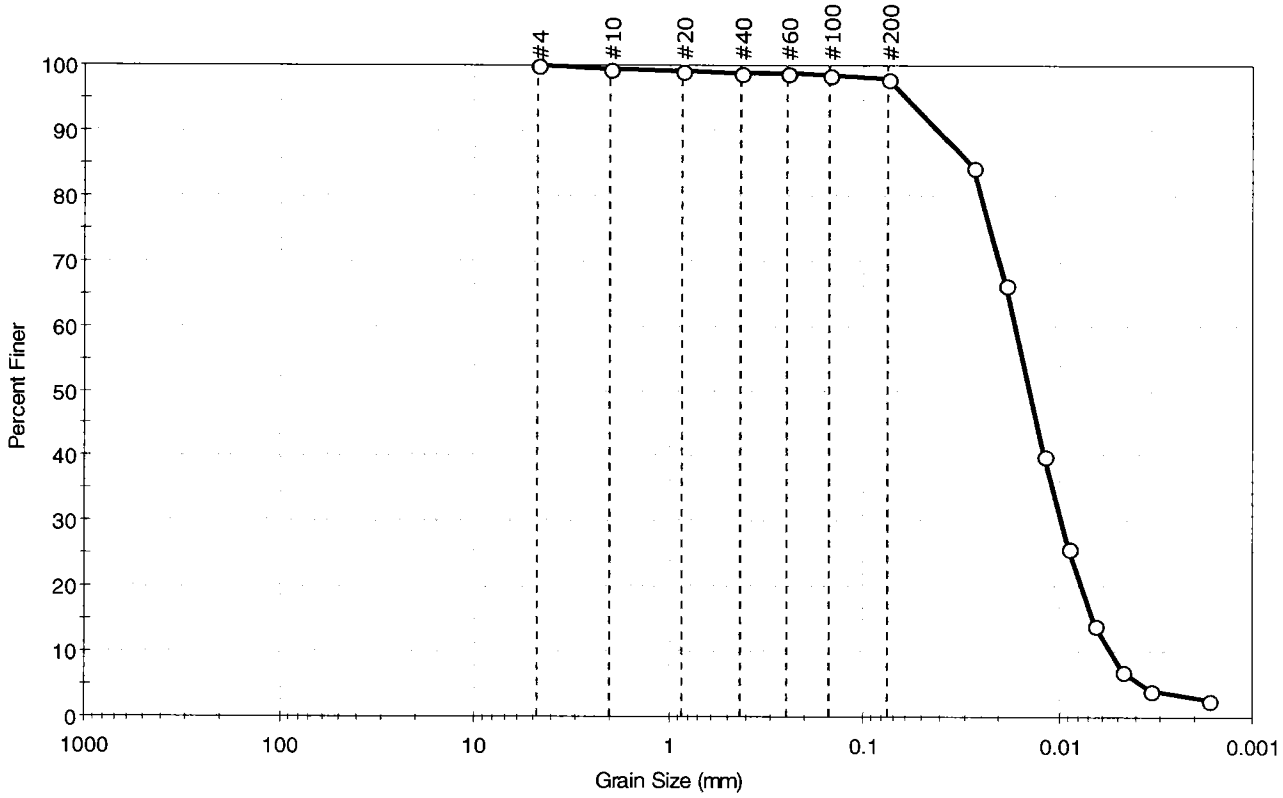
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764

Boring ID: NES-4
Sample ID:S-4
Depth : 14-16 ft
Sample Type: jar
Test Date: 07/21/10
Test Id: 185189
Tested By: jbr
Checked By: jdt

Test Comment: ---
Sample Description: Moist, light olive brown silty sandy clay
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	1.9	98.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	99		
#20	0.85	99		
#40	0.42	99		
#60	0.25	99		
#100	0.15	98		
#200	0.075	98		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0274	84		
---	0.0186	66		
---	0.0121	40		
---	0.0089	26		
---	0.0065	14		
---	0.0047	7		
---	0.0033	4		
---	0.0017	3		

Coefficients

D_{85} =0.0285 mm
D_{30} =0.0097 mm
D_{60} =0.0168 mm
D_{15} =0.0067 mm
D_{50} =0.0142 mm
D_{10} =0.0054 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

printed 7/21/2010 12:32:21 PM

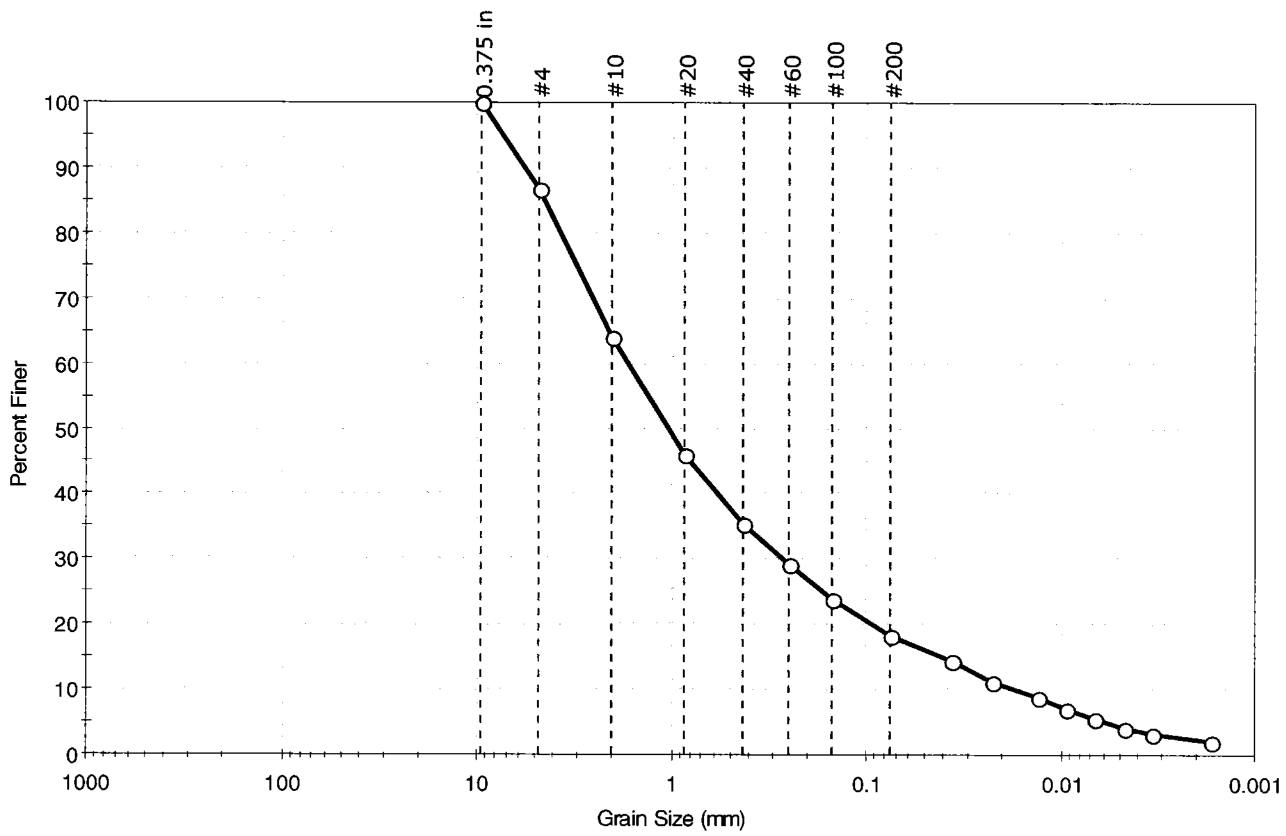
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764

Boring ID: NES-5
Sample ID:S-2
Depth : 4-4.33 ft
Sample Type: jar
Test Date: 07/21/10
Test Id: 185188
Tested By: jbr
Checked By: jdt

Test Comment: ---
Sample Description: Moist, light olive gray silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	13.3	68.3	18.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	87		
#10	2.00	64		
#20	0.85	46		
#40	0.42	35		
#60	0.25	29		
#100	0.15	24		
#200	0.075	18		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0363	14		
---	0.0229	11		
---	0.0133	9		
---	0.0095	7		
---	0.0067	6		
---	0.0047	4		
---	0.0033	3		
---	0.0017	2		

Coefficients

D_{85} =4.4610 mm
D_{30} =0.2696 mm
D_{60} =1.6488 mm
D_{15} =0.0399 mm
D_{50} =1.0270 mm
D_{10} =0.0174 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

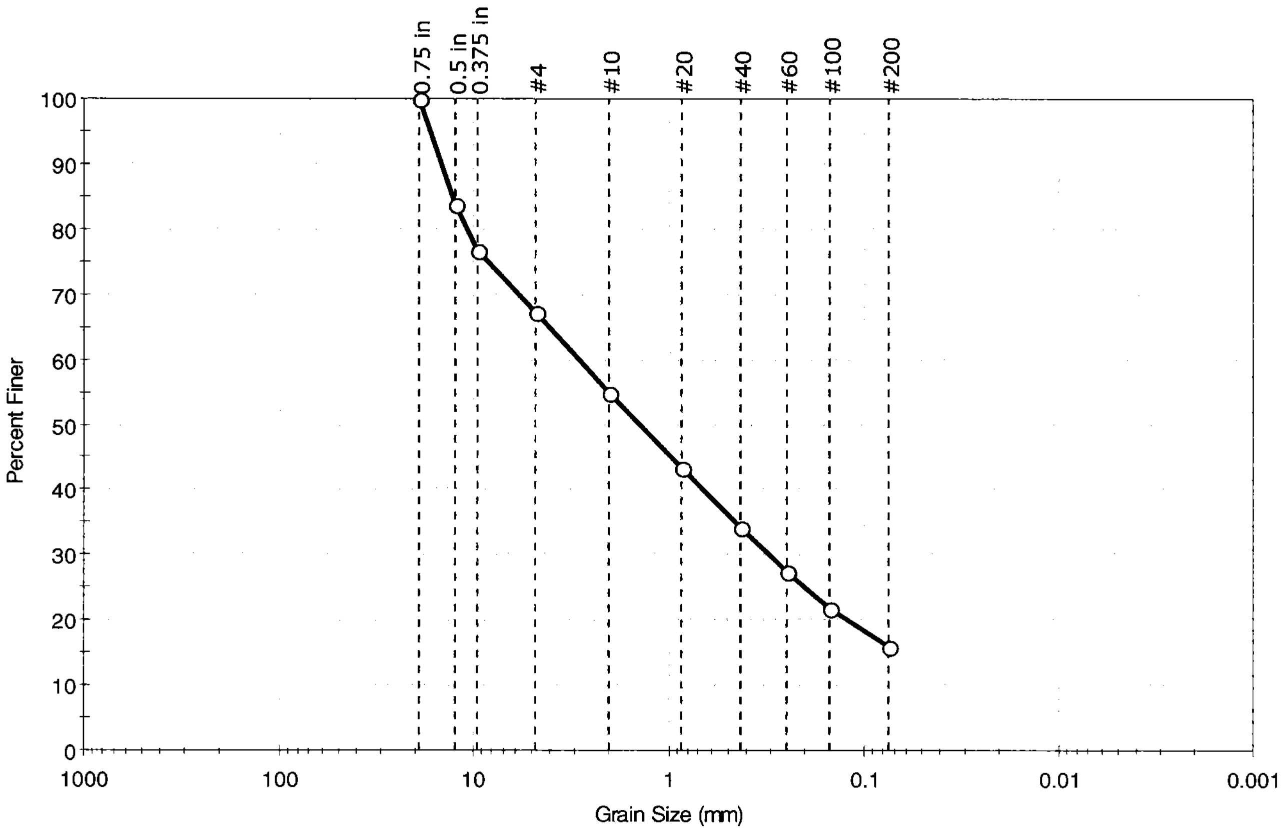
printed 7/21/2010 12:30:02 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	NES-14	Sample Type:	jar	Tested By:	jbr
Sample ID:	S-2	Test Date:	07/14/10	Checked By:	jdt
Depth :	4-6 ft	Test Id:	185198		

Test Comment: ---
Sample Description: Moist, olive silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	32.7	51.3	16.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	84		
0.375 in	9.50	77		
#4	4.75	67		
#10	2.00	55		
#20	0.85	43		
#40	0.42	34		
#60	0.25	28		
#100	0.15	22		
#200	0.075	16		

Coefficients

D_{85} =12.9421 mm
D_{30} =0.3042 mm
D_{60} =2.8531 mm
D_{15} =N/A
D_{50} =1.3841 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

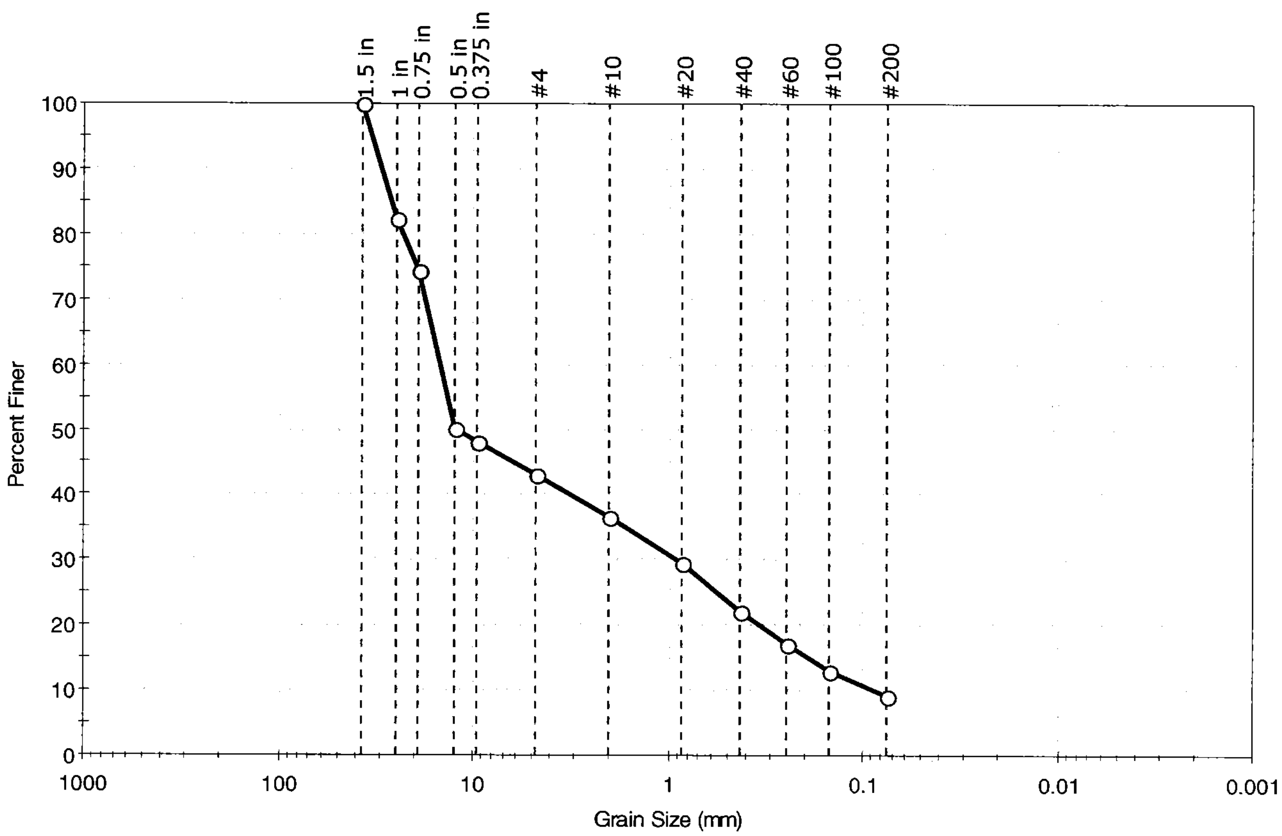
printed 7/20/2010 9:52:50 AM

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.			
Project: South Coast Rail			
Location: MA		Project No:	GTX-9764
Boring ID: NES-21	Sample Type: jar	Tested By:	jbr
Sample ID:S-2	Test Date: 07/14/10	Checked By:	jdt
Depth : 4-6 ft	Test Id: 185199		

Test Comment: ---
Sample Description: Moist, olive gray gravel with silt and sand
Sample Comment: sample jar received broken

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	56.9	34.1	9.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	82		
0.75 in	19.00	74		
0.5 in	12.50	50		
0.375 in	9.50	48		
#4	4.75	43		
#10	2.00	37		
#20	0.85	29		
#40	0.42	22		
#60	0.25	17		
#100	0.15	13		
#200	0.075	9		

Coefficients

D_{85} =26.6354 mm	D_{30} =0.9130 mm
D_{60} =14.8269 mm	D_{15} =0.1950 mm
D_{50} =12.1561 mm	D_{10} =0.0897 mm
C_u =165.294	C_c =0.627

Classification

ASTM	N/A
AASHTO	Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

APPENDIX C: GEOTECHNICAL CALCULATIONS

- Allowable Bearing Capacity and Estimated Settlement
- Seismic Site Class Evaluation

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

SHEET 1 OF 2
JOB MBTA South Coast Rail
SUBJECT North Easton Station
CALCULATED BY DH **DATE** 1/23/2012
CHECKED BY PM **DATE** 1/23/2012

PURPOSE: Evaluate bearing resistance for platform shallow foundations.

REFERENCE: AASHTO LRFD Bridge Design Specifications, 2010
AREMA Manual for Railway Engineering, 2011 Edition

ASSUMPTIONS:

- Platform footing is 4 ft wide by 10 ft long.
- Bearing surface is well graded sand (SW) or silty sand (SM) w/ gravel.
- Footing embedment is at least 4 feet below ground surface.
- Groundwater level is at 15 feet below surface.
- Footing eccentricity is assumed to be zero.
- Estimated soil properties (experience, geotech literature, Table 10.4.6.2.4-1):

	γ (pcf)	ϕ
Sand or silty sand:	120	33

BEARING CAPACITY FACTORS (Table 10.6.3.1.2a-1):

	ϕ	N_c	N_q	N_γ
Med. Dense Sand or Silty Sand with gravel:	33	38.6	26.1	35.2

CALCULATE EFFECTIVE FOOTING WIDTH (B'):

$e < B/4$ (Section 10.6.3.3)

where: B = footing width (ft) = 4
e = eccentricity (ft)

Assume no footing eccentricity, thus, e = 0

B' = B-2e 4

NOMINAL BEARING RESISTANCE (q_n):

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$ (Eqn. 10.6.3.1.2a-1)

where: c = cohesion = 0
γ = total unit weight 120
D_f = depth of footing (ft) = 4 Assumed
B' = effective width of footing (ft) = 4
L = length of footing (ft) = 10
B'/L = 0.40
D_f /B' = 1.00
C_{wq} $C_{w\gamma}$ = groundwater correction factors (using B')
C_{wq} = 1.0 (Table 10.6.3.1.2a-2)
$C_{w\gamma}$ = 1.0 (Table 10.6.3.1.2a-2)

N_{cm} N_{qm} $N_{\gamma m}$ = bearing capacity factors

$N_{qm} = N_q s_q d_q i_q$ (Eqn. 10.6.3.1.2a-3)

s_q = 1.26 (Table 10.6.3.1.2a-3)

d_q = 1.20 (Table 10.6.3.1.2a-4)

i_q = 1.0 (see AASHTO p. 10-62)

N_{qm} = 39.5

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

$s_\gamma =$ 0.84 (Table 10.6.3.1.2a-3)

$i_\gamma =$ 1 (see AASHTO p. 10-62)

$N_{\gamma m} =$ 29.6

$q_n =$ 26,035 psf

ALLOWABLE BEARING RESISTANCE (q_a):

$q_a = q_n$/FOS

where: FOS = factor of safety = 2.5 for sand

$q_a =$ 10,414 psf

use

$\boxed{\mathbf{q_a = 10.41\ ksf}}$ strength limit value

Note: Based on the anticipated light loads and potentially small footing sizes, an allowable bearing capacity of 5 ksf is recommended.

Elastic Settlement Calculations:

$$S_e = \frac{\left(q_o\,(1-v^2)\sqrt{A'}\right)}{144E_s\beta_z}$$ eqn. 10.6.2.4.2-1

where: q_o = applied vert. stress (ksf)
v = Poisson's Ratio
E_s = Young's Modulus (ksi)
β_z = Shape/Rigidity Factor

v = Poisson's Ratio = 0.25 (Table C10.4.6.3-1)
E_s = Young's Modulus (ksi) = 5.00 (Table C10.4.6.3-1)
β_z = Shape/Rigidity Factor = 1.11 (Table 10.6.2.4.2-1)

where: B' = eff. width of footing (ft) = 4 (from bearing resistance calcs)
L = length of footing (ft): 10 (from bearing resistance calcs)
A' =(B'xL) = footing area (ft^2): 40 ft^2

Settlement (S_e) for a given q_o:

q_o = applied vertical stress (ksf) = 5.00 ksf (assumed)

Se (inches) = 0.45 inches

JACOBS

Authored by: DH 1/23/2012
Seismic Parameters_NES.xls

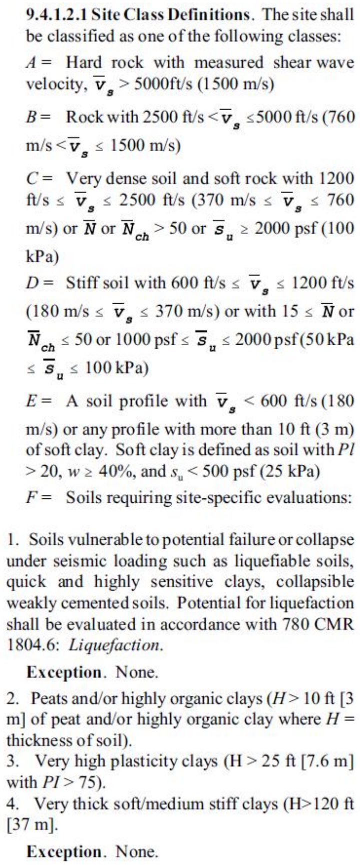
Checked by: PM 1/23/2012

North Easton Station Seismic Site Class Evaluation

Based on the platform boring with the deepest soil overburden (worst case)

Boring No.	Sample No.	N Value	Di	D_i/N_i	N_{bar}
NES-4	S-1	17	4	0.24	59
	S-2	21	5	0.24	
	S-3	40	5	0.13	
	S-4	39	5	0.13	
	S-5	37	5	0.14	
	S-6	44	5	0.11	
	S-7	92	6	0.07	
	Weathered rock	100	65	0.65	
	Total Depth =	100			
	Depth to Bedrock =	35			

Per 9.4.1.2.1*, $N_{bar} > 50$, Site Class C



9.4.1.2.1 Site Class Definitions. The site shall be classified as one of the following classes:

A = Hard rock with measured shear wave velocity, $\overline{v}_s$ > 5000ft/s (1500 m/s)

B = Rock with 2500 ft/s < $\overline{v}_s$ ≤ 5000 ft/s (760 m/s < $\overline{v}_s$ ≤ 1500 m/s)

C = Very dense soil and soft rock with 1200 ft/s ≤ $\overline{v}_s$ ≤ 2500 ft/s (370 m/s ≤ $\overline{v}_s$ ≤ 760 m/s) or $\overline{N}$ or $\overline{N}_{ch}$ > 50 or $\overline{s}_u$ ≥ 2000 psf (100 kPa)

D = Stiff soil with 600 ft/s ≤ $\overline{v}_s$ ≤ 1200 ft/s (180 m/s ≤ $\overline{v}_s$ ≤ 370 m/s) or with 15 ≤ $\overline{N}$ or $\overline{N}_{ch}$ ≤ 50 or 1000 psf ≤ $\overline{s}_u$ ≤ 2000 psf (50 kPa ≤ $\overline{s}_u$ ≤ 100 kPa)

E = A soil profile with $\overline{v}_s$ < 600 ft/s (180 m/s) or any profile with more than 10 ft (3 m) of soft clay. Soft clay is defined as soil with *PI* > 20, *w* ≥ 40%, and s_u < 500 psf (25 kPa)

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. Potential for liquefaction shall be evaluated in accordance with 780 CMR 1804.6: *Liquefaction*.

Exception. None.

2. Peats and/or highly organic clays (*H* > 10 ft [3 m] of peat and/or highly organic clay where *H* = thickness of soil).
3. Very high plasticity clays (H > 25 ft [7.6 m] with *PI* > 75).
4. Very thick soft/medium stiff clays (H>120 ft [37 m].

Exception. None.

Approx. Project Coordinates

Lat	42.088658
Long	-71.098197

Seismic Coefficients

S_S = 0.25 (Table 1604.10*)
S_1 = 0.064 (Table 1604.10*)

For Site Class C

F_A = 1.2 (See Table 9.4.1.2.4a*)
F_V = 1.7 (See Table 9.4.1.2.4b*)

Design Spectral Response Parameters

S_{MS} = Ss x F_A = 0.300
S_{M1} = S_1 x F_V = 0.109

S_{DS} = 2/3 x S_{MS} = 0.200
S_{D1} = 2/3 x S_{M1} = 0.073

Notes: * The Massachusetts State Building Code, 8th Edition (2010)

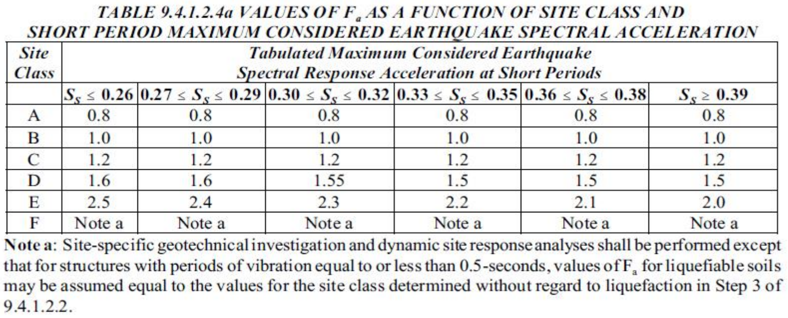


TABLE 9.4.1.2.4a VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods*					
	$S_S \le 0.26$	$0.27 \le S_S \le 0.29$	$0.30 \le S_S \le 0.32$	$0.33 \le S_S \le 0.35$	$0.36 \le S_S \le 0.38$	$S_S \ge 0.39$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5	1.5	1.5
E	2.5	2.4	2.3	2.2	2.1	2.0
F	Note a	Note a	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

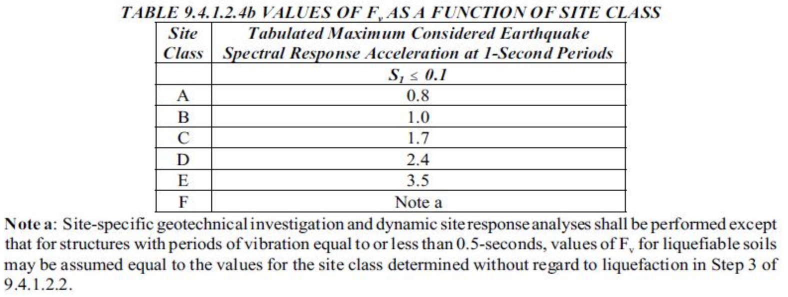


TABLE 9.4.1.2.4b VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods*
	$S_1 \le 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

TABLE 1604.10 GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

(For R-3 of three stories or less one- and two-family stand alone buildings, see 780 CMR 53.00 for snow and wind loads)

City/Town	Ground Snow Load $p_{g,}$ psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Cambridge	45	105	0.28	0.068
Canton	55	100	0.26	0.066
Carlisle	55	100	0.29	0.071
Carver	45	110	0.24	0.060
Charlemont	65	100	0.22	0.068
Charlton	55	100	0.23	0.065
Chatham	35	120	0.17	0.050
Chelmsford	55	100	0.30	0.073
Chelsea	45	105	0.29	0.069
Cheshire	65	90	0.22	0.068
Chester	65	100	0.22	0.066
Chesterfield	65	100	0.22	0.067
Chicopee	55	100	0.23	0.066
Chilmark	35	120	0.18	0.051
Clarksburg	65	90	0.22	0.069
Clinton	55	100	0.26	0.068
Cohasset	45	110	0.27	0.066
Colrain	65	100	0.23	0.069
Concord	55	100	0.29	0.070
Conway	65	100	0.22	0.068
Cummington	65	100	0.22	0.067
Dalton	65	90	0.22	0.067
Danvers	45	110	0.32	0.073
Dartmouth	45	110	0.23	0.058
Dedham	55	100	0.26	0.066
Deerfield	65	100	0.23	0.068
Dennis	35	120	0.19	0.052
Dighton	55	110	0.24	0.061
Douglas	55	100	0.23	0.064
Dover	55	100	0.26	0.066
Dracut	55	100	0.33	0.075
Dudley	55	100	0.23	0.064
Dunstable	65	100	0.31	0.074
Duxbury	45	110	0.25	0.062
East Bridgewater	45	110	0.25	0.063
East Brookfield	55	100	0.23	0.066
East Longmeadow	55	100	0.23	0.065
Eastham	35	120	0.19	0.052
Easthampton	55	100	0.23	0.066
Easton	55	110	0.25	0.064
Edgartown	35	120	0.18	0.050
Egremont	65	90	0.23	0.066
Erving	65	100	0.23	0.069
Essex	45	110	0.33	0.073
Everett	45	105	0.29	0.069
Fairhaven	45	110	0.22	0.057
Fall River	45	110	0.23	0.059
Falmouth	35	120	0.20	0.054
Fitchburg	65	100	0.27	0.071
Florida	65	90	0.22	0.069

Stormwater Report

Raynham Park Station

Town of Raynham, Massachusetts

Prepared for

massDOT
Massachusetts Department of Transportation
10 Park Plaza
Boston, Massachusetts

Prepared by

VHB/**Vanasse Hangen Brustlin, Inc.**
Transportation, Land Development, Environmental Services
99 High Street
Boston, Massachusetts 02110
617 728 7777

June 2012

Table of Contents

List of Figures

List of Tables

Appendices

Checklist for Stormwater Report

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

✓ tab

return ✗

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☒ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

  ☐ Credit 1

  ☐ Credit 2

  ☐ Credit 3

☒ Use of “country drainage” versus curb and gutter conveyance and pipe

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☐ Other (describe): ______________________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☒ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

---

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☒ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

  ☒ The ½" or 1" Water Quality Volume or

  ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☒ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☒ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

  ☐ Name of the stormwater management system owners;

  ☐ Party responsible for operation and maintenance;

  ☐ Schedule for implementation of routine and non-routine maintenance tasks;

  ☐ Plan showing the location of all stormwater BMPs maintenance access areas;

  ☐ Description and delineation of public safety features;

  ☐ Estimated operation and maintenance budget; and

  ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

  ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;

  ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Water Quality Certification Regulations (314 CMR 9.00).

Project Description

The Applicant, MassDOT, is proposing to construct a train station at Raynham Park located at 1958 Broadway Street in Raynham, Massachusetts along the Stoughton Rail Road Line (the Project). The Project will involve a center platform with canopy, ancillary landscape improvements, 432 parking spaces, bicycle parking facilities, and utility improvements to support this use. The Project involves demolishing abandoned kennels and several small buildings that currently exist on the site.

The site is not considered a Land Use with Higher Potential Pollutant Loads (LUHPPL) as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Site Description

The Project Site is an 11.4-acre parcel of land (the Site) located at 1958 Broadway Street in Raynham, Massachusetts (see Figure 1, Site Locus Map and Figure 2, Site Aerial). The site is located to the south of the former Raynham Park Greyhound Track and is adjacent to industrial buildings to the south, Route 138 (Broadway) to the east, and the MBTA railroad right-of-way to the west.

Wetland Resource Areas on the Site, shown on Figures 3 and 4, are described in Table 1. For additional information regarding the wetland resource areas present on the site see the Abbreviated Notice of Resource Area Delineation (ANRAD) prepared by VHB dated May 2011.

Table 1
Wetland Resource Areas

Name	*Critical Area*	*Zone 1 or Zone A*	*ORW or SRW*	*Zone II or IWPA*	*Description*
Wetland R62.1	No	No	No	No	PSS/PEM/OW
Wetland R4	No	No	No	No	PFO
Wetland R5	No	No	No	No	PFO

Notes: Wetland Classifications: OW = Open Water, PEM = Palustrine Emergent, PFO = Palustrine Forested, PSS = Palustrine Scrub/Shrub

According to the National Resources Conservation Service (NRCS), surface soils on the Site include Scarboro mucky loamy fine sand, Whitman fine sandy loam, and Urban land, and are all classified as Hydrologic Soil Groups (HSG) D. Based on the soil evaluation, the Site is not considered to be within an area of rapid infiltration (soils with a saturated hydraulic conductivity greater than 2.4 inches per hour) and high bedrock is indicated. The poorly drained soils onsite have a very low potential for infiltration. According to 1982 Rawls Rates, infiltration rates for the soils will be approximately 0.09 inches per hour.

The project is not located within the 100-year flood plain as shown on the FEMA Floodway Map, Town of Raynham, Massachusetts Bristol County, Community Panel Number 25005C0152F dated July 7, 2009. This map is included in Appendix B.

Existing Drainage Conditions

Under existing conditions the Site is almost entirely developed, impervious land. For the existing conditions hydrologic analysis, the site was divided into four drainage areas that contribute to four separate design points. The following is a summary of each drainage area.

Drainage Area 1 – This 6.85-acre area in the northeast portion of the site consists mainly of urban land that includes both paved and dirt roads. This area sheet flows, untreated, to the existing parking lot to the north where it is captured by the closed drainage system on the adjacent parcel.

Drainage Area 2 – This 1.63-acre area in the southeast portion of the site consists mainly of paved areas and some small dirt roads that sheet flows, untreated, to Wetland R5 east of the site.

Drainage Area 3 – This 7.54-acre area in the northwest portion of the site consists predominantly of paved areas with small patches of grassed areas that sheet flows, untreated, to the parking area to the north where it is captured by a closed drainage system on the adjacent parcel.

Drainage Area 4 – This 3.94-acre area in the southwest portion of the site consists predominantly of urban land that includes paved parking areas and driveways and small buildings and kennels. This area sheet flows, untreated, to the west to Wetland R62.1 via an unnamed perennial stream that continues to flow to the north.

Figure 3 illustrates the existing drainage patterns on the Site. Table 2 below provides a summary of the existing conditions hydrologic data.

Table 2
Existing Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Adjacent Parking Area	1	6.85	97	6.1
2	Wetland R5	2	1.63	94	3.7
3	Adjacent Parking Area / Drainage System	3	7.54	94	19.6
4	Wetland R62.1 (Perennial Stream)	4	3.94	89	17.1

Proposed Drainage Conditions

Figure 4 illustrates the proposed "post construction" drainage conditions for the project. As shown, the Site would be divided into four drainage areas that discharge treated stormwater to the same four existing Design Points. Existing drainage and grading patterns were maintained to the maximum extent possible in proposed conditions. Low impact development stormwater management techniques have been incorporated into the design. These practices are focused on decentralizing stormwater management techniques into the design that will reduce peak runoff rates, maximize groundwater recharge and treat for water quality. The following is a summary of each drainage area.

Drainage Areas 1 (1.1 & 1.2) – These two drainage areas combined, are the 6.60-acre area in the northeast portion of the site that consists of existing landscaped and broken pavement area that would remain unchanged in proposed conditions and a paved driveway leading to the station. The paved driveway of this area will sheet flow into two new grassed swales and then conveyed into a bioretention basin for treatment. During large events the bioretention basin will overflow at a designed overflow weir and sheet flow across the adjacent parcel and be captured by the catch basins as it does in existing conditions. The landscaped and broken paved areas would continue to sheet flow as it does in existing conditions before being captured by catch basins and discharged to the existing closed drainage system on the adjacent parcel.

Drainage Area 2 – This 2.03-acre area in the southeast portion of the site will be an entirely landscaped area and would sheet flow to Wetland R5 east of the site. Under existing conditions this area is predominantly pavement and discharges, untreated, to the same design point.

Drainage Area 3.1 – This 2.04-acre area in the northwest portion of the site will consist of paved parking areas for the station and landscaped islands . The paved parking areas for the station would be collected by two deep sump hooded catch basins that then discharge to a sediment forebay and bioretention area for further treatment. In larger storm events the bioretention basin would overflow at a designed overflow weir and sheet flow to the adjacent parcel before being captured by the existing catch basins as it does under existing conditions.

Drainage Area 3.2 – This 5.71-acre area in the northwest portion of the site will consist of paved roadways and existing landscaped areas that would remain unchanged. This portion of the drainage area 3 would sheet flow, as it does in existing conditions, to the adjacent parcel before being captured by the existing catch basins as it does under existing conditions.

Drainage Area 4 – This 4.20-acre area in the southwest portion of the site will consist predominantly of paved parking areas for the station which will sheet flow through a gravel and grass filter strip then into a bioretention swale before being discharged to a culvert beneath the rail tracks and then to the unnamed perennial stream, as it does in existing conditions.

Table 3 below provides a summary of the proposed conditions hydrologic data.

Table 3
Proposed Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Adjacent Parking Area	1	6.60	95	8.4
2	Wetland R5	2	2.03	89	10.4
3.1	Adjacent Parking Area/Drainage System	3	2.04	96	14.1
3.2	Adjacent Parking Area/Drainage System	3	5.71	91	15.1
4	Wetland R62.1 (Perennial Stream)	4	4.20	91	16.6

The site has been designed with a comprehensive stormwater management system that has been developed in accordance with the Massachusetts Stormwater Handbook. Although the site does not discharge directly to a critical area, the proposed stormwater management system has been designed to treat the 1.0 inch Water Quality Volume, because drainage from the site ultimately discharges to an Area of Critical Environmental Concern (ACEC).

Environmentally Sensitive and Low Impact Development (LID) Techniques

Low Impact Development (LID) techniques and stormwater Best Management Practices (BMPs) incorporated in the site design include:

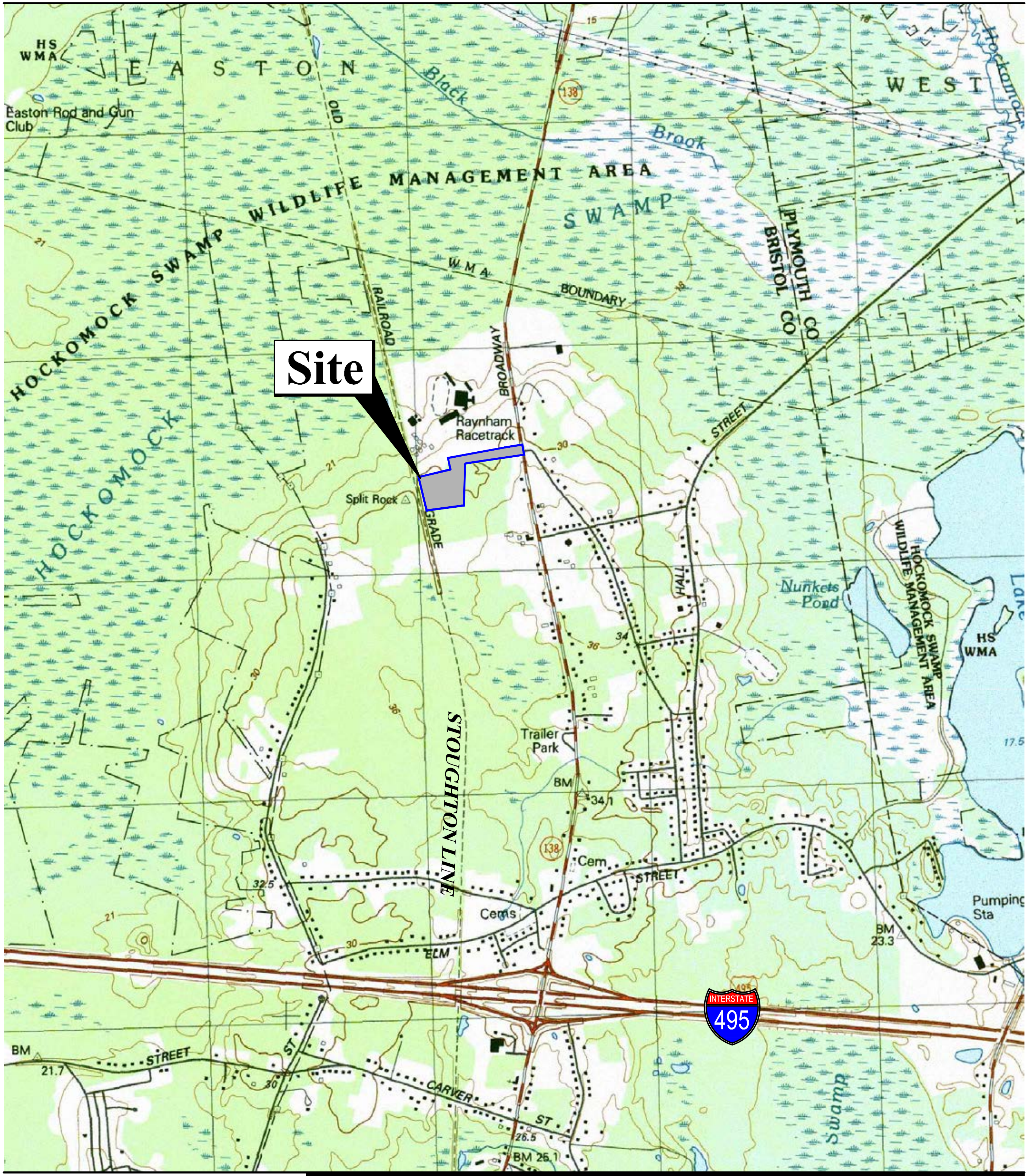
- Reduction of impervious area of 0.5 acres.
- Minimal disturbance to exiting trees and vegetation
- Grassed channel
- Gravel and grass filter strip
- Two bioretention basins and swales
- Bioretention swale

In general, stormwater runoff from all impervious surfaces in proposed conditions would receive some form of treatment for stormwater quality prior to discharge to the existing design points. Under existing conditions no such treatment is provided for stormwater runoff.

Hydraulic Analysis

The closed drainage system was designed for the 25-year storm event, in accordance with the Massachusetts Bay Transportation Authority, Railroad Operations, Commuter Rail Design Standards Manual, Volume 1.

Drainage pipes were sized using Manning's Equation for full-flow capacity and the Rational Method. Pipe sizing calculations are included in Appendix A of this report.

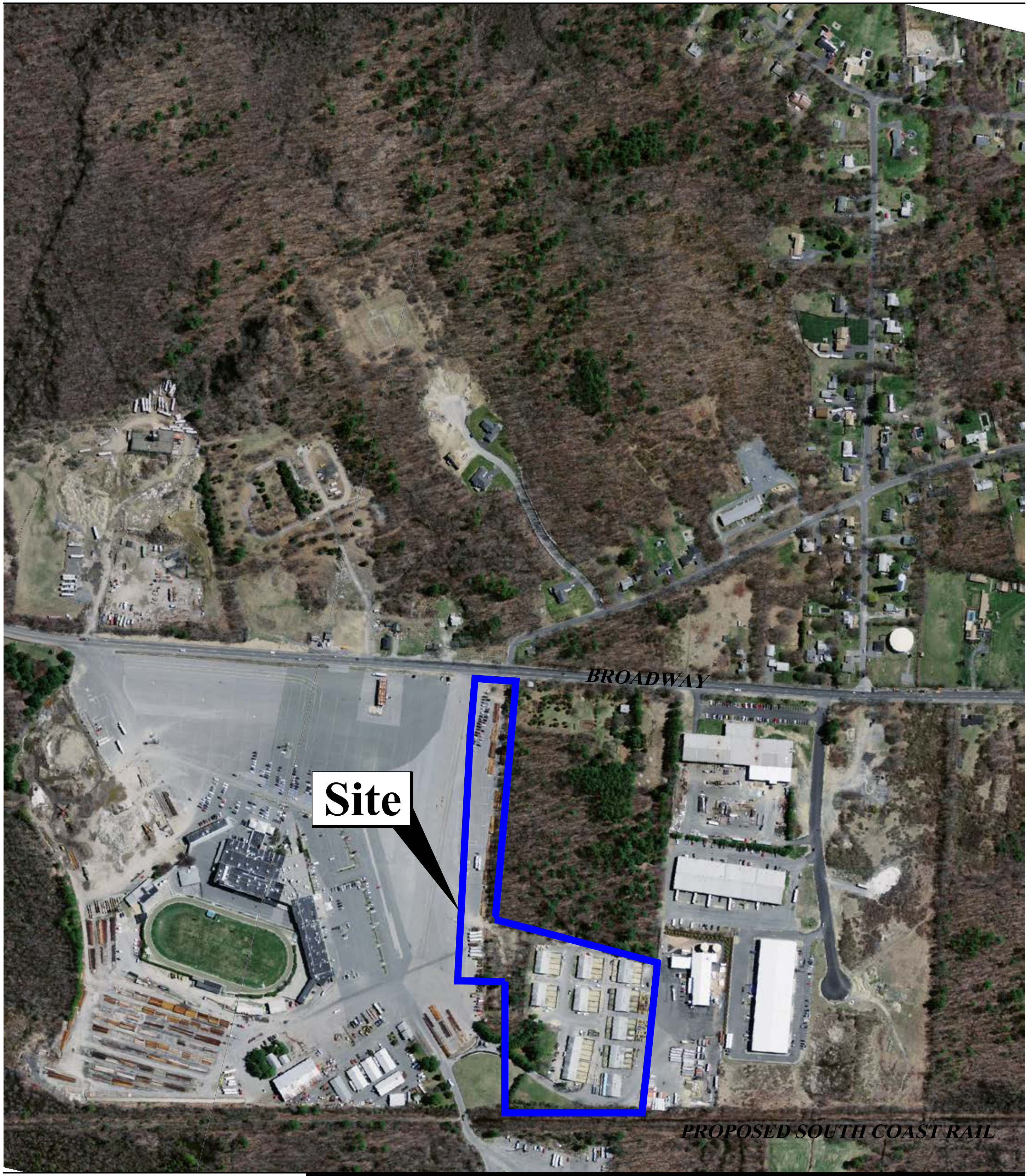


Vanasse Hangen Brustlin, Inc.

USGS Locus Map

Raynham Park Station
South Coast Rail
Raynham, Massachusets

Figure 1
May 2012

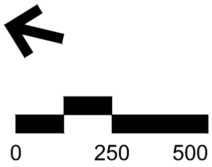


Vanasse Hangen Brustlin, Inc.

Site Aerial Map

Raynham Park Station
South Coast Rail
Raynham, Massachusets

Figure 2
May 2012



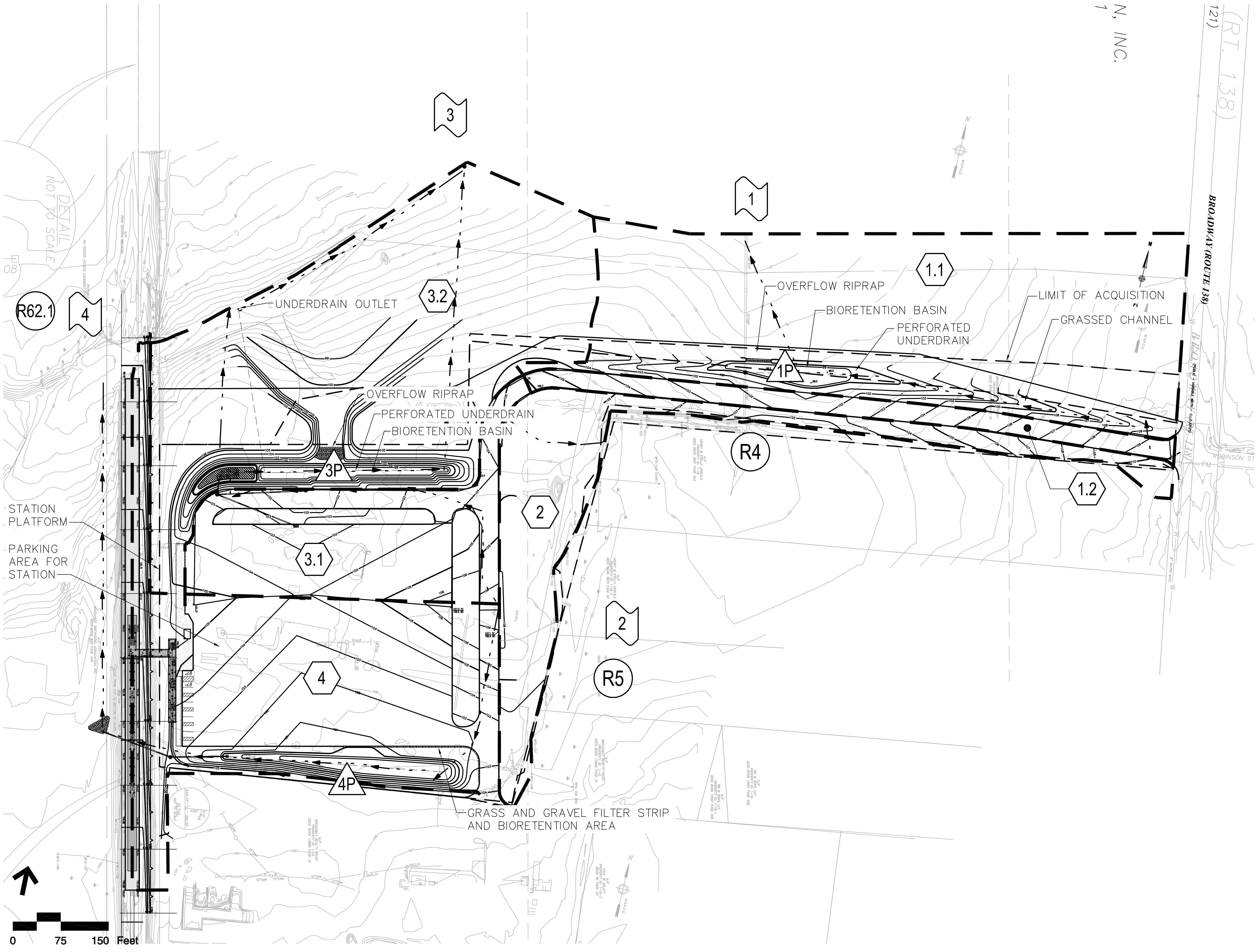
\\Vhb\proj\Boston\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Raynham Park\Stormwater Figures\Figure 3\Raynham Park_Existing Conditions.dwg

Vanasse Hangen Brustlin, Inc.

Figure 3 May 2012

Existing Conditions Drainage Areas

Raynham Park Station
Raynham, Massachusetts



LEGEND

1	SUBCATCHMENT DRAINAGE AREA DESIGNATION
1	POND/BIORETENTION AREA
1	DESIGN POINT
1	WETLAND RESOURCE AREA
▬ ▬ ▬	DRAINAGE AREA BOUNDARY
- · - · ➝	TIME OF CONCENTRATION FLOW LINE
— · —	100' BUFFER ZONE
4-220 4-219	WETLAND BOUNDARY

Vanasse Hangen Brustlin, Inc.

Figure 4 May 2012

Proposed Conditions Drainage Areas

Raynham Park Station
Raynham, Massachusetts

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards at 310 CMR 10.05.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges would result from the Project are presented through compliance with Standards 4 through 6.

All proposed Project stormwater outlets and conveyances have been designed to not cause erosion or scour to wetlands or receiving waters. Outlets from closed drainage systems have been designed with flared end sections and stone protection to dissipate discharge velocities. Overflows from BMPs that impound stormwater have been designed with stone to protect down gradient areas from erosion.

Computations and supporting information for the sizing and selection of materials used to protect from scour and erosion are included in Appendix A.

Standard 2: Peak Rate Attenuation

The Project has been designed to fully comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, and 100-years. The results of the analysis, as summarized in Table 4 below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions.

Computations and supporting information regarding the hydrologic modeling are included in Appendix B.

Table 4
Peak Discharge Rates (cfs*)

Design Point	*2-year*	*10-year*	*100-year*
Design Point 1: Adjacent Parking Area			
Existing	21.8	31.1	45.7
Proposed	16.9	27.6	41.0
Design Point 2: Wetland R5			
Existing	5.3	7.8	11.6
Proposed	3.1	5.5	9.5
Design Point 3: Adjacent Parking Area/Drainage System			
Existing	15.8	23.2	34.7
Proposed	12.1	18.4	28.1
Design Point 4: Wetland R62.1			
Existing	7.4	11.6	18.0
Proposed	4.9	9.6	15.8

Standard 3: Stormwater Recharge

Due to the fact the site is comprised wholly of C and D soils and high bedrock as indicated in the geotechnical report, the project currently does not provide significant recharge and has been designed to infiltrate the required recharge volume to the maximum extent possible. The addition of pervious area and better subgrade soils in proposed basins will contribute to improved recharge.

Each infiltration BMP has been designed with an underdrain, due to the poor soils so it will drain completely within 72 hours.

A Geotechnical Report that describes subsurface soil conditions is included as an appendix to this report.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum of 80% TSS removal for stormwater runoff from all proposed impervious surfaces. While not required, one-inch of water quality treatment for impervious surface runoff has been provided since the Site is in close proximity to the Hockomock Swamp Area of Critical Environmental Concern (ACEC).

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a LUHPPL as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Standard 6: Critical Areas

The Project would discharge treated storm water near a critical area, the Hockomock Swamp Area of Critical Environmental Concern, via an unnamed stream and therefore has been designed with suitable BMPs sized to treat the 1-inch Water Quality Volume and provide the pretreatment requirement of 44% TSS removal prior to infiltration. Proposed source controls and pollution prevention measures have been identified in the Long-Term Pollution Prevention Plan for the project.

For computations and supporting information regarding the sizing of BMPs suitable for treatment of runoff near or to critical areas, see Appendix D.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is a redevelopment, but has still been designed to fully comply with all ten of the Stormwater Management Standards.

Refer directly to each Standard for applicable computations and supporting information demonstrating compliance with each.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Controls

The Project would disturb approximately 11.4 acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) would be developed and a Notice of Intent for the CGP would be submitted by the contractor and owner at least 14 days before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls were discussed in the DEIR/S. Appropriate controls will be prepared and implemented by the contractor and MassDOT (MBTA) during construction in accordance with the final design and NPDES SWPPP

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan will be developed by the MBTA during final design for the Project.

Standard 10: Prohibition of Illicit Discharges

Storm drainage structures remaining from the previous development which are part of the redevelopment area will be removed. The design plans submitted with this report have been designed so that the components included therein are in full compliance with current standards. No statement is made with regard to the drainage system in portions of the site not included in the redevelopment project area. The Long-Term Pollution Prevention Plan will include measures to prevent illicit discharges.

Appendix A
Standard 1 Computations and Supporting Information

Vanasse Hangen Brustlin, Inc.
Transportation
Land Development
Environmental Services
101 Walnut St., Watertown, MA 02471
(617) 924-1770

Storm Drainage Computations

Name: Raynham Park Station
Raynham, MA
Client: MassDOT

Proj. No.: **10111.00**
Date: **5/21/2012**
Computed by: **DAG**
Checked by: **EJM**

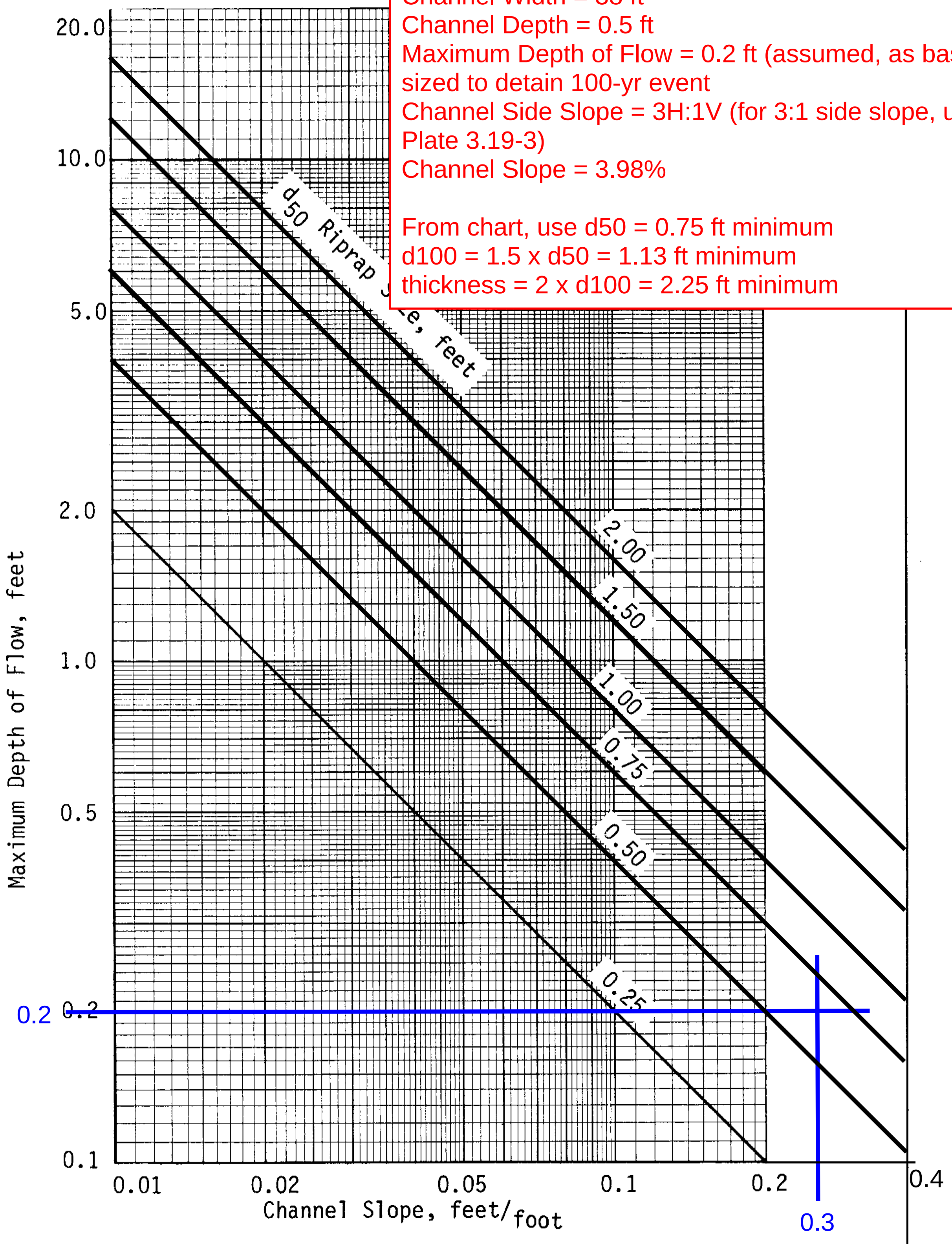
Design Parameters:
25 **Year Storm**
Boston, MA **IDF Curve**
k_e= **0.5**

DESCRIPTION	LOCATION		AREA	C	C x A	SUM	FLOW TIME (MIN)		i*	DESIGN					CAPACITY		PROFILE						
	FROM	TO	(AC.)			C x A	PIPE	CONC TIME		Q cfs	V fps	n	PIPE SIZE	SLOPE	Q full ft^3/s	V full ft/s	LENGTH ft	FALL ft	RIM	INV UPPER	INV LOWER	W.S.E. ft	Freeboard ft
A SERIES	CB A5	DMH A3	1.16	0.85	0.99	0.99	0.40	5.0	6.0	5.9	5.4	0.013	15	0.0100	6.5	5.3	130	1.30	102.4	99.4	98.1	99.0	3.4
	CB A4	DMH A3	0.90	0.72	0.64	0.64	0.57	5.0	6.0	3.9	3.8	0.013	15	0.0054	4.7	3.9	130	0.70	101.6	98.6	97.9	98.4	3.2
	DMH A3	FES A2	---	---	---	1.64	0.05	5.0	6.0	9.8	6.2	0.013	18	0.0100	10.5	5.9	20	0.20	102.7	97.7	97.5	97.2	5.5
B SERIES	OCS B3	DMH B2	3.15	0.85	2.68	2.68	0.22	5.0	6.0	16.1	6.8	0.013	24	0.0100	22.6	7.2	90	0.90	100.5	96.0	95.1	95.4	5.1
	DMH B2	FES B1	---	---	---	2.68	0.27	5.0	6.0	16.1	6.8	0.013	24	0.0100	22.6	7.2	110	1.10	105.5	95.0	93.9	94.4	11.1

Project No: 10111
Project Name: SCR
Date: April 2012
Location: Raynham, MA
Calculated By: DAG
Re: Bioretention Basin 1 Overflow Stone Sizing

Channel Width = 38 ft
Channel Depth = 0.5 ft
Maximum Depth of Flow = 0.2 ft (assumed, as basin is sized to detain 100-yr event
Channel Side Slope = 3H:1V (for 3:1 side slope, use Plate 3.19-3)
Channel Slope = 3.98%

From chart, use d50 = 0.75 ft minimum
d100 = 1.5 x d50 = 1.13 ft minimum
thickness = 2 x d100 = 2.25 ft minimum



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

Source: VDOT Drainage Manual

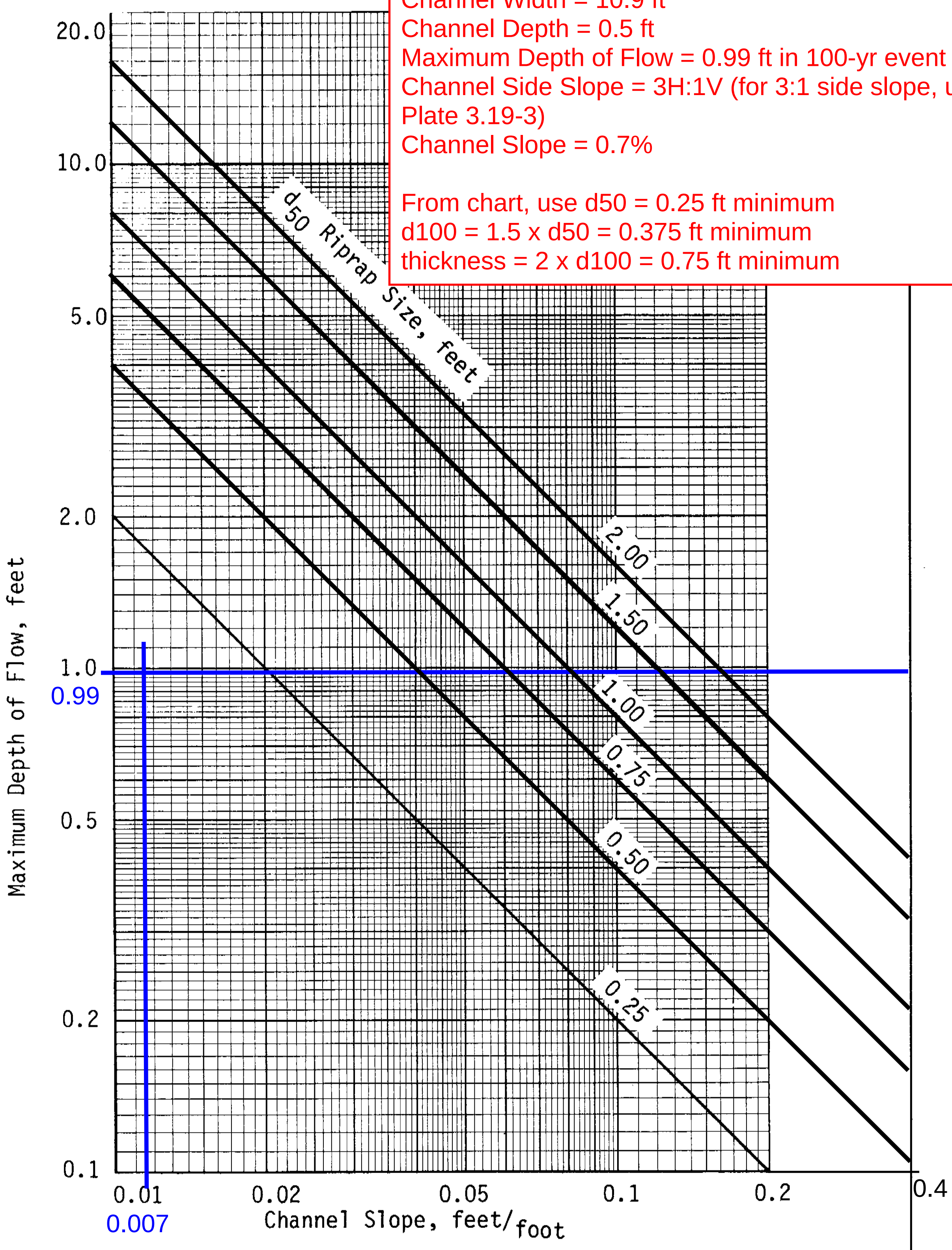
Plate 3.19-3

*Sizing calculations represent minimum stone size. Larger stone may be required per detail plans.

Project No: 10111
Date: April 2012
Calculated By: DAG
Project Name: SCR
Location: Raynham, MA
Re: Bioretention Basin 3 Overflow Stone Sizing

Channel Width = 10.9 ft
Channel Depth = 0.5 ft
Maximum Depth of Flow = 0.99 ft in 100-yr event
Channel Side Slope = 3H:1V (for 3:1 side slope, use Plate 3.19-3)
Channel Slope = 0.7%

From chart, use d50 = 0.25 ft minimum
d100 = 1.5 x d50 = 0.375 ft minimum
thickness = 2 x d100 = 0.75 ft minimum



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

Source: VDOT Drainage Manual

Plate 3.19-3

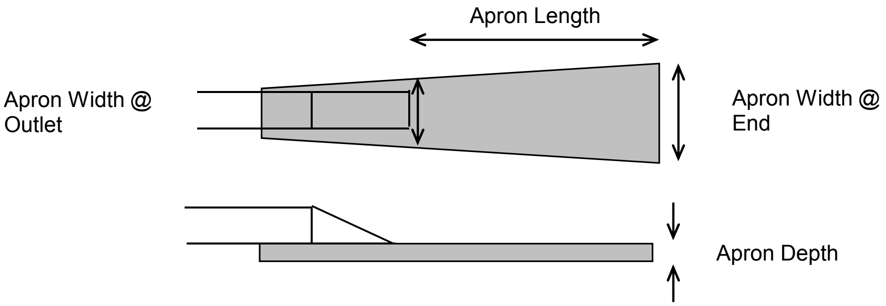
*Sizing calculations represent minimum stone size. Larger stone may be required per detail plans.

Project #: 10111
Project: Raynham Park Station - SCR
Location: Raynham, MA
Calculated by: DAG Date: April 4, 2012
Checked by: VHB Date: April 4, 2012
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

Design Element	Outlet Description FES C1
Design Storm (yr):	100
Defined Channel (yes/no)	no
Pipe Dia (D), in	22
Tail Water (Tw), ft	Tw < 0.5D during low tide
Flow (Q), cfs	17.4
Apron Width (outlet), ft	6
Apron Length, ft	17
Apron Width (end), ft	19
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Appendix B
Standard 2 Computations and Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Bristol County. Runoff coefficients for the existing and proposed conditions, as previously shown in Tables 1 and 2 respectively, were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

FEMA Flood Map

MAP SCALE 1" = 500'

250 0 500 1000 FEET

METE

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0152F

FIRM

FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 152 OF 550

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
EASTON, TOWN OF	250053	0152	F
RAYNHAM, TOWN OF	250061	0152	F
TAUNTON, CITY OF	250066	0152	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

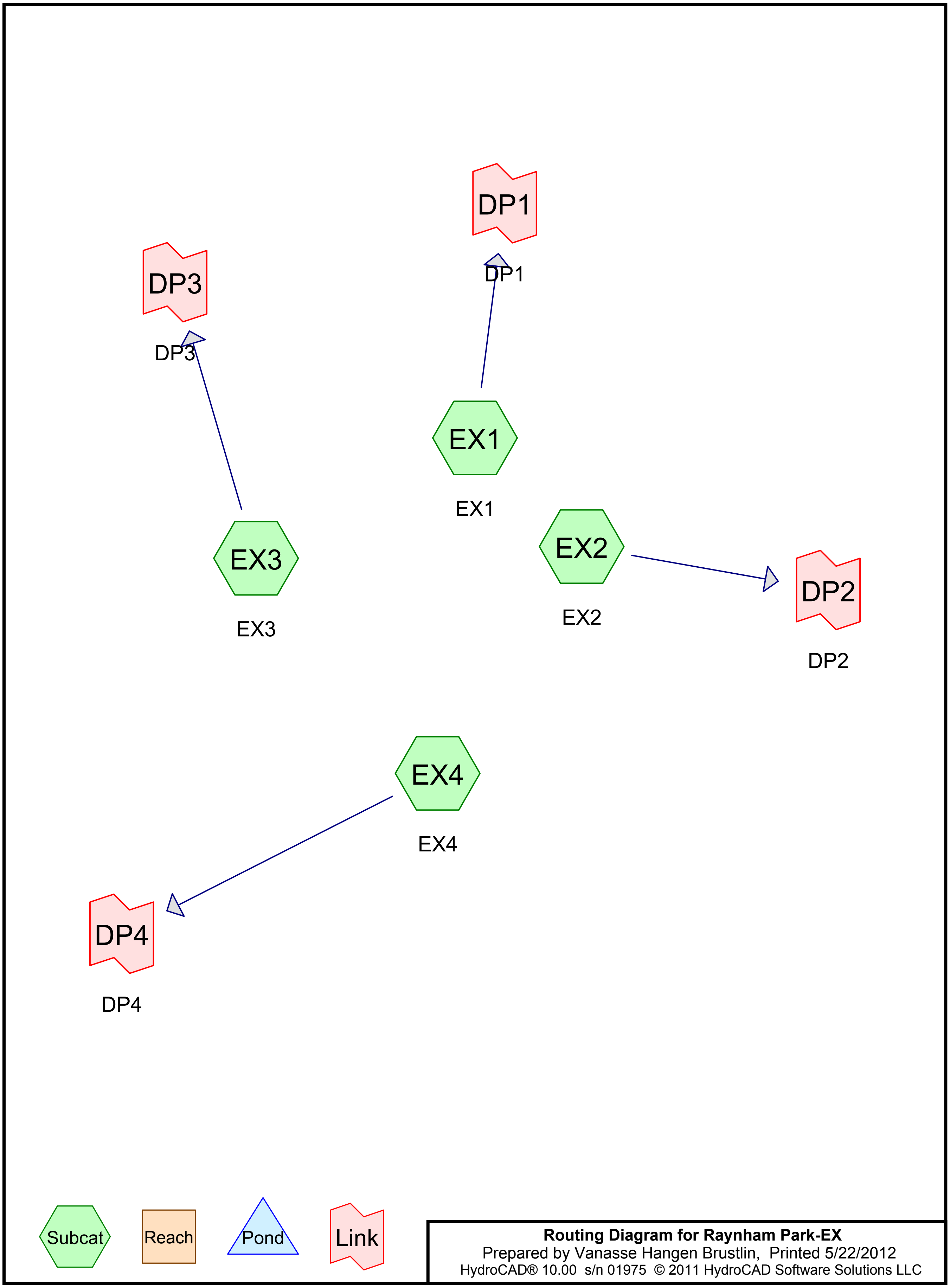
MAP NUMBER
25005C0152F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

HydroCAD Analysis: Existing Conditions



Routing Diagram for Raynham Park-EX
Prepared by Vanasse Hangen Brustlin, Printed 5/22/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.491	60	Woods, Fair, HSG B (EX4)
0.126	69	50-75% Grass cover, Fair, HSG B (EX4)
0.038	73	Woods, Fair, HSG C (EX1)
0.261	79	Woods, Fair, HSG D (EX2, EX3, EX4)
0.013	82	Dirt roads, HSG B (EX4)
0.010	83	Woods, Poor, HSG D (EX4)
2.294	84	50-75% Grass cover, Fair, HSG D (EX2, EX3, EX4)
0.187	87	Dirt roads, HSG C (EX1)
1.384	89	Dirt roads, HSG D (EX1, EX2, EX3, EX4)
0.401	94	Fallow, bare soil, HSG D (EX1)
0.961	96	Gravel surface, HSG D (EX2, EX3)
0.011	98	Paved parking, HSG C (EX1)
10.951	98	Paved parking, HSG D (EX1, EX2, EX3)
1.582	98	Paved roads w/curbs & sewers, HSG D (EX4)
0.037	98	Roofs, HSG B (EX4)
1.048	98	Roofs, HSG D (EX2, EX3, EX4)
0.121	98	Water Surface, HSG B (EX4)
0.041	98	Water Surface, HSG D (EX4)
19.957	**94**	**TOTAL AREA**

2-Year Storm Event - Existing

```
                      Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
                          Runoff by SCS TR-20 method, UH=SCS
         Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentEX1: EX1              Runoff Area=6.849 ac   90.83% Impervious   Runoff Depth>3.05"
                               Flow Length=777'   Tc=6.1 min   CN=97   Runoff=21.76 cfs  1.743 af

SubcatchmentEX2: EX2              Runoff Area=1.629 ac   54.33% Impervious   Runoff Depth>2.74"
                                Flow Length=234'   Tc=3.7 min   CN=94   Runoff=5.30 cfs  0.372 af

SubcatchmentEX3: EX3              Runoff Area=7.543 ac   58.56% Impervious   Runoff Depth>2.73"
                              Flow Length=659'   Tc=19.6 min   CN=94   Runoff=15.79 cfs  1.716 af

SubcatchmentEX4: EX4              Runoff Area=3.936 ac   57.62% Impervious   Runoff Depth>2.26"
                             Flow Length=1,346'   Tc=17.1 min   CN=89   Runoff=7.42 cfs  0.741 af

Link DP1: DP1                                                      Inflow=21.76 cfs  1.743 af
                                                                  Primary=21.76 cfs  1.743 af

Link DP2: DP2                                                       Inflow=5.30 cfs  0.372 af
                                                                   Primary=5.30 cfs  0.372 af

Link DP3: DP3                                                      Inflow=15.79 cfs  1.716 af
                                                                  Primary=15.79 cfs  1.716 af

Link DP4: DP4                                                       Inflow=7.42 cfs  0.741 af
                                                                   Primary=7.42 cfs  0.741 af

        Total Runoff Area = 19.957 ac   Runoff Volume = 4.571 af   Average Runoff Depth = 2.75"
                                    30.90% Pervious = 6.166 ac     69.10% Impervious = 13.791 ac
```

Summary for Subcatchment EX1: EX1

Runoff = 21.76 cfs @ 12.09 hrs, Volume= 1.743 af, Depth> 3.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.187	87	Dirt roads, HSG C
0.002	89	Dirt roads, HSG D
0.401	94	Fallow, bare soil, HSG D
0.011	98	Paved parking, HSG C
6.210	98	Paved parking, HSG D
0.038	73	Woods, Fair, HSG C
6.849	97	Weighted Average
0.628		9.17% Pervious Area
6.221		90.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	50	0.0320	0.44		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
4.2	727	0.0199	2.86		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
6.1	777	Total			

Summary for Subcatchment EX2: EX2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 5.30 cfs @ 12.06 hrs, Volume= 0.372 af, Depth> 2.74"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.611	89	Dirt roads, HSG D
0.038	89	Dirt roads, HSG D
0.018	96	Gravel surface, HSG D
0.590	98	Paved parking, HSG D
0.068	84	50-75% Grass cover, Fair, HSG D
0.295	98	Roofs, HSG D
0.009	79	Woods, Fair, HSG D
0.000	79	Woods, Fair, HSG D
1.629	94	Weighted Average
0.744		45.67% Pervious Area
0.885		54.33% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	50	0.0060	0.75		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.6	184	0.0034	1.18		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.7	234	Total			

Summary for Subcatchment EX3: EX3

Runoff = 15.79 cfs @ 12.26 hrs, Volume= 1.716 af, Depth> 2.73"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.131	89	Dirt roads, HSG D
0.104	89	Dirt roads, HSG D
0.615	96	Gravel surface, HSG D
0.328	96	Gravel surface, HSG D
0.548	98	Paved parking, HSG D
3.603	98	Paved parking, HSG D
0.241	84	50-75% Grass cover, Fair, HSG D
1.509	84	50-75% Grass cover, Fair, HSG D
0.229	98	Roofs, HSG D
0.037	98	Roofs, HSG D
0.025	79	Woods, Fair, HSG D
0.173	79	Woods, Fair, HSG D
7.543	94	Weighted Average
3.126		41.44% Pervious Area
4.417		58.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1	50	0.0090	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
5.6	227	0.0093	0.68		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	155	0.0774	1.95		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	159	0.0107	2.10		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	68	0.0485	4.47		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
19.6	659	Total			

Summary for Subcatchment EX4: EX4

Runoff = 7.42 cfs @ 12.23 hrs, Volume= 0.741 af, Depth> 2.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.013	82	Dirt roads, HSG B
0.449	89	Dirt roads, HSG D
0.049	89	Dirt roads, HSG D
0.275	98	Paved roads w/curbs & sewers, HSG D
1.202	98	Paved roads w/curbs & sewers, HSG D
0.105	98	Paved roads w/curbs & sewers, HSG D
0.126	69	50-75% Grass cover, Fair, HSG B
0.068	84	50-75% Grass cover, Fair, HSG D
0.408	84	50-75% Grass cover, Fair, HSG D
0.037	98	Roofs, HSG B
0.438	98	Roofs, HSG D
0.049	98	Roofs, HSG D
0.121	98	Water Surface, HSG B
0.041	98	Water Surface, HSG D
0.491	60	Woods, Fair, HSG B
0.054	79	Woods, Fair, HSG D
0.010	83	Woods, Poor, HSG D
3.936	89	Weighted Average
1.668		42.38% Pervious Area
2.268		57.62% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	50	0.0140	0.31		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
1.8	141	0.0065	1.30		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.9	145	0.0159	2.56		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.2	285	0.0019	1.49	1.83	**Pipe Channel, CMP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.020 Corrugated PE, corrugated interior
0.1	78	0.0410	11.00	53.98	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.020 Corrugated PE, corrugated interior
8.4	647	0.0073	1.28		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
17.1	1,346	Total			

Summary for Link DP1: DP1

```
Inflow Area =      6.849 ac, 90.83% Impervious,  Inflow Depth >   3.05"    for  2-Year event
Inflow      =      21.76 cfs @   12.09 hrs,  Volume=          1.743 af
Primary     =      21.76 cfs @   12.09 hrs,  Volume=          1.743 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP2: DP2

```
Inflow Area =      1.629 ac, 54.33% Impervious,  Inflow Depth >   2.74"    for  2-Year event
Inflow      =       5.30 cfs @   12.06 hrs,  Volume=          0.372 af
Primary     =       5.30 cfs @   12.06 hrs,  Volume=          0.372 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP3: DP3

```
Inflow Area =      7.543 ac, 58.56% Impervious,  Inflow Depth >   2.73"    for  2-Year event
Inflow      =      15.79 cfs @   12.26 hrs,  Volume=          1.716 af
Primary     =      15.79 cfs @   12.26 hrs,  Volume=          1.716 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP4: DP4

```
Inflow Area =      3.936 ac, 57.62% Impervious,  Inflow Depth >   2.26"    for  2-Year event
Inflow      =       7.42 cfs @   12.23 hrs,  Volume=          0.741 af
Primary     =       7.42 cfs @   12.23 hrs,  Volume=          0.741 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

10-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=6.849 ac 90.83% Impervious Runoff Depth>4.44"
Flow Length=777' Tc=6.1 min CN=97 Runoff=31.09 cfs 2.537 af

SubcatchmentEX2: EX2 Runoff Area=1.629 ac 54.33% Impervious Runoff Depth>4.11"
Flow Length=234' Tc=3.7 min CN=94 Runoff=7.77 cfs 0.558 af

SubcatchmentEX3: EX3 Runoff Area=7.543 ac 58.56% Impervious Runoff Depth>4.10"
Flow Length=659' Tc=19.6 min CN=94 Runoff=23.20 cfs 2.577 af

SubcatchmentEX4: EX4 Runoff Area=3.936 ac 57.62% Impervious Runoff Depth>3.57"
Flow Length=1,346' Tc=17.1 min CN=89 Runoff=11.55 cfs 1.171 af

Link DP1: DP1 Inflow=31.09 cfs 2.537 af
Primary=31.09 cfs 2.537 af

Link DP2: DP2 Inflow=7.77 cfs 0.558 af
Primary=7.77 cfs 0.558 af

Link DP3: DP3 Inflow=23.20 cfs 2.577 af
Primary=23.20 cfs 2.577 af

Link DP4: DP4 Inflow=11.55 cfs 1.171 af
Primary=11.55 cfs 1.171 af

Total Runoff Area = 19.957 ac Runoff Volume = 6.843 af Average Runoff Depth = 4.11"
30.90% Pervious = 6.166 ac 69.10% Impervious = 13.791 ac

Summary for Subcatchment EX1: EX1

Runoff = 31.09 cfs @ 12.09 hrs, Volume= 2.537 af, Depth> 4.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.187	87	Dirt roads, HSG C
0.002	89	Dirt roads, HSG D
0.401	94	Fallow, bare soil, HSG D
0.011	98	Paved parking, HSG C
6.210	98	Paved parking, HSG D
0.038	73	Woods, Fair, HSG C
6.849	97	Weighted Average
0.628		9.17% Pervious Area
6.221		90.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	50	0.0320	0.44		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
4.2	727	0.0199	2.86		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
6.1	777	Total			

Summary for Subcatchment EX2: EX2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 7.77 cfs @ 12.05 hrs, Volume= 0.558 af, Depth> 4.11"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.611	89	Dirt roads, HSG D
0.038	89	Dirt roads, HSG D
0.018	96	Gravel surface, HSG D
0.590	98	Paved parking, HSG D
0.068	84	50-75% Grass cover, Fair, HSG D
0.295	98	Roofs, HSG D
0.009	79	Woods, Fair, HSG D
0.000	79	Woods, Fair, HSG D
1.629	94	Weighted Average
0.744		45.67% Pervious Area
0.885		54.33% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	50	0.0060	0.75		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.6	184	0.0034	1.18		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.7	234	Total			

Summary for Subcatchment EX3: EX3

Runoff = 23.20 cfs @ 12.26 hrs, Volume= 2.577 af, Depth> 4.10"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.131	89	Dirt roads, HSG D
0.104	89	Dirt roads, HSG D
0.615	96	Gravel surface, HSG D
0.328	96	Gravel surface, HSG D
0.548	98	Paved parking, HSG D
3.603	98	Paved parking, HSG D
0.241	84	50-75% Grass cover, Fair, HSG D
1.509	84	50-75% Grass cover, Fair, HSG D
0.229	98	Roofs, HSG D
0.037	98	Roofs, HSG D
0.025	79	Woods, Fair, HSG D
0.173	79	Woods, Fair, HSG D
7.543	94	Weighted Average
3.126		41.44% Pervious Area
4.417		58.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1	50	0.0090	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
5.6	227	0.0093	0.68		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	155	0.0774	1.95		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	159	0.0107	2.10		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	68	0.0485	4.47		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
19.6	659	Total			

Summary for Subcatchment EX4: EX4

Runoff = 11.55 cfs @ 12.23 hrs, Volume= 1.171 af, Depth> 3.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.013	82	Dirt roads, HSG B
0.449	89	Dirt roads, HSG D
0.049	89	Dirt roads, HSG D
0.275	98	Paved roads w/curbs & sewers, HSG D
1.202	98	Paved roads w/curbs & sewers, HSG D
0.105	98	Paved roads w/curbs & sewers, HSG D
0.126	69	50-75% Grass cover, Fair, HSG B
0.068	84	50-75% Grass cover, Fair, HSG D
0.408	84	50-75% Grass cover, Fair, HSG D
0.037	98	Roofs, HSG B
0.438	98	Roofs, HSG D
0.049	98	Roofs, HSG D
0.121	98	Water Surface, HSG B
0.041	98	Water Surface, HSG D
0.491	60	Woods, Fair, HSG B
0.054	79	Woods, Fair, HSG D
0.010	83	Woods, Poor, HSG D
3.936	89	Weighted Average
1.668		42.38% Pervious Area
2.268		57.62% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	50	0.0140	0.31		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
1.8	141	0.0065	1.30		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.9	145	0.0159	2.56		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.2	285	0.0019	1.49	1.83	**Pipe Channel, CMP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.020 Corrugated PE, corrugated interior
0.1	78	0.0410	11.00	53.98	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.020 Corrugated PE, corrugated interior
8.4	647	0.0073	1.28		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
17.1	1,346	Total			

Summary for Link DP1: DP1

```
Inflow Area =       6.849 ac, 90.83% Impervious, Inflow Depth >  4.44"   for 10-Year event
Inflow      =      31.09 cfs @  12.09 hrs, Volume=          2.537 af
Primary     =      31.09 cfs @  12.09 hrs, Volume=          2.537 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP2: DP2

```
Inflow Area =       1.629 ac, 54.33% Impervious, Inflow Depth >  4.11"   for 10-Year event
Inflow      =       7.77 cfs @  12.05 hrs, Volume=          0.558 af
Primary     =       7.77 cfs @  12.05 hrs, Volume=          0.558 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP3: DP3

```
Inflow Area =       7.543 ac, 58.56% Impervious, Inflow Depth >  4.10"   for 10-Year event
Inflow      =      23.20 cfs @  12.26 hrs, Volume=          2.577 af
Primary     =      23.20 cfs @  12.26 hrs, Volume=          2.577 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Link DP4: DP4

```
Inflow Area =       3.936 ac, 57.62% Impervious, Inflow Depth >  3.57"   for 10-Year event
Inflow      =      11.55 cfs @  12.23 hrs, Volume=          1.171 af
Primary     =      11.55 cfs @  12.23 hrs, Volume=          1.171 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

100-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=6.849 ac 90.83% Impervious Runoff Depth>6.64"
Flow Length=777' Tc=6.1 min CN=97 Runoff=45.66 cfs 3.789 af

SubcatchmentEX2: EX2 Runoff Area=1.629 ac 54.33% Impervious Runoff Depth>6.29"
Flow Length=234' Tc=3.7 min CN=94 Runoff=11.60 cfs 0.853 af

SubcatchmentEX3: EX3 Runoff Area=7.543 ac 58.56% Impervious Runoff Depth>6.27"
Flow Length=659' Tc=19.6 min CN=94 Runoff=34.70 cfs 3.942 af

SubcatchmentEX4: EX4 Runoff Area=3.936 ac 57.62% Impervious Runoff Depth>5.69"
Flow Length=1,346' Tc=17.1 min CN=89 Runoff=18.01 cfs 1.868 af

Link DP1: DP1 Inflow=45.66 cfs 3.789 af
Primary=45.66 cfs 3.789 af

Link DP2: DP2 Inflow=11.60 cfs 0.853 af
Primary=11.60 cfs 0.853 af

Link DP3: DP3 Inflow=34.70 cfs 3.942 af
Primary=34.70 cfs 3.942 af

Link DP4: DP4 Inflow=18.01 cfs 1.868 af
Primary=18.01 cfs 1.868 af

Total Runoff Area = 19.957 ac Runoff Volume = 10.452 af Average Runoff Depth = 6.28"
30.90% Pervious = 6.166 ac 69.10% Impervious = 13.791 ac

Summary for Subcatchment EX1: EX1

Runoff = 45.66 cfs @ 12.09 hrs, Volume= 3.789 af, Depth> 6.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.187	87	Dirt roads, HSG C
0.002	89	Dirt roads, HSG D
0.401	94	Fallow, bare soil, HSG D
0.011	98	Paved parking, HSG C
6.210	98	Paved parking, HSG D
0.038	73	Woods, Fair, HSG C
6.849	97	Weighted Average
0.628		9.17% Pervious Area
6.221		90.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	50	0.0320	0.44		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
4.2	727	0.0199	2.86		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
6.1	777	Total			

Summary for Subcatchment EX2: EX2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 11.60 cfs @ 12.05 hrs, Volume= 0.853 af, Depth> 6.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.611	89	Dirt roads, HSG D
0.038	89	Dirt roads, HSG D
0.018	96	Gravel surface, HSG D
0.590	98	Paved parking, HSG D
0.068	84	50-75% Grass cover, Fair, HSG D
0.295	98	Roofs, HSG D
0.009	79	Woods, Fair, HSG D
0.000	79	Woods, Fair, HSG D
1.629	94	Weighted Average
0.744		45.67% Pervious Area
0.885		54.33% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	50	0.0060	0.75		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.6	184	0.0034	1.18		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.7	234	Total			

Summary for Subcatchment EX3: EX3

Runoff = 34.70 cfs @ 12.26 hrs, Volume= 3.942 af, Depth> 6.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.131	89	Dirt roads, HSG D
0.104	89	Dirt roads, HSG D
0.615	96	Gravel surface, HSG D
0.328	96	Gravel surface, HSG D
0.548	98	Paved parking, HSG D
3.603	98	Paved parking, HSG D
0.241	84	50-75% Grass cover, Fair, HSG D
1.509	84	50-75% Grass cover, Fair, HSG D
0.229	98	Roofs, HSG D
0.037	98	Roofs, HSG D
0.025	79	Woods, Fair, HSG D
0.173	79	Woods, Fair, HSG D
7.543	94	Weighted Average
3.126		41.44% Pervious Area
4.417		58.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.1	50	0.0090	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
5.6	227	0.0093	0.68		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	155	0.0774	1.95		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.3	159	0.0107	2.10		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	68	0.0485	4.47		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
19.6	659	Total			

Summary for Subcatchment EX4: EX4

Runoff = 18.01 cfs @ 12.23 hrs, Volume= 1.868 af, Depth> 5.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.013	82	Dirt roads, HSG B
0.449	89	Dirt roads, HSG D
0.049	89	Dirt roads, HSG D
0.275	98	Paved roads w/curbs & sewers, HSG D
1.202	98	Paved roads w/curbs & sewers, HSG D
0.105	98	Paved roads w/curbs & sewers, HSG D
0.126	69	50-75% Grass cover, Fair, HSG B
0.068	84	50-75% Grass cover, Fair, HSG D
0.408	84	50-75% Grass cover, Fair, HSG D
0.037	98	Roofs, HSG B
0.438	98	Roofs, HSG D
0.049	98	Roofs, HSG D
0.121	98	Water Surface, HSG B
0.041	98	Water Surface, HSG D
0.491	60	Woods, Fair, HSG B
0.054	79	Woods, Fair, HSG D
0.010	83	Woods, Poor, HSG D
3.936	89	Weighted Average
1.668		42.38% Pervious Area
2.268		57.62% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	50	0.0140	0.31		**Sheet Flow,** Fallow n= 0.050 P2= 3.30"
1.8	141	0.0065	1.30		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.9	145	0.0159	2.56		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.2	285	0.0019	1.49	1.83	**Pipe Channel, CMP_Round 15"** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.020 Corrugated PE, corrugated interior
0.1	78	0.0410	11.00	53.98	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.020 Corrugated PE, corrugated interior
8.4	647	0.0073	1.28		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
17.1	1,346	Total			

Summary for Link DP1: DP1

```
Inflow Area =       6.849 ac,  90.83% Impervious,  Inflow Depth >   6.64"    for  100-Year event
Inflow      =      45.66 cfs @   12.09 hrs,  Volume=          3.789 af
Primary     =      45.66 cfs @   12.09 hrs,  Volume=          3.789 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP2: DP2

```
Inflow Area =       1.629 ac,  54.33% Impervious,  Inflow Depth >   6.29"    for  100-Year event
Inflow      =      11.60 cfs @   12.05 hrs,  Volume=          0.853 af
Primary     =      11.60 cfs @   12.05 hrs,  Volume=          0.853 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

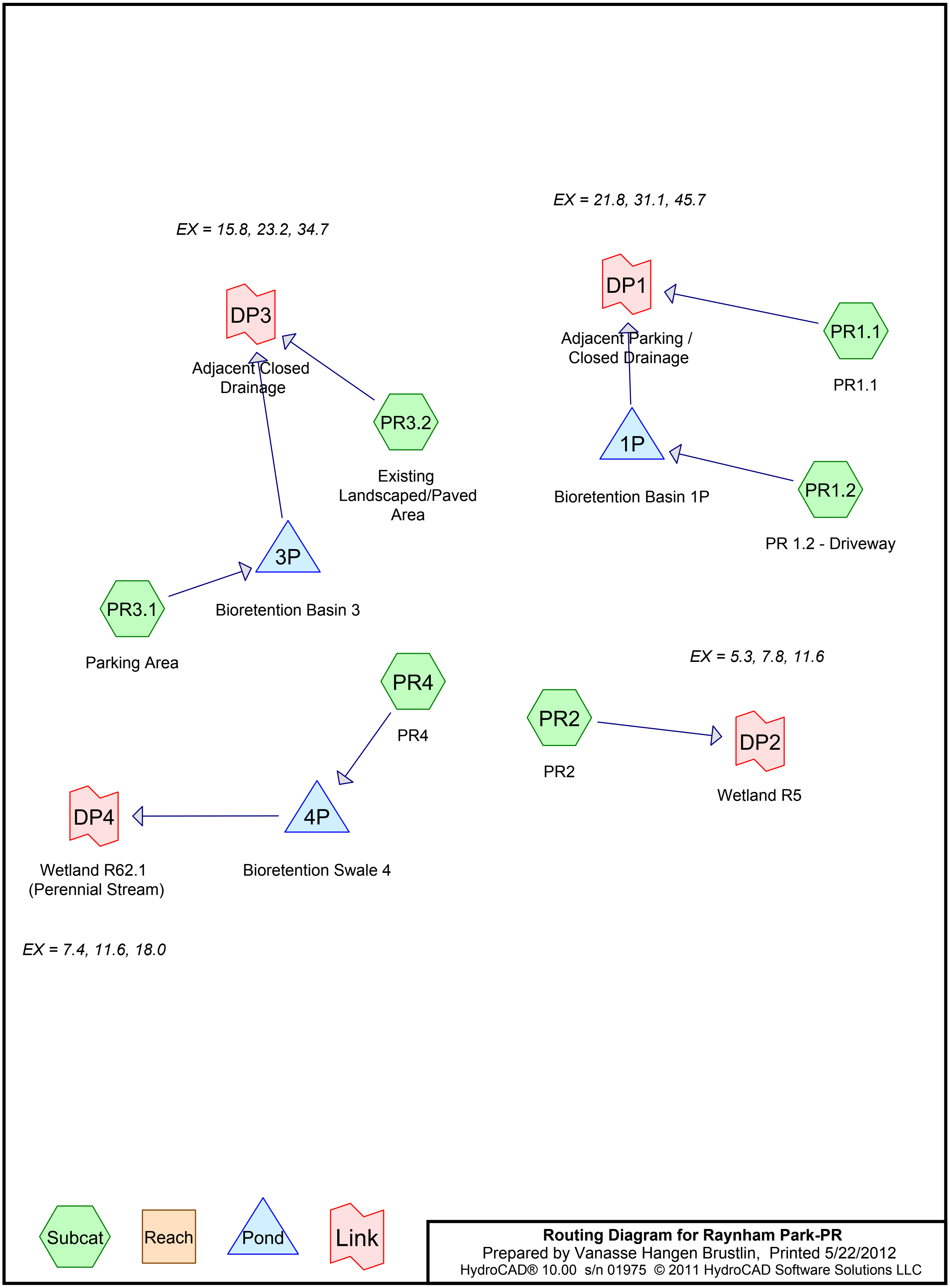
Summary for Link DP3: DP3

```
Inflow Area =       7.543 ac,  58.56% Impervious,  Inflow Depth >   6.27"    for  100-Year event
Inflow      =      34.70 cfs @   12.26 hrs,  Volume=          3.942 af
Primary     =      34.70 cfs @   12.26 hrs,  Volume=          3.942 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP4: DP4

```
Inflow Area =       3.936 ac,  57.62% Impervious,  Inflow Depth >   5.69"    for  100-Year event
Inflow      =      18.01 cfs @   12.23 hrs,  Volume=          1.868 af
Primary     =      18.01 cfs @   12.23 hrs,  Volume=          1.868 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

HydroCAD Analysis: Proposed Conditions



Routing Diagram for Raynham Park-PR
Prepared by Vanasse Hangen Brustlin, Printed 5/22/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.798	69	50-75% Grass cover, Fair, HSG B (PR3.2, PR4)
0.042	73	Woods, Fair, HSG C (PR1.1)
0.137	79	50-75% Grass cover, Fair, HSG C (PR1.1)
0.009	79	Woods, Fair, HSG D (PR2)
2.022	80	>75% Grass cover, Good, HSG D (PR2)
4.363	84	50-75% Grass cover, Fair, HSG D (PR1.1, PR3.1, PR3.2, PR4)
0.032	94	Fallow, bare soil, HSG D (PR1.1)
0.689	98	Paved parking, HSG A (PR1.2)
0.509	98	Paved parking, HSG B (PR3.2, PR4)
11.919	98	Paved parking, HSG D (PR1.1, PR3.1, PR3.2, PR4)
0.054	98	Paved roads w/curbs & sewers, HSG C (PR1.1)
20.574	**92**	**TOTAL AREA**

2-Year Storm Event - Proposed

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PR1.1: PR1.1 Runoff Area=5.908 ac 80.97% Impervious Runoff Depth>2.84"
Flow Length=682' Tc=8.4 min CN=95 Runoff=16.88 cfs 1.397 af

Subcatchment PR1.2: PR 1.2 - Driveway Runoff Area=0.689 ac 100.00% Impervious Runoff Depth>3.17"
Tc=5.0 min CN=98 Runoff=2.29 cfs 0.182 af

Subcatchment PR2: PR2 Runoff Area=2.031 ac 0.00% Impervious Runoff Depth>1.55"
Flow Length=162' Slope=0.0090 '/' Tc=10.4 min CN=80 Runoff=3.14 cfs 0.263 af

Subcatchment PR3.1: Parking Area Runoff Area=2.040 ac 83.82% Impervious Runoff Depth>2.94"
Flow Length=1,335' Tc=14.1 min CN=96 Runoff=5.06 cfs 0.500 af

Subcatchment PR3.2: Existing Runoff Area=5.706 ac 56.17% Impervious Runoff Depth>2.44"
Flow Length=646' Tc=15.1 min CN=91 Runoff=12.11 cfs 1.161 af

Subcatchment PR4: PR4 Runoff Area=4.200 ac 66.26% Impervious Runoff Depth>2.44"
Flow Length=1,380' Tc=16.6 min CN=91 Runoff=8.60 cfs 0.854 af

Pond 1P: Bioretention Basin 1P Peak Elev=99.54' Storage=4,244 cf Inflow=2.29 cfs 0.182 af
Discarded=0.01 cfs 0.015 af Primary=0.98 cfs 0.073 af Outflow=0.99 cfs 0.088 af

Pond 3P: Bioretention Basin 3 Peak Elev=100.35' Storage=20,402 cf Inflow=5.06 cfs 0.500 af
Discarded=0.02 cfs 0.032 af Primary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.032 af

Pond 4P: Bioretention Swale 4 Peak Elev=100.03' Storage=15,341 cf Inflow=8.60 cfs 0.854 af
Discarded=0.02 cfs 0.024 af Primary=4.90 cfs 0.587 af Outflow=4.93 cfs 0.611 af

Link DP1: Adjacent Parking / Closed Drainage Inflow=16.88 cfs 1.470 af
Primary=16.88 cfs 1.470 af

Link DP2: Wetland R5 Inflow=3.14 cfs 0.263 af
Primary=3.14 cfs 0.263 af

Link DP3: Adjacent Closed Drainage Inflow=12.11 cfs 1.161 af
Primary=12.11 cfs 1.161 af

Link DP4: Wetland R62.1 (Perennial Stream) Inflow=4.90 cfs 0.587 af
Primary=4.90 cfs 0.587 af

Total Runoff Area = 20.574 ac Runoff Volume = 4.357 af Average Runoff Depth = 2.54"
35.98% Pervious = 7.403 ac 64.02% Impervious = 13.171 ac

Summary for Subcatchment PR1.1: PR1.1

Runoff = 16.88 cfs @ 12.12 hrs, Volume= 1.397 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.032	94	Fallow, bare soil, HSG D
0.054	98	Paved roads w/curbs & sewers, HSG C
4.730	98	Paved parking, HSG D
0.042	73	Woods, Fair, HSG C
0.911	84	50-75% Grass cover, Fair, HSG D
0.137	79	50-75% Grass cover, Fair, HSG C
0.002	84	50-75% Grass cover, Fair, HSG D
5.908	95	Weighted Average
1.124		19.03% Pervious Area
4.784		80.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.0280	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
0.4	77	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.4	330	0.0240	2.32		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.5	103	0.0040	3.39	2.66	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.3	122	0.0254	6.92	33.99	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.025 Corrugated metal
8.4	682	Total			

Summary for Subcatchment PR1.2: PR 1.2 - Driveway

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.29 cfs @ 12.07 hrs, Volume= 0.182 af, Depth> 3.17"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.689	98	Paved parking, HSG A
0.689		100.00% Impervious Area

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

Summary for Subcatchment PR2: PR2

Runoff = 3.14 cfs @ 12.15 hrs, Volume= 0.263 af, Depth> 1.55"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
2.022	80	>75% Grass cover, Good, HSG D
0.009	79	Woods, Fair, HSG D
2.031	80	Weighted Average
2.031		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.6	50	0.0090	0.11		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
2.8	112	0.0090	0.66		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.4	162	Total			

Summary for Subcatchment PR3.1: Parking Area

Runoff = 5.06 cfs @ 12.19 hrs, Volume= 0.500 af, Depth> 2.94"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
1.710	98	Paved parking, HSG D
0.330	84	50-75% Grass cover, Fair, HSG D
2.040	96	Weighted Average
0.330		16.18% Pervious Area
1.710		83.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0196	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.6	78	0.0196	2.10		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.8	50	0.0120	0.99		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.4	318	0.0116	2.19		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	34	0.0080	4.80	3.77	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.5	329		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
1.6	476	0.0050	4.97	8.78	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
14.1	1,335	Total			

Summary for Subcatchment PR3.2: Existing Landscaped/Paved Area

Runoff = 12.11 cfs @ 12.20 hrs, Volume= 1.161 af, Depth> 2.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.025	98	Paved parking, HSG B
3.180	98	Paved parking, HSG D
0.251	69	50-75% Grass cover, Fair, HSG B
2.250	84	50-75% Grass cover, Fair, HSG D
5.706	91	Weighted Average
2.501		43.83% Pervious Area
3.205		56.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9	50	0.0120	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.8	171	0.0610	3.70		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.5	300	0.0120	1.42		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.9	125	0.0120	2.22		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
15.1	646	Total			

Summary for Subcatchment PR4: PR4

Runoff = 8.60 cfs @ 12.22 hrs, Volume= 0.854 af, Depth> 2.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.484	98	Paved parking, HSG B
2.127	98	Paved parking, HSG D
0.172	98	Paved parking, HSG D
0.547	69	50-75% Grass cover, Fair, HSG B
0.870	84	50-75% Grass cover, Fair, HSG D
4.200	91	Weighted Average
1.417		33.74% Pervious Area
2.783		66.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	33	0.0220	1.16		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.8	163	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.7	240	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	177	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.1	38	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
8.3	689	0.0085	1.38		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.6	1,380	Total			

Summary for Pond 1P: Bioretention Basin 1P

Inflow Area = 0.689 ac,100.00% Impervious, Inflow Depth > 3.17" for 2-Year event
Inflow = 2.29 cfs @ 12.07 hrs, Volume= 0.182 af
Outflow = 0.99 cfs @ 12.27 hrs, Volume= 0.088 af, Atten= 57%, Lag= 12.1 min
Discarded = 0.01 cfs @ 12.27 hrs, Volume= 0.015 af
Primary = 0.98 cfs @ 12.27 hrs, Volume= 0.073 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 99.54' @ 12.27 hrs Surf.Area= 4,877 sf Storage= 4,244 cf

Plug-Flow detention time= 242.8 min calculated for 0.088 af (49% of inflow)
Center-of-Mass det. time= 115.8 min (869.7 - 753.9)

Volume	Invert	Avail.Storage	Storage Description
#1	98.50'	6,927 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.50	3,319	353.0	0	0	3,319
99.00	4,106	413.0	1,853	1,853	6,981
99.50	4,733	423.0	2,208	4,061	7,679
100.00	6,793	591.0	2,866	6,927	21,237

Device	Routing	Invert	Outlet Devices
#1	Primary	99.50'	**40.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height
#2	Discarded	98.50'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.01 cfs @ 12.27 hrs HW=99.54' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.91 cfs @ 12.27 hrs HW=99.54' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir**(Weir Controls 0.91 cfs @ 0.63 fps)

Summary for Pond 3P: Bioretention Basin 3

Inflow Area = 2.040 ac, 83.82% Impervious, Inflow Depth > 2.94" for 2-Year event
Inflow = 5.06 cfs @ 12.19 hrs, Volume= 0.500 af
Outflow = 0.02 cfs @ 24.00 hrs, Volume= 0.032 af, Atten= 100%, Lag= 708.7 min
Discarded = 0.02 cfs @ 24.00 hrs, Volume= 0.032 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.35' @ 24.00 hrs Surf.Area= 11,945 sf Storage= 20,402 cf

Plug-Flow detention time= 510.8 min calculated for 0.031 af (6% of inflow)
Center-of-Mass det. time= 164.1 min (942.7 - 778.6)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	28,805 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.00	5,654	805.6	0	0	5,654
99.00	8,176	893.3	6,876	6,876	17,541
100.00	10,935	891.3	9,522	16,398	18,477
101.00	13,939	955.3	12,407	28,805	27,927

Device	Routing	Invert	Outlet Devices
#1	Discarded	98.00'	**0.090 in/hr Exfiltration over Surface area**
#2	Primary	100.70'	**8.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 24.00 hrs HW=100.35' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=98.00' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir**(Controls 0.00 cfs)

Summary for Pond 4P: Bioretention Swale 4

Inflow Area = 4.200 ac, 66.26% Impervious, Inflow Depth > 2.44" for 2-Year event
Inflow = 8.60 cfs @ 12.22 hrs, Volume= 0.854 af
Outflow = 4.93 cfs @ 12.48 hrs, Volume= 0.611 af, Atten= 43%, Lag= 15.4 min
Discarded = 0.02 cfs @ 12.48 hrs, Volume= 0.024 af
Primary = 4.90 cfs @ 12.48 hrs, Volume= 0.587 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.03' @ 12.48 hrs Surf.Area= 10,833 sf Storage= 15,341 cf

Plug-Flow detention time= 160.6 min calculated for 0.610 af (71% of inflow)
Center-of-Mass det. time= 72.4 min (880.7 - 808.4)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	29,092 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.00	5,101	559.0	0	0	5,101
99.00	7,395	693.0	6,213	6,213	18,466
99.50	8,686	757.0	4,016	10,229	25,860
100.00	10,672	776.0	4,831	15,060	28,209
101.00	17,687	824.0	14,033	29,092	34,373

Device	Routing	Invert	Outlet Devices
#1	Primary	96.00'	**18.0" Round Culvert** L= 90.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 96.00' / 95.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#2	Device 1	99.50'	**48.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	100.50'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 8 rows C= 0.600 in 24.0" x 48.0" Grate Limited to weir flow at low heads
#4	Discarded	98.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.02 cfs @ 12.48 hrs HW=100.03' (Free Discharge)
└─**4=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=4.88 cfs @ 12.48 hrs HW=100.03' (Free Discharge)
└─**1=Culvert** (Passes 4.88 cfs of 14.80 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 4.88 cfs @ 2.33 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)

Summary for Link DP1: Adjacent Parking / Closed Drainage

```
Inflow Area =      6.597 ac, 82.96% Impervious, Inflow Depth >  2.67"   for 2-Year event
Inflow    =      16.88 cfs @  12.12 hrs, Volume=         1.470 af
Primary   =      16.88 cfs @  12.12 hrs, Volume=         1.470 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP2: Wetland R5

```
Inflow Area =      2.031 ac,  0.00% Impervious, Inflow Depth >  1.55"   for 2-Year event
Inflow    =       3.14 cfs @  12.15 hrs, Volume=         0.263 af
Primary   =       3.14 cfs @  12.15 hrs, Volume=         0.263 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP3: Adjacent Closed Drainage

```
Inflow Area =      7.746 ac, 63.45% Impervious, Inflow Depth >  1.80"   for 2-Year event
Inflow    =      12.11 cfs @  12.20 hrs, Volume=         1.161 af
Primary   =      12.11 cfs @  12.20 hrs, Volume=         1.161 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP4: Wetland R62.1 (Perennial Stream)

```
Inflow Area =      4.200 ac, 66.26% Impervious, Inflow Depth >  1.68"   for 2-Year event
Inflow    =       4.90 cfs @  12.48 hrs, Volume=         0.587 af
Primary   =       4.90 cfs @  12.48 hrs, Volume=         0.587 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

10-Year Storm Event- Proposed

```
                    Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
                         Runoff by SCS TR-20 method, UH=SCS
            Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentPR1.1: PR1.1                 Runoff Area=5.908 ac   80.97% Impervious   Runoff Depth>4.22"
                                      Flow Length=682'   Tc=8.4 min   CN=95   Runoff=24.53 cfs  2.076 af

SubcatchmentPR1.2: PR 1.2 - Driveway    Runoff Area=0.689 ac   100.00% Impervious   Runoff Depth>4.56"
                                                          Tc=5.0 min   CN=98   Runoff=3.25 cfs  0.262 af

SubcatchmentPR2: PR2                     Runoff Area=2.031 ac   0.00% Impervious   Runoff Depth>2.71"
                     Flow Length=162'   Slope=0.0090 '/'   Tc=10.4 min   CN=80   Runoff=5.53 cfs  0.459 af

SubcatchmentPR3.1: Parking Area          Runoff Area=2.040 ac   83.82% Impervious   Runoff Depth>4.33"
                                    Flow Length=1,335'   Tc=14.1 min   CN=96   Runoff=7.29 cfs  0.735 af

SubcatchmentPR3.2: Existing              Runoff Area=5.706 ac   56.17% Impervious   Runoff Depth>3.78"
                                     Flow Length=646'   Tc=15.1 min   CN=91   Runoff=18.39 cfs  1.797 af

SubcatchmentPR4: PR4                     Runoff Area=4.200 ac   66.26% Impervious   Runoff Depth>3.78"
                                   Flow Length=1,380'   Tc=16.6 min   CN=91   Runoff=13.07 cfs  1.323 af

Pond 1P: Bioretention Basin 1P             Peak Elev=99.58'  Storage=4,462 cf   Inflow=3.25 cfs  0.262 af
                     Discarded=0.01 cfs  0.016 af   Primary=3.11 cfs  0.152 af   Outflow=3.12 cfs  0.168 af

Pond 3P: Bioretention Basin 3            Peak Elev=100.75'  Storage=25,460 cf   Inflow=7.29 cfs  0.735 af
                     Discarded=0.03 cfs  0.036 af   Primary=0.33 cfs  0.126 af   Outflow=0.35 cfs  0.162 af

Pond 4P: Bioretention Swale 4           Peak Elev=100.32'  Storage=18,810 cf   Inflow=13.07 cfs  1.323 af
                     Discarded=0.03 cfs  0.027 af   Primary=9.55 cfs  1.050 af   Outflow=9.58 cfs  1.077 af

Link DP1: Adjacent Parking / Closed Drainage                                   Inflow=27.61 cfs  2.229 af
                                                                              Primary=27.61 cfs  2.229 af

Link DP2: Wetland R5                                                            Inflow=5.53 cfs  0.459 af
                                                                               Primary=5.53 cfs  0.459 af

Link DP3: Adjacent Closed Drainage                                             Inflow=18.39 cfs  1.923 af
                                                                              Primary=18.39 cfs  1.923 af

Link DP4: Wetland R62.1 (Perennial Stream)                                      Inflow=9.55 cfs  1.050 af
                                                                               Primary=9.55 cfs  1.050 af

          Total Runoff Area = 20.574 ac   Runoff Volume = 6.653 af   Average Runoff Depth = 3.88"
                                     35.98% Pervious = 7.403 ac     64.02% Impervious = 13.171 ac
```

Summary for Subcatchment PR1.1: PR1.1

Runoff = 24.53 cfs @ 12.11 hrs, Volume= 2.076 af, Depth> 4.22"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.032	94	Fallow, bare soil, HSG D
0.054	98	Paved roads w/curbs & sewers, HSG C
4.730	98	Paved parking, HSG D
0.042	73	Woods, Fair, HSG C
0.911	84	50-75% Grass cover, Fair, HSG D
0.137	79	50-75% Grass cover, Fair, HSG C
0.002	84	50-75% Grass cover, Fair, HSG D
5.908	95	Weighted Average
1.124		19.03% Pervious Area
4.784		80.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.0280	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
0.4	77	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.4	330	0.0240	2.32		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.5	103	0.0040	3.39	2.66	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.3	122	0.0254	6.92	33.99	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.025 Corrugated metal
8.4	682	Total			

Summary for Subcatchment PR1.2: PR 1.2 - Driveway

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.25 cfs @ 12.07 hrs, Volume= 0.262 af, Depth> 4.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.689	98	Paved parking, HSG A
0.689		100.00% Impervious Area

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

Summary for Subcatchment PR2: PR2

Runoff = 5.53 cfs @ 12.15 hrs, Volume= 0.459 af, Depth> 2.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
2.022	80	>75% Grass cover, Good, HSG D
0.009	79	Woods, Fair, HSG D
2.031	80	Weighted Average
2.031		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.6	50	0.0090	0.11		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
2.8	112	0.0090	0.66		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.4	162	Total			

Summary for Subcatchment PR3.1: Parking Area

Runoff = 7.29 cfs @ 12.19 hrs, Volume= 0.735 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
1.710	98	Paved parking, HSG D
0.330	84	50-75% Grass cover, Fair, HSG D
2.040	96	Weighted Average
0.330		16.18% Pervious Area
1.710		83.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0196	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.6	78	0.0196	2.10		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.8	50	0.0120	0.99		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.4	318	0.0116	2.19		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	34	0.0080	4.80	3.77	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.5	329		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
1.6	476	0.0050	4.97	8.78	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
14.1	1,335	Total			

Summary for Subcatchment PR3.2: Existing Landscaped/Paved Area

Runoff = 18.39 cfs @ 12.20 hrs, Volume= 1.797 af, Depth> 3.78"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.025	98	Paved parking, HSG B
3.180	98	Paved parking, HSG D
0.251	69	50-75% Grass cover, Fair, HSG B
2.250	84	50-75% Grass cover, Fair, HSG D
5.706	91	Weighted Average
2.501		43.83% Pervious Area
3.205		56.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9	50	0.0120	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.8	171	0.0610	3.70		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.5	300	0.0120	1.42		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.9	125	0.0120	2.22		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
15.1	646	Total			

Summary for Subcatchment PR4: PR4

Runoff = 13.07 cfs @ 12.22 hrs, Volume= 1.323 af, Depth> 3.78"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.484	98	Paved parking, HSG B
2.127	98	Paved parking, HSG D
0.172	98	Paved parking, HSG D
0.547	69	50-75% Grass cover, Fair, HSG B
0.870	84	50-75% Grass cover, Fair, HSG D
4.200	91	Weighted Average
1.417		33.74% Pervious Area
2.783		66.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	33	0.0220	1.16		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.8	163	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.7	240	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	177	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.1	38	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
8.3	689	0.0085	1.38		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.6	1,380	Total			

Summary for Pond 1P: Bioretention Basin 1P

```
Inflow Area =      0.689 ac,100.00% Impervious,  Inflow Depth >   4.56"    for  10-Year event
Inflow      =      3.25 cfs @   12.07 hrs,  Volume=         0.262 af
Outflow     =      3.12 cfs @   12.10 hrs,  Volume=         0.168 af,  Atten= 4%,  Lag= 1.9 min
Discarded  =       0.01 cfs @   12.10 hrs,  Volume=         0.016 af
Primary     =      3.11 cfs @   12.10 hrs,  Volume=         0.152 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 99.58' @ 12.10 hrs Surf.Area= 5,046 sf Storage= 4,462 cf

Plug-Flow detention time= 190.3 min calculated for 0.168 af (64% of inflow)
Center-of-Mass det. time= 86.8 min (834.3 - 747.4)

```
Volume      Invert    Avail.Storage   Storage Description
  #1        98.50'         6,927 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation        Surf.Area    Perim.        Inc.Store        Cum.Store          Wet.Area
    (feet)          (sq-ft)    (feet)     (cubic-feet)     (cubic-feet)           (sq-ft)
     98.50            3,319     353.0                0                0             3,319
     99.00            4,106     413.0            1,853            1,853             6,981
     99.50            4,733     423.0            2,208            4,061             7,679
    100.00            6,793     591.0            2,866            6,927            21,237

Device  Routing           Invert   Outlet Devices
   #1   Primary           99.50'   40.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
                                   1.0' Crest Height
   #2   Discarded         98.50'   0.090 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.01 cfs @ 12.10 hrs  HW=99.58'   (Free Discharge)
└─2=Exfiltration (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=3.09 cfs @ 12.10 hrs  HW=99.58'   (Free Discharge)
└─1=Sharp-Crested Rectangular Weir(Weir Controls 3.09 cfs @ 0.95 fps)
```

Summary for Pond 3P: Bioretention Basin 3

```
Inflow Area =        2.040 ac,  83.82% Impervious,  Inflow Depth >   4.33"    for  10-Year event
Inflow      =       7.29 cfs @   12.19 hrs,  Volume=           0.735 af
Outflow     =       0.35 cfs @   15.33 hrs,  Volume=           0.162 af,  Atten= 95%,  Lag= 188.7 min
Discarded   =       0.03 cfs @   15.33 hrs,  Volume=           0.036 af
Primary     =       0.33 cfs @   15.33 hrs,  Volume=           0.126 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.75' @ 15.33 hrs   Surf.Area= 13,163 sf   Storage= 25,460 cf

Plug-Flow detention time= 486.6 min calculated for 0.162 af (22% of inflow)
Center-of-Mass det. time= 272.5 min ( 1,042.2 - 769.6 )

Volume      Invert    Avail.Storage   Storage Description
  #1        98.00'        28,805 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation        Surf.Area    Perim.        Inc.Store        Cum.Store          Wet.Area
    (feet)          (sq-ft)    (feet)     (cubic-feet)     (cubic-feet)           (sq-ft)
     98.00            5,654     805.6                0                0             5,654
     99.00            8,176     893.3            6,876            6,876            17,541
    100.00           10,935     891.3            9,522           16,398            18,477
    101.00           13,939     955.3           12,407           28,805            27,927

Device  Routing           Invert   Outlet Devices
   #1   Discarded         98.00'   0.090 in/hr Exfiltration over Surface area
   #2   Primary          100.70'   8.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
```

Discarded OutFlow Max=0.03 cfs @ 15.33 hrs HW=100.75' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.32 cfs @ 15.33 hrs HW=100.75' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.32 cfs @ 0.75 fps)

Summary for Pond 4P: Bioretention Swale 4

Inflow Area =	4.200 ac, 66.26% Impervious, Inflow Depth > 3.78" for 10-Year event			
Inflow =	13.07 cfs @	12.22 hrs, Volume=	1.323 af	
Outflow =	9.58 cfs @	12.38 hrs, Volume=	1.077 af,	Atten= 27%, Lag= 9.6 min
Discarded =	0.03 cfs @	12.38 hrs, Volume=	0.027 af	
Primary =	9.55 cfs @	12.38 hrs, Volume=	1.050 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.32' @ 12.38 hrs Surf.Area= 12,731 sf Storage= 18,810 cf

Plug-Flow detention time= 128.5 min calculated for 1.077 af (81% of inflow)
Center-of-Mass det. time= 57.4 min (853.8 - 796.4)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	29,092 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.00	5,101	559.0	0	0	5,101
99.00	7,395	693.0	6,213	6,213	18,466
99.50	8,686	757.0	4,016	10,229	25,860
100.00	10,672	776.0	4,831	15,060	28,209
101.00	17,687	824.0	14,033	29,092	34,373

Device	Routing	Invert	Outlet Devices
#1	Primary	96.00'	**18.0" Round Culvert** L= 90.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 96.00' / 95.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#2	Device 1	99.50'	**48.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	100.50'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 8 rows C= 0.600 in 24.0" x 48.0" Grate Limited to weir flow at low heads
#4	Discarded	98.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.03 cfs @ 12.38 hrs HW=100.32' (Free Discharge)
└─**4=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=9.52 cfs @ 12.38 hrs HW=100.32' (Free Discharge)
└─**1=Culvert** (Passes 9.52 cfs of 15.42 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 9.52 cfs @ 2.91 fps)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)

Summary for Link DP1: Adjacent Parking / Closed Drainage

```
Inflow Area =       6.597 ac, 82.96% Impervious,  Inflow Depth >  4.05"   for  10-Year event
Inflow      =      27.61 cfs @  12.11 hrs,  Volume=          2.229 af
Primary     =      27.61 cfs @  12.11 hrs,  Volume=          2.229 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP2: Wetland R5

```
Inflow Area =       2.031 ac,   0.00% Impervious,  Inflow Depth >  2.71"   for  10-Year event
Inflow      =       5.53 cfs @  12.15 hrs,  Volume=          0.459 af
Primary     =       5.53 cfs @  12.15 hrs,  Volume=          0.459 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP3: Adjacent Closed Drainage

```
Inflow Area =       7.746 ac, 63.45% Impervious,  Inflow Depth >  2.98"   for  10-Year event
Inflow      =      18.39 cfs @  12.20 hrs,  Volume=          1.923 af
Primary     =      18.39 cfs @  12.20 hrs,  Volume=          1.923 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP4: Wetland R62.1 (Perennial Stream)

```
Inflow Area =       4.200 ac, 66.26% Impervious,  Inflow Depth >  3.00"   for  10-Year event
Inflow      =       9.55 cfs @  12.38 hrs,  Volume=          1.050 af
Primary     =       9.55 cfs @  12.38 hrs,  Volume=          1.050 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

100-Year Storm Event – Proposed

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PR1.1: PR1.1 Runoff Area=5.908 ac 80.97% Impervious Runoff Depth>6.40"
Flow Length=682' Tc=8.4 min CN=95 Runoff=36.42 cfs 3.151 af

Subcatchment PR1.2: PR 1.2 - Driveway Runoff Area=0.689 ac 100.00% Impervious Runoff Depth>6.76"
Tc=5.0 min CN=98 Runoff=4.76 cfs 0.388 af

Subcatchment PR2: PR2 Runoff Area=2.031 ac 0.00% Impervious Runoff Depth>4.69"
Flow Length=162' Slope=0.0090 '/' Tc=10.4 min CN=80 Runoff=9.47 cfs 0.793 af

Subcatchment PR3.1: Parking Area Runoff Area=2.040 ac 83.82% Impervious Runoff Depth>6.51"
Flow Length=1,335' Tc=14.1 min CN=96 Runoff=10.77 cfs 1.107 af

Subcatchment PR3.2: Existing Runoff Area=5.706 ac 56.17% Impervious Runoff Depth>5.93"
Flow Length=646' Tc=15.1 min CN=91 Runoff=28.14 cfs 2.818 af

Subcatchment PR4: PR4 Runoff Area=4.200 ac 66.26% Impervious Runoff Depth>5.92"
Flow Length=1,380' Tc=16.6 min CN=91 Runoff=20.01 cfs 2.074 af

Pond 1P: Bioretention Basin 1P Peak Elev=99.61' Storage=4,586 cf Inflow=4.76 cfs 0.388 af
Discarded=0.01 cfs 0.017 af Primary=4.60 cfs 0.278 af Outflow=4.61 cfs 0.294 af

Pond 3P: Bioretention Basin 3 Peak Elev=100.97' Storage=28,361 cf Inflow=10.77 cfs 1.107 af
Discarded=0.03 cfs 0.039 af Primary=3.61 cfs 0.493 af Outflow=3.64 cfs 0.531 af

Pond 4P: Bioretention Swale 4 Peak Elev=100.60' Storage=22,677 cf Inflow=20.01 cfs 2.074 af
Discarded=0.03 cfs 0.029 af Primary=15.76 cfs 1.795 af Outflow=15.79 cfs 1.824 af

Link DP1: Adjacent Parking / Closed Drainage Inflow=40.95 cfs 3.428 af
Primary=40.95 cfs 3.428 af

Link DP2: Wetland R5 Inflow=9.47 cfs 0.793 af
Primary=9.47 cfs 0.793 af

Link DP3: Adjacent Closed Drainage Inflow=28.14 cfs 3.311 af
Primary=28.14 cfs 3.311 af

Link DP4: Wetland R62.1 (Perennial Stream) Inflow=15.76 cfs 1.795 af
Primary=15.76 cfs 1.795 af

Total Runoff Area = 20.574 ac Runoff Volume = 10.331 af Average Runoff Depth = 6.03"
35.98% Pervious = 7.403 ac 64.02% Impervious = 13.171 ac

Summary for Subcatchment PR1.1: PR1.1

Runoff = 36.42 cfs @ 12.11 hrs, Volume= 3.151 af, Depth> 6.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.032	94	Fallow, bare soil, HSG D
0.054	98	Paved roads w/curbs & sewers, HSG C
4.730	98	Paved parking, HSG D
0.042	73	Woods, Fair, HSG C
0.911	84	50-75% Grass cover, Fair, HSG D
0.137	79	50-75% Grass cover, Fair, HSG C
0.002	84	50-75% Grass cover, Fair, HSG D
5.908	95	Weighted Average
1.124		19.03% Pervious Area
4.784		80.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.0280	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
0.4	77	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.4	330	0.0240	2.32		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.5	103	0.0040	3.39	2.66	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.3	122	0.0254	6.92	33.99	**Pipe Channel, CMP_Round 30"** 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.025 Corrugated metal
8.4	682	Total			

Summary for Subcatchment PR1.2: PR 1.2 - Driveway

[49] Hint: Tc<2dt may require smaller dt

Runoff = 4.76 cfs @ 12.07 hrs, Volume= 0.388 af, Depth> 6.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.689	98	Paved parking, HSG A
0.689		100.00% Impervious Area

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

Summary for Subcatchment PR2: PR2

Runoff = 9.47 cfs @ 12.15 hrs, Volume= 0.793 af, Depth> 4.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
2.022	80	>75% Grass cover, Good, HSG D
0.009	79	Woods, Fair, HSG D
2.031	80	Weighted Average
2.031		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.6	50	0.0090	0.11		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
2.8	112	0.0090	0.66		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.4	162	Total			

Summary for Subcatchment PR3.1: Parking Area

Runoff = 10.77 cfs @ 12.19 hrs, Volume= 1.107 af, Depth> 6.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
1.710	98	Paved parking, HSG D
0.330	84	50-75% Grass cover, Fair, HSG D
2.040	96	Weighted Average
0.330		16.18% Pervious Area
1.710		83.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.1	50	0.0196	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.6	78	0.0196	2.10		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.8	50	0.0120	0.99		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
2.4	318	0.0116	2.19		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	34	0.0080	4.80	3.77	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.5	329		11.35		**Lake or Reservoir,** Mean Depth= 4.00'
1.6	476	0.0050	4.97	8.78	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
14.1	1,335	Total			

Summary for Subcatchment PR3.2: Existing Landscaped/Paved Area

Runoff = 28.14 cfs @ 12.20 hrs, Volume= 2.818 af, Depth> 5.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.025	98	Paved parking, HSG B
3.180	98	Paved parking, HSG D
0.251	69	50-75% Grass cover, Fair, HSG B
2.250	84	50-75% Grass cover, Fair, HSG D
5.706	91	Weighted Average
2.501		43.83% Pervious Area
3.205		56.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9	50	0.0120	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.30"
0.8	171	0.0610	3.70		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.5	300	0.0120	1.42		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.9	125	0.0120	2.22		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
15.1	646	Total			

Summary for Subcatchment PR4: PR4

Runoff = 20.01 cfs @ 12.22 hrs, Volume= 2.074 af, Depth> 5.92"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.484	98	Paved parking, HSG B
2.127	98	Paved parking, HSG D
0.172	98	Paved parking, HSG D
0.547	69	50-75% Grass cover, Fair, HSG B
0.870	84	50-75% Grass cover, Fair, HSG D
4.200	91	Weighted Average
1.417		33.74% Pervious Area
2.783		66.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	33	0.0220	1.16		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.30"
0.8	163	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.7	240	0.0100	0.70		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	177	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.1	38	0.0100	5.36	4.21	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
8.3	689	0.0085	1.38		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
16.6	1,380	Total			

Summary for Pond 1P: Bioretention Basin 1P

Inflow Area = 0.689 ac,100.00% Impervious, Inflow Depth > 6.76" for 100-Year event
Inflow = 4.76 cfs @ 12.07 hrs, Volume= 0.388 af
Outflow = 4.61 cfs @ 12.10 hrs, Volume= 0.294 af, Atten= 3%, Lag= 1.6 min
Discarded = 0.01 cfs @ 12.10 hrs, Volume= 0.017 af
Primary = 4.60 cfs @ 12.10 hrs, Volume= 0.278 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 99.61' @ 12.10 hrs Surf.Area= 5,140 sf Storage= 4,586 cf

Plug-Flow detention time= 158.1 min calculated for 0.294 af (76% of inflow)
Center-of-Mass det. time= 73.2 min (814.9 - 741.7)

Volume	Invert	Avail.Storage	Storage Description
#1	98.50'	6,927 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.50	3,319	353.0	0	0	3,319
99.00	4,106	413.0	1,853	1,853	6,981
99.50	4,733	423.0	2,208	4,061	7,679
100.00	6,793	591.0	2,866	6,927	21,237

Device	Routing	Invert	Outlet Devices
#1	Primary	99.50'	**40.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height
#2	Discarded	98.50'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.01 cfs @ 12.10 hrs HW=99.61' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=4.55 cfs @ 12.10 hrs HW=99.61' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 4.55 cfs @ 1.08 fps)

Summary for Pond 3P: Bioretention Basin 3

Inflow Area = 2.040 ac, 83.82% Impervious, Inflow Depth > 6.51" for 100-Year event
Inflow = 10.77 cfs @ 12.19 hrs, Volume= 1.107 af
Outflow = 3.64 cfs @ 12.57 hrs, Volume= 0.531 af, Atten= 66%, Lag= 23.3 min
Discarded = 0.03 cfs @ 12.57 hrs, Volume= 0.039 af
Primary = 3.61 cfs @ 12.57 hrs, Volume= 0.493 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.97' @ 12.57 hrs Surf.Area= 13,837 sf Storage= 28,361 cf

Plug-Flow detention time= 270.5 min calculated for 0.531 af (48% of inflow)
Center-of-Mass det. time= 141.3 min (902.6 - 761.3)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	28,805 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.00	5,654	805.6	0	0	5,654
99.00	8,176	893.3	6,876	6,876	17,541
100.00	10,935	891.3	9,522	16,398	18,477
101.00	13,939	955.3	12,407	28,805	27,927

Device	Routing	Invert	Outlet Devices
#1	Discarded	98.00'	**0.090 in/hr Exfiltration over Surface area**
#2	Primary	100.70'	**8.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.03 cfs @ 12.57 hrs HW=100.97' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=3.58 cfs @ 12.57 hrs HW=100.97' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir**(Weir Controls 3.58 cfs @ 1.69 fps)

Summary for Pond 4P: Bioretention Swale 4

```
Inflow Area =      4.200 ac, 66.26% Impervious, Inflow Depth >  5.92"   for 100-Year event
Inflow      =     20.01 cfs @  12.22 hrs, Volume=        2.074 af
Outflow     =     15.79 cfs @  12.35 hrs, Volume=        1.824 af, Atten= 21%, Lag= 8.1 min
Discarded   =      0.03 cfs @  12.35 hrs, Volume=        0.029 af
Primary     =     15.76 cfs @  12.35 hrs, Volume=        1.795 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.60' @ 12.35 hrs Surf.Area= 14,692 sf Storage= 22,677 cf

Plug-Flow detention time= 102.9 min calculated for 1.821 af (88% of inflow)
Center-of-Mass det. time= 49.1 min (833.8 - 784.7)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	29,092 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
98.00	5,101	559.0	0	0	5,101
99.00	7,395	693.0	6,213	6,213	18,466
99.50	8,686	757.0	4,016	10,229	25,860
100.00	10,672	776.0	4,831	15,060	28,209
101.00	17,687	824.0	14,033	29,092	34,373

Device	Routing	Invert	Outlet Devices
#1	Primary	96.00'	**18.0" Round Culvert** L= 90.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 96.00' / 95.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#2	Device 1	99.50'	**48.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	100.50'	**4.0" x 4.0" Horiz. Orifice/Grate X 4.00 columns** X 8 rows C= 0.600 in 24.0" x 48.0" Grate Limited to weir flow at low heads
#4	Discarded	98.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.03 cfs @ 12.35 hrs HW=100.60' (Free Discharge)
└─**4=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=15.72 cfs @ 12.35 hrs HW=100.60' (Free Discharge)
└─**1=Culvert** (Passes 15.72 cfs of 16.00 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 14.44 cfs @ 3.61 fps)
  └─**3=Orifice/Grate** (Weir Controls 1.28 cfs @ 1.05 fps)

Summary for Link DP1: Adjacent Parking / Closed Drainage

```
Inflow Area =       6.597 ac, 82.96% Impervious, Inflow Depth >  6.24"   for  100-Year event
Inflow     =      40.95 cfs @  12.11 hrs, Volume=          3.428 af
Primary    =      40.95 cfs @  12.11 hrs, Volume=          3.428 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP2: Wetland R5

```
Inflow Area =       2.031 ac,  0.00% Impervious, Inflow Depth >  4.69"   for  100-Year event
Inflow     =       9.47 cfs @  12.15 hrs, Volume=          0.793 af
Primary    =       9.47 cfs @  12.15 hrs, Volume=          0.793 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Summary for Link DP3: Adjacent Closed Drainage

```
Inflow Area =       7.746 ac, 63.45% Impervious, Inflow Depth >  5.13"   for  100-Year event
Inflow     =      28.14 cfs @  12.20 hrs, Volume=          3.311 af
Primary    =      28.14 cfs @  12.20 hrs, Volume=          3.311 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

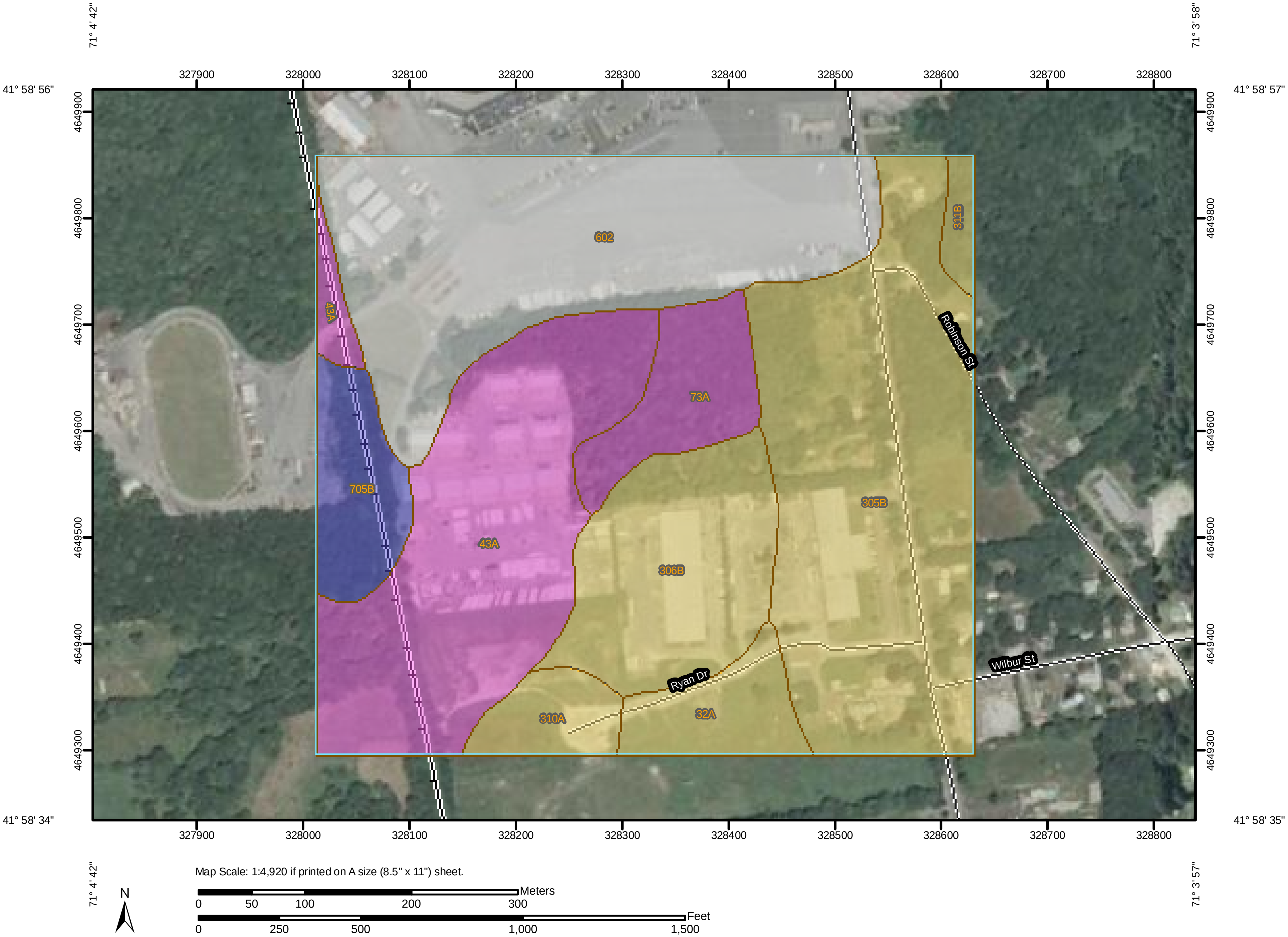
Summary for Link DP4: Wetland R62.1 (Perennial Stream)

```
Inflow Area =       4.200 ac, 66.26% Impervious, Inflow Depth >  5.13"   for  100-Year event
Inflow     =      15.76 cfs @  12.35 hrs, Volume=          1.795 af
Primary    =      15.76 cfs @  12.35 hrs, Volume=          1.795 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
```

Appendix C
Standard 3 Computations and Supporting Information

Soil Evaluation and Analysis

Hydrologic Soil Group—Bristol County, Massachusetts, Northern Part



Map Scale: 1:4,920 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

- ☐ Area of Interest (AOI)

Soils

- ☐ Soil Map Units

Soil Ratings

- 🟫 A
- 🟩 A/D
- 🟪 B
- 🟦 B/D
- 🟨 C
- 🟦 C/D
- 🟪 D
- ⬜ Not rated or not available

Political Features

- ● Cities

Water Features

- ∿ Streams and Canals

Transportation

- ┼┼┼ Rails
- ∿ Interstate Highways
- ∿ US Routes
- ∿ Major Roads
- ∿ Local Roads

MAP INFORMATION

Map Scale: 1:4,920 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bristol County, Massachusetts, Northern Part
Survey Area Data: Version 5, Jul 27, 2010

Date(s) aerial images were photographed: 7/10/2003; 7/31/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Northern Part (MA602)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
32A	Wareham loamy sand, 0 to 3 percent slopes	C	3.2	3.8%
43A	Scarboro mucky loamy fine sand, 0 to 3 percent slopes	D	18.5	21.5%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	4.3	4.9%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	C	22.9	26.6%
306B	Paxton fine sandy loam, 0 to 8 percent slopes, very stony	C	9.4	11.0%
310A	Woodbridge fine sandy loam, 0 to 3 percent slopes	C	2.3	2.7%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C	0.9	1.0%
602	Urban land		20.6	23.9%
705B	Charlton - Paxton fine sandy loams, 3 to 8 percent slopes, rocky	B	3.9	4.5%
Totals for Area of Interest			**85.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Required and Provided Recharge Volumes

Recharge Calculations

Project Name: **Raynham Park Station**
Proj. No.: 10111.00
Project Location: **Raynham, MA**
Date: 18-May-12
Calculated by: DAG
Checked by: EJM

Proposed Impervious Surface Summary

Net Proposed Impervious Areas by Hydrologic Soil Group (HSG) in acres

Subcatchment	HSG A	HSG B	HSG C	HSG D	Total Area
1	0.0	0.0	0.1	5.4	5.5
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	1.7	1.7
4	0.0	0.0	0.0	2.3	2.3
TOTAL	**0.0**	**0.0**	**0.1**	**9.4**	**9.5**

Required Recharge Volume (Cubic Feet)

HSG	Area (acres)	Recharge Depth * (in.)	Volume (c.f.)
A	0.0	0.60	0
B	0.0	0.35	61
C	0.1	0.25	49
D	9.4	0.10	3,422
TOTAL			**3,533**

* Per 2008 Massachusetts DEP Recharge Requirement

Provided Recharge Volume (Cubic Feet)

Infiltration Volumes Provided in Infiltration Basins (below lowest overflow outlet)

Pond 1P	741	
Pond 3P	1,699	
Pond 4P	1,263	
Total	**3,703**	c.f.

72-hour Drawdown Analysis

Drawdown Calculations

Project Name: Raynham Park **Proj. No.:** 10111.00

Date: 5/18/2012

Project Location: Raynham, MA **Calculated by:** EJM

Bioretention Basin - 1

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
98.50	3,319	0
99.00	4,106	1,856
99.50	4,733	4,066
TOTAL		**4,066**

Assumptions:

Recharge Rate: 1.00 in/hr* * Bioretention Basin Soil Media Infiltration Rate

Drawdown Time: 14.7 hours

Bioretention Basin - 3

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
98.00	5,654	0
99.00	8,176	6,915
100.00	10,935	16,471
101.00	13,939	28,908
TOTAL		**28,908**

Assumptions:

Recharge Rate: 1.00 in/hr* * Bioretention Basin Soil Media Infiltration Rate

Drawdown Time: 61.4 hours

Infiltration Basin - 4

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
98.00	5,101	0
99.00	7,395	6,248
99.50	8,686	10,268
TOTAL		**10,268**

Assumptions:

Recharge Rate: 1.00 in/hr* * Bioretention Basin Soil Media Infiltration Rate

Drawdown Time: 24.2 hours

Appendix D
Standard 4 Computations and Supporting Information

Water Quality Volume Calculations

VHB

Water Quality Volume Calculations

Project Name: Raynham Park Station
Proj. No.: 10111.00
Project Location: Raynham, MA
Date: 5/18/2012
Calculated by: EJM

Bioretention Basin 1P
(Runoff from Area DA-1 Driveway)

Total Impervious Area = 0.69 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	250
Water Quality Volume	1	2,501

Provided:

Bioretention Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	98.5	3,319	0
	99.0	4,106	1,856
	99.5	4,733	4,066

Biofiltration Swale 3P
(Runoff from Parking Area DA-3)

Total Impervious Area = 4.96 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	1,801
Water Quality Volume	1	18,012

Provided:

Bioinfiltration Swale	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	98.0	5,654	0
	99.0	8,176	6,915
	100.0	10,935	16,471
	101.0	13,939	28,908

Bioretention Basin 4P
(Runoff from Parking Area DA-4)

Total Impervious Area = 2.39 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	867
Water Quality Volume	1	8,675

Provided:

Bioretention Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	98.0	5,101	0
	99.0	7,395	6,248
	99.5	8,686	10,268

TSS Removal Worksheets

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Raynham Park Station**
Project Number: **10111.00**
Location: **Raynham, MA**
Discharge Point: **DP-1**
Drainage Area(s): **DA-1**

Sheet: **1 of 3**
Date: **6-Apr-2012**
Computed by: **DAG**
Checked by: **VHB**

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area w/ Grassed Swale Pretreatment	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Raynham Park Station**
Project Number: **10111.00**
Location: **Raynham, MA**
Discharge Point: **DP-3**
Drainage Area(s): **DA-3**

Sheet: **2 of 3**
Date: **6-Apr-2012**
Computed by: **DAG**
Checked by: **VHB**

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area w/ Sediment Forebay Pretreatment	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Raynham Park Station**
Project Number: **10111.00**
Location: **Raynham, MA**
Discharge Point: **DP-4**
Drainage Area(s): **DA-4**

Sheet: **3 of 3**
Date: **6-Apr-2012**
Computed by: **DAG**
Checked by: **VHB**

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area w/ Grass and Gravel Filter Strip Pretreament	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

\\Vhb\proj\Boston\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Raynham Park\Appendices\Appendix D_Standard 4 Support\TSS Removal Worksheet

Appendix E
Geotechnical Report

JACOBS
343 Congress Street
Boston, MA 02210

Design Memorandum

Date February 29, 2012

To Rick Carey, Natasha Velickovic - VHB

From Paul Murphy, Da Ha, Peter Chou - Jacobs

Subject MBTA South Coast Rail (New Bedford/Fall River Commuter Rail Extension)
Raynham Park Station Geotechnical Design Memorandum
Raynham, MA

Project No. E2347101

INTRODUCTION

The South Coast Rail project will restore passenger rail transportation from South Station in Boston to the cities of Fall River and New Bedford along an existing rail freight corridor running south from Taunton to Fall River and New Bedford. The project will include the construction of several existing and new passenger stations and two terminal layover facilities. This geotechnical design memorandum presents the foundation design considerations for the new station platform at the proposed Raynham Park Station in Raynham, Massachusetts. The design recommendations presented in this report are based on the results of subsurface investigation performed by Jacobs in 2010.

Existing Conditions

The proposed Raynham Park Station is at the site of the Raynham-Taunton Greyhound Track, off Route 138 in Raynham, MA (Figure 1). The station site itself is within a larger, developed site that contains industrial facilities, a telephone pole storage yard, the greyhound track and associated uses, and a parking area. Existing grades at the platform location range from elevations 92 to 96 feet (NGVD29 Datum), generally sloping downward from south to north. The existing buildings and their foundations will need to be removed.

Proposed Construction

Current station plans are to construct an 800 foot long, 12 foot wide high level center platform adjacent to the existing tracks with some track relocation required, as well as the addition of a second track, a new parking area, access roads, and a new drop-off area. Access to the platform will be from a new ramp/stair structure along the east side of the tracks with a bridge over the track to the platform. Approximately 400 feet of the platform will be under a canopy. The details of new track layout (including grading), associated sidewalks and ramps of the proposed station are still under development at the time of this report preparation. This report focuses on the foundations for the platform only.

SCOPE OF WORK

This memorandum was prepared by Jacobs in accordance with the scope of work under the contract between Jacobs and VHB for work on the New Bedford/Fall River Commuter Rail Line Extension Project for Massachusetts Bay Transportation Authority (MBTA). The geotechnical work included the following tasks:

- Perform a geotechnical exploration and laboratory testing program;
- Report and interpret the results of the exploration and laboratory testing program; and

- Provide geotechnical recommendations for design and construction of the platform foundations.

The Jacobs scope of work did not include environmental analyses to assess the potential presence of any hazardous materials at the project site.

LOCAL GEOLOGY

The site is located in the Narragansett Basin of southeastern Massachusetts. The rocks in the Narragansett Basin consist mostly of lightly metamorphosed shale and sandstone of Pennsylvanian and Permian age. The Raynham Park Station is located in the area of the Rhode Island Formation. The rocks encountered in the borings include conglomerate, sandstone, greywacke and siltstone. These rocks are all similar in that they are strongly cemented mixtures of fine to coarse sand with silt. Conglomerate includes gravel; greywacke includes all grain sizes, including a high percentage of fines. Weathering in these rocks commonly involves the breakdown of the mineral cements leading to eventual disaggregation of the matrix and the formation of residual soil. The rocks in the borings had sub-horizontal joints that appear to follow the bedding in the rock. These joints are probably the result of vertical unloading following deglaciation.

The top of rock was encountered in the borings between elevation 103 feet and elevation 84 feet. The thickness of overburden above the rock ranged from 26 feet to less than one foot.

GEOTECHNICAL EXPLORATIONS

Jacobs planned the subsurface exploration program and retained the drilling contractor (New Hampshire Boring) to perform the explorations. The geotechnical data report was submitted in 2010. Seven borings (RPS-1 to RPS-7) were conducted in the general vicinity of the proposed station platform area and eighteen borings (RPS-8, RPS-10, RPS-12 to RPS-26 and RPS-28) were drilled in the general vicinity of the proposed parking lot and its access roads. Boring locations are shown on the Subsurface Exploration Plan (Figures 2 & 3).

The borings were drilled by New Hampshire Boring using either a CME-550 or D-50 ATV mounted drill rig, or a CME-75 truck mounted drill rig. The borings were advanced through the soil by hollow-stem auger or wash boring methods using a 4-inch casing and roller bit with water. Standard penetration tests (SPT), consisting of a 140-pound hammer dropping 30 inches on a standard 2-inch-diameter (OD) split-spoon sampler, were performed with a safety hammer or automatic hammer to establish the consistency of the subsurface soils. The SPT's were typically performed at five foot intervals of depth. The obtained samples were sealed in glass jars to retain their natural moisture. Bedrock was encountered and cored around the proposed platform area.

The borings were observed and logged by a representative from Jacobs. The soil samples were classified in the field in accordance with ASTM D-2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) by Jacobs’ representative, and appropriate stratum breaks were interpolated from drilling and sampling observations. The boring logs were prepared by Jacobs based on the field classifications and laboratory testing, and are presented in Appendix A.

LABORATORY TESTING

The results of the laboratory testing were previously submitted to VHB in a report entitled “South Coast Rail, Jacobs Geotechnical Data Report”, dated November 2010.

Grain size distribution analyses were performed to evaluate the gradation of the natural granular soils for potential reuse as backfill, if needed, and to confirm sample classifications. The analyses are summarized in Table 1 below and are presented in Appendix B.

Table 1: Laboratory Soil Classification Summary

BORING NO.	SAMPLE NO.	ELEVATION (FEET)	USCS SOIL CLASSIFICATION	W (%)	GRAVEL (%)	SAND (%)	FINES (%)
RPS – 4 OW	S2	90.0	Silty Sand w/ Gravel (SM)	NT	37.7	45.2	17.1
RPS – 13 OW	S3	93.0	Silty Sand w/ Gravel (SM)	6.2	16.0	49.6	34.4
RPS - 16	S3	95.0	Silty Sand (SM)	11.6	4.9	74.8	20.3
RPS - 19	S4	92.0	Sandy Silt (ML)	2.7	6.0	44.4	49.6
RPS - 22	S3	97.0	Sandy Silt (ML)	14.5	6.0	40.0	54.0

Where: w = natural moisture content, NT = Not Tested.

SUBSURFACE CONDITIONS

The subsurface conditions at the site were inferred from the boring data collected for the Raynham Park Station project, with some interpretations. The subsurface conditions encountered at the station platform area generally consist of a relatively thin layer of granular fill with thickness of about 0 to 3 feet, underlain by a granular soil layer with thickness ranging from 0 to 10 feet overlying bedrock. Bedrock was encountered at a depth of about 0.7 to 10 feet in the platform area, corresponding to approximately elevations 86.0 to 103.0 feet.

Fill materials with thicknesses ranging from approximately 0 to 10 feet, were also encountered in the vicinity of the proposed parking lot and access roads area. Bedrock was encountered at a depth about 2 to 21 feet (corresponding to elevations 84.0 to 101.0 feet). Shallower bedrock was found on the north side of the parking lot and in the area of the proposed Pond 1.

Subsurface soil conditions are summarized in Table 2 and discussed below.

Table 2: Summary of Subsurface Conditions at Borings

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Platform Borings							
RPS - 1	96.0	0	96.0	86.0	79.0	96.5	Boring in flowing stream.
RPS - 2	93.0	0	93.0	92.3	90.5	93.5	Boring in flowing stream.
RPS - 3	92.0	0	92.0	89.0	87.5	92.5	Boring in flowing stream.
RPS - 4 OW	93.0	3.0	90.0	89.5	77.0	89.5	
RPS - 5	106.0	0	106.0	103.0	85.0	104.0	
RPS - 6	105.0	3.0	102.0	98.0	93.0	100.5	Boring offset ~30 ft E.
RPS - 7	107.0	3.0	104.0	91.0	81.5	NR	

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Site Borings							
RPS - 8	106.0	0	106.0	95.0	92.0	NR	
RPS - 10	108.0	5.0	103.0	98.5	98.0	100.5	Auger Boring
RPS - 12	103.0	4.0	99.0	87.0	87.0	NR	
RPS - 13 OW	107.0	3.0	104.0	86.0	83.0	102.3	Well screened from 14 to 24 ft.
RPS - 14	104.0	0	104.0	98.6	98.6	NR	Auger Boring
RPS - 15	107.0	3.0	104.0	101.0	98.0	NR	
RPS - 16	107.0	4.0	103.0	NE	91.0	NR	
RPS - 17	106.0	3.0	103.0	NE	90.0	NR	
RPS - 18	105.0	3.0	102.0	98.0	98.0	NR	Boring offset ~18 ft S (utilities), Auger Boring
RPS - 19	106.0	10	96.0	NE	90.0	98.0	Boring offset ~8 ft E (utilities), Auger Boring
RPS - 20	106.0	3.0	103.0	NE	90.0	NR	
RPS - 21	105.0	3.0	102.0	91.0	88.0	99.0	
RPS - 22	105.0	3.0	102.0	84.0	81.0	100.0	
RPS - 23	106.0	4.0	102.0	NE	80.0	NR	
RPS - 24	103.0	2.0	101.0	101.0	100.5	101.0	Auger Boring
RPS - 25	103.0	4.0	99.0	99.0	98.5	NR	Boring offset ~5 ft W, Auger Boring
RPS – 26	104.0	0	104	99.0	97.5	NR	
RPS – 28	105.0	1.0	104.0	97.0	95.0	NR	

NE: Not encountered at the boring during drilling. NR: Not recorded

Soil conditions in the platform area generally consisted of the following:

Fill: The fill layer typically consists of mostly granular, loose to medium dense sand or gravel with up to 10% silt. The fill layer is generally about 0 to 3 feet thick in the area of the platform.

Natural Granular Deposits: The natural soil deposits below the fill generally consist of predominantly sand with gravel. These deposits are medium dense to very dense with Standard Penetration Test (SPT) N-values ranging between 15 and more than 50 blows per foot (bpf).

Bedrock: Bedrock was encountered in the platform area near ground surface to a depth of 10 feet below existing ground surface, corresponding to approximately elevations 86.0 to 92.3 feet. The bedrock was fine grained, severely jointed and joint weathering SANDSTONE or highly jointed, moderately weathered CONGLOMERATE. Bedrock RQD values at the platform range from zero to 47.

Bedrock was encountered at elevations ranging from about 84.0 to 103.0 feet in other site areas.

Groundwater: Groundwater levels were measured in the observation wells and in test borings using a weighted tape during and at completion of drilling. The data indicated the groundwater level ranged from approximate elevations 89.5 to 104 feet along the platform alignment, and from elevations 98 to 102 feet in the general area of the proposed parking lot. The use of wash boring techniques for some of the soil borings may have artificially increased the water level readings due to the addition of water to the borings. Trapped/perched water is also commonly seen at a higher elevation within existing fill and silty materials. The longer term water level readings taken at Boring RPS–04 OW on July 7, 2010 indicated the water at a depth of about 3.5 feet (Elevation 89.5 feet). The longer term water level readings taken at Boring RPS–13 OW on July 7, 2010 and September 12, 2011 indicated the water at a depth of about 7.5 feet (Elevation 99.5 feet) and 4.7 feet (Elevation 102.3 feet). Based upon these short-term observations and readings from the observation wells, it is anticipated that the groundwater could be within 3 to 4 feet below existing grade at the platform area and within 4 to 8 feet below grade in the parking lot area.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. Local and periodic variations of ground water elevations may also be influenced by local subsurface drainage, leaking water or sewer pipes, and precipitation.

GEOTECHNICAL RECOMMENDATIONS

Based on the review of available subsurface conditions, the proposed station platforms can be supported on spread footings bearing directly within either competent natural soil, structural fill placed above suitable natural soils or on bedrock. Platform and canopy design loads were not available at the time of this report preparation. However, it is anticipated that the station platform will be lightly (axially) loaded with limited horizontal forces from wind and seismic loads.

The following paragraphs provide project specific geotechnical recommendations for foundation soil preparation, structural fill/backfill placement, and design and construction of spread footings.

Platform Foundations

Spread footings are recommended for the platform foundations, bearing on compacted structural fill, natural granular deposits, or bedrock. The existing fill is not suitable for support of the spread footings and should be removed within the zone of influence of the footing, defined by a line extending one foot horizontally from the bottom edge of footing and then down and away at a 1H:1V slope until natural granular soils or bedrock are encountered. The bottom of footing elevation should be at least 4 feet below final finished grades for frost protection for footings bearing on soil and at least 3 feet below final grade for footings bearing on bedrock.

The recommended allowable design bearing capacity for spread footings bearing on structural fill or natural sand and gravel deposits is 6 ksf, provided that subgrades are prepared as described herein. This provides an adequate factor of safety against bearing failure and limits the total estimated settlement to less than one inch and the differential settlement to less than ½ inch. For footings bearing directly on moderately weathered bedrock, we recommend an allowable bearing capacity of 16 ksf. However, since the actual bearing surface may not be known until construction, consideration should be given to designing all the footings for the 6 ksf bearing capacity. All footings should be at least 3 feet wide.

The structural fill material, if needed, should be free from organics and other deleterious substances and should conform to the requirements listed in the MBTA Standard Specification Section 02200 - Earthwork for Type B Gravel Borrow. The structural fill should be compacted to 95% of the maximum dry density as determined by the Modified Proctor compaction test (ASTM D1557).

All temporary open cuts required for footing construction should be in accordance with the related OSHA regulations and should have side slopes of no steeper than 1.5H:1V.

Seismic Consideration

The seismic design should comply with the requirements of the most current Massachusetts State Building Code 780 CMR and other relevant project design codes such as AREMA and AASHTO. Modification of the peak acceleration by the soils overlying bedrock depends upon the type of soil at the site. For the subsurface conditions encountered, the station site is classified as Seismic Site Class C soil profile in accordance with 780 CMR Chapter 1614.0 Section 9.4 Site Ground Motion. The structure could be designed for the total lateral seismic force using the equations specified in the code, or by the response spectrum method using the design spectra presented in the code. The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods (Ss) and at 1-sec (S_1) obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4.

For Site Class C Soils at the location of this station:

S_{MS} = 0.288 and S_{M1} = 0.105

S_{DS} = 0.192 and S_{D1} = 0.070

where:

- S_{MS} is the maximum consider earthquake spectral response acceleration for short periods adjusted for site class
- S_{M1} is the maximum consider earthquake spectral response acceleration at 1-sec adjusted for site class
- S_{DS} is the design earthquake spectral response acceleration for short periods adjusted for site class
- S_{D1} is the design earthquake spectral response acceleration at 1-sec adjusted for site class

The building code also requires that the soil be evaluated for the following potential hazards: slope instability, soil liquefaction, or surface rupture due to faulting or lateral spreading. The proposed grading is relatively flat and we are not aware of any pre-existing slope instability in this area. The existing overburden soils do not appear to be subject to surface rupture due to faulting or lateral spreading.

Liquefaction

Based on the observed subsurface conditions, recorded water levels, percentage of fine contents and sample relative densities, the existing soils underlying the site are judged not susceptible to liquefaction.

CONSTRUCTION CONSIDERATIONS

Platform Foundations - Spread Footings

The existing fill should be stripped off and removed from within the zone of influence of the platform and any walkway areas down to natural granular deposits or bedrock using a smooth edge excavation bucket, and replaced by compacted granular soils.

Following excavation to the top of the natural granular deposits or bedrock, the exposed surface should be observed by an on-site representative of the project geotechnical engineer and soil subgrades shall be proof-compacted with at least 10 passes of a large vibratory drum roller. Any yielding areas should be observed by geotechnical personnel to assess if localized undercutting is necessary. Footing subgrade observations should include hand auger probes by the geotechnical personnel to check for soft/weak zones. The need for undercutting and backfilling with structural fill should be closely evaluated in the field based on encountered conditions.

If bedrock is encountered at the proposed bottom of footing elevation, the footing should either bear entirely on bedrock or entirely on soil. Where partial bedrock subgrade is encountered at the bottom of footing elevation, the bedrock should be over-excavated to a depth of at least 10 inches below the bottom of footing elevation and replaced with compacted Gravel Borrow to provide a uniform bearing surface.

In areas where seepage is encountered within footing excavations, the need for placing a 3" thick lean concrete mud mat or a layer of ¾-inch crushed stone to protect the bearing surface should be evaluated in the field. Crushed stone thicker than 4 inches shall be wrapped by non-woven filter fabric.

Following observation of the bearing soils by geotechnical personnel, reinforcing steel and concrete can be placed in the excavation. It is recommended that footing reinforcing steel and concrete be placed the same day as the footing excavation is made, where possible, to avoid significant moisture content changes in the bearing soils. No water should be allowed to pond within excavations and drainage should be maintained away from foundations both during and after construction. The footing excavation should be free of loose debris at the time of concrete placement.

Subgrade Preparation

Prior to performing any required grading operations and excavations in the proposed structure footprints, walkway and paved areas, these areas should be stripped of topsoil, vegetation, fill, former building foundations and existing pavement, if present. The topsoil should be placed in a designated area for reuse during final grading. Following site clearing and stripping, the exposed soil subgrade should be proof compacted with 10 passes of a large vibratory drum roller (minimum 10,000 pound static weight). Any pockets of excessively soft, wet or disturbed soil or unsuitable soils should be removed and replaced with properly compacted fill materials. Where subgrade soils are close to the existing groundwater level or where silty subgrade soils are encountered, proof-compaction using non-vibratory methods may be considered by the geotechnical engineer. Bedrock subgrades shall be free of all loose, fractured bedrock.

If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches but not exceeding eighteen inches, aerated, re-compacted, and retested to provide uniform compaction. Following satisfactory compaction of the subgrade, controlled compacted fill material should be placed to bring the site to the required grade.

Fill should not be placed over frozen soil. Soil subgrades should be protected against frost both during and after construction.

Proper drainage of construction areas should be provided to protect the subgrades from the detrimental effects of weather conditions. Excavations should be made with as few passes of the backhoe bucket as possible to reduce disturbance of the subgrade. A backhoe bucket fitted with a smooth blade should be used during the final subgrade preparation, where necessary. The exposed base should be kept free of standing water at all times. The site should be graded to carry any surface runoff away from the work areas. Construction traffic should be controlled to prevent excessive stresses and disturbance to the subgrade.

If pavements are not constructed immediately after grading, the subgrade should be shaped so as to prevent water ponding. If there is a substantial lapse in time between grading and paving, or if the subgrade is disturbed, it should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during proof-rolling or initial construction should be removed and replaced with compacted granular fill.

Within the proposed paved areas, and extending a distance of five feet beyond the edge on all sides, excavate existing granular fill soils to a depth of two feet below existing site grades. It may be possible to reuse the existing granular fill, depending on the suitability of the material, as described herein.

Fill Placement and Compaction

Fill materials most likely will be obtained by importing granular fill materials from off-site borrow sources. However, it may be possible to reuse existing site granular fill material provided that it can be properly placed and compacted. The gradation shall be in accordance with MBTA Standard Specification Section 02200-Earthwork for Type B Gravel Borrow.

All structural fill should be free of organics, demolition debris or other deleterious substances. The fill material should have a plasticity index (PI) less than 4 and a liquid limit (LL) less than 10, and contain fragments less than 4 inches in maximum dimension. Each lift should be compacted to the specified density prior to placing any subsequent lift. All materials to be used as structural fill should be tested in the laboratory to determine their project suitability and compaction characteristics.

The fill should be systematically compacted to the following percentages of the maximum dry density:

Table 3: Fill Compaction Requirements

DESCRIPTION	MINIMUM PERCENT COMPACTION (ASTM D-1557)
General Site Fills, Structural Fill (Below Footings and Slabs)	95
Behind Retaining Walls	92
Landscape Area	90

Soils which exhibit a well-defined moisture content–dry density relationship should be compacted to within plus or minus two percentage points of the optimum moisture content as determined by the Modified Proctor test (ASTM D-1557).

Where fill materials are placed against an existing embankment slope, the slope should be benched as the fill is brought up in layers. Benching should be of a sufficient width to permit placing and compaction of fill material upon the existing embankment materials. Typically, benches are between four to eight feet wide. Each bench cut should begin at the intersection of the existing embankment and the vertical side of the previous bench. Trench backfills over pipelines or utility structures should be performed so as not to adversely impact the underlying utilities. In fill areas, the backfill material, compaction method, and degree of compaction requirements should be similar to that for the fill adjacent to the trench.

Construction Dewatering

All excavations should be performed in the dry condition. Pumped water should be discharged in accordance with all federal, state and/or local regulations which may require a discharge permit and possible filtration and chemical testing of the water prior to discharge.

Permanent Slopes

Permanent slopes with loamed and seeded surfaces should not be steeper than 2-1/2 horizontal to 1 vertical (2-1/2H:1V) without slope protection to limit erosion and surficial sloughing of the slope. Additional analyses may be required to assess the stability of slopes for Pond 1 as the station design is finalized.

Excavation Slopes and Shoring

The slopes of temporary open cuts should be no steeper than 1-1/2H:1V. Open cuts should not be used below the water table because of the likelihood of soil sloughing into the excavation.

The temporary excavation support system, if needed, should be selected by the Contractor and designed by an experienced registered Professional Engineer in the Commonwealth of Massachusetts and retained by the Contractor. Where excavation sides can be sloped back, they should be performed in accordance with the Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

Protection of Existing Facilities

It is recommended that a geotechnical instrumentation and monitoring program be performed during construction of the project to evaluate impacts on structures slated to remain adjacent to the station. It is recommended that the program be developed to provide data for the following considerations:

- To monitor ground movements and vibration levels during construction.
- To provide early warning of potentially adverse trends by presenting sufficient data to determine the source of unanticipated ground movements, if present.
- If necessary, to plan remedial measures to limit damage to embankments and structures and to provide early warning when alternative means of protection are necessary.
- To document impacts of construction on adjacent facilities.
- To evaluate the performance and structural integrity of the constructed facilities.

If needed, we recommend the following instrumentation program to measure:

- Ground surface settlement and lateral movement adjacent to proposed construction.
- Horizontal and vertical movement of any excavation support system, and existing structures.
- Vibrations as a result of construction activities.

Vertical and horizontal survey points should be established on the adjacent structures. The monitoring points should be surveyed prior to the start of construction and monitored during construction to detect movement.

Vibration monitoring shall be conducted within 100 feet of existing structures during construction activities.

We recommend conducting a pre-construction survey of structures and utilities within 100 feet of the site to document existing conditions prior to construction. Documentation should include photographs, video, sketches, and/or written comments.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

CLOSING

This report and the recommendations contained herein have been prepared for the exclusive use of MBTA and VHB and their representatives for specific application to the design and construction of the proposed Raynham Park Station in Raynham, Massachusetts.

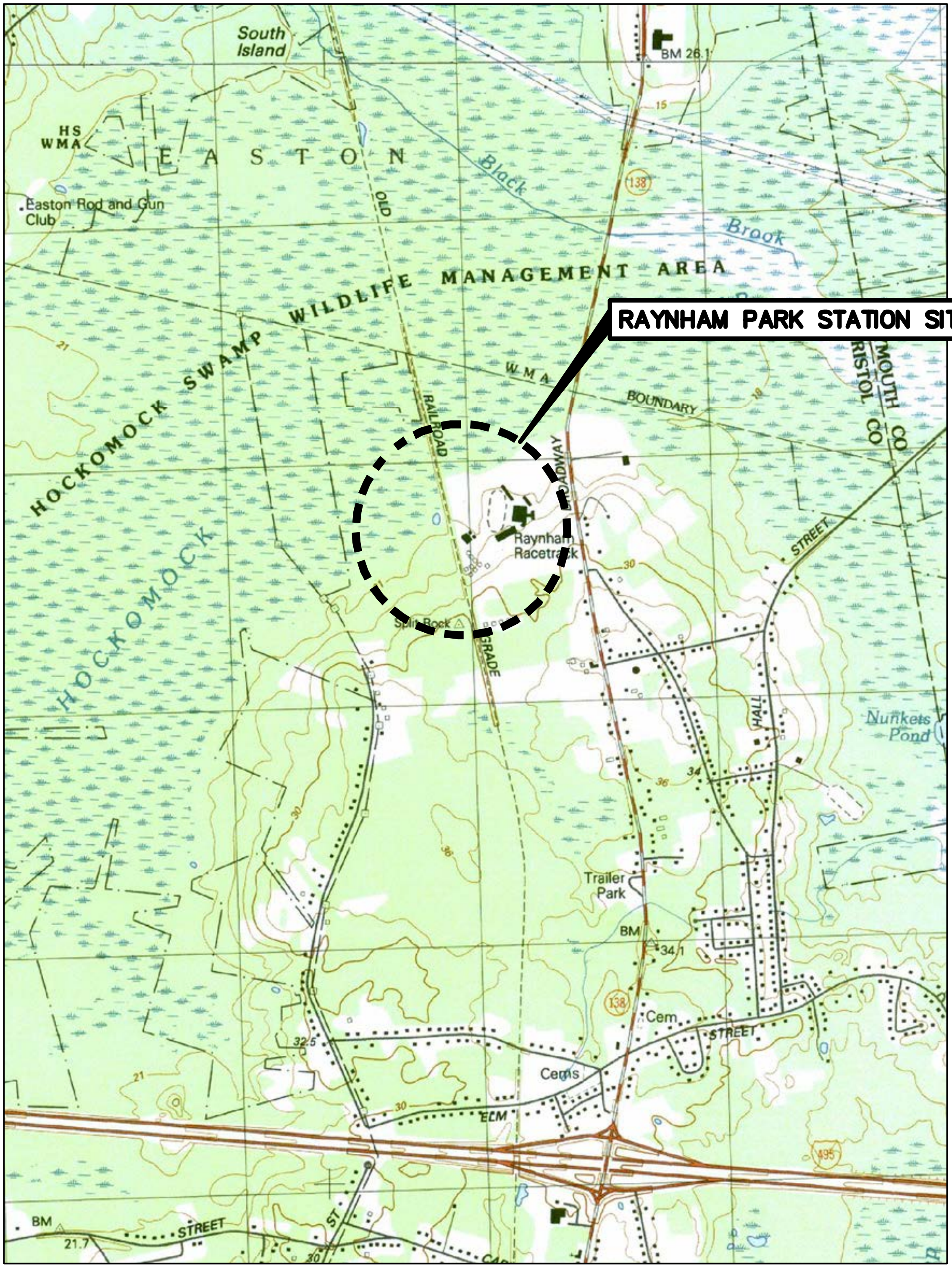
This report was prepared in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations then appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

ATTACHMENTS

FIGURE 1 – SITE LOCATION PLAN
FIGURES 2&3 – SUBSURFACE EXPLORATION PLAN
FIGURE 4 – SUBSURFACE SOIL PROFILES
APPENDIX A – TEST BORING LOGS
APPENDIX B – LABORATORY DATA
APPENDIX C – GEOTECHNICAL CALCULATIONS

F:\Proj\013471\600 Discipline Files\610 Studies and Reports\2011 GIR\05 - Raynham Park\ Raynham Park.doc

FIGURES



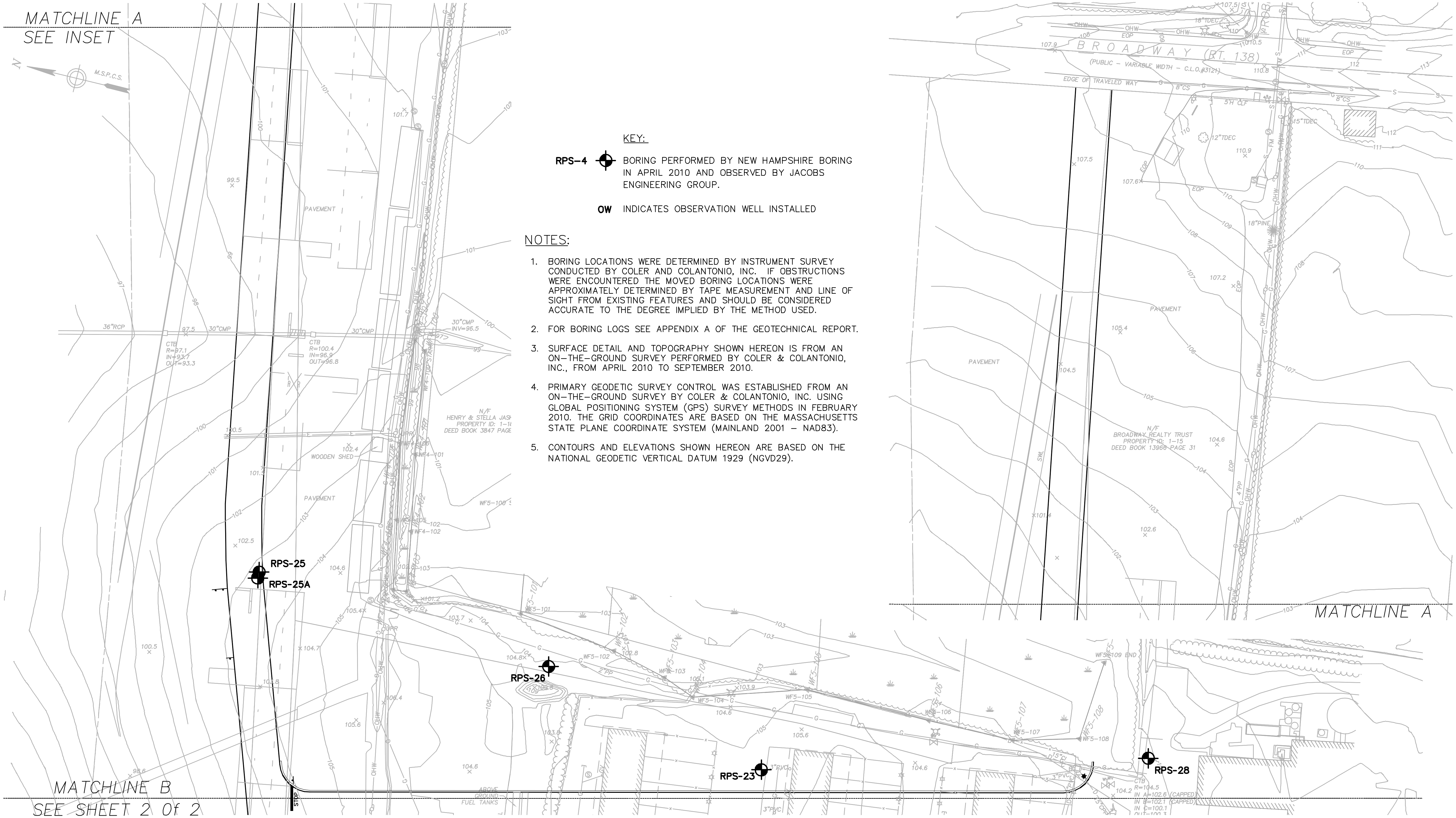
RAYNHAM PARK STATION
PROJECT LOCUS PLAN

NOT TO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

RAYNHAM PARK STATION
RAYNHAM, MASSACHUSETTS
FIGURE 1



KEY:

RPS-4 ⌖ BORING PERFORMED BY NEW HAMPSHIRE BORING IN APRIL 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.

OW INDICATES OBSERVATION WELL INSTALLED

NOTES:

1. BORING LOCATIONS WERE DETERMINED BY INSTRUMENT SURVEY CONDUCTED BY COLER AND COLANTONIO, INC. IF OBSTRUCTIONS WERE ENCOUNTERED THE MOVED BORING LOCATIONS WERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENT AND LINE OF SIGHT FROM EXISTING FEATURES AND SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.
2. FOR BORING LOGS SEE APPENDIX A OF THE GEOTECHNICAL REPORT.
3. SURFACE DETAIL AND TOPOGRAPHY SHOWN HEREON IS FROM AN ON–THE–GROUND SURVEY PERFORMED BY COLER & COLANTONIO, INC., FROM APRIL 2010 TO SEPTEMBER 2010.
4. PRIMARY GEODETIC SURVEY CONTROL WAS ESTABLISHED FROM AN ON–THE–GROUND SURVEY BY COLER & COLANTONIO, INC. USING GLOBAL POSITIONING SYSTEM (GPS) SURVEY METHODS IN FEBRUARY 2010. THE GRID COORDINATES ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (MAINLAND 2001 – NAD83).
5. CONTOURS AND ELEVATIONS SHOWN HEREON ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29).

RAYNHAM PARK STATION
BORING LOCATION PLAN
SCALE: 1"=80'

80 40 0 80 160
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_RaynhamPark.dwg Feb 24, 2012

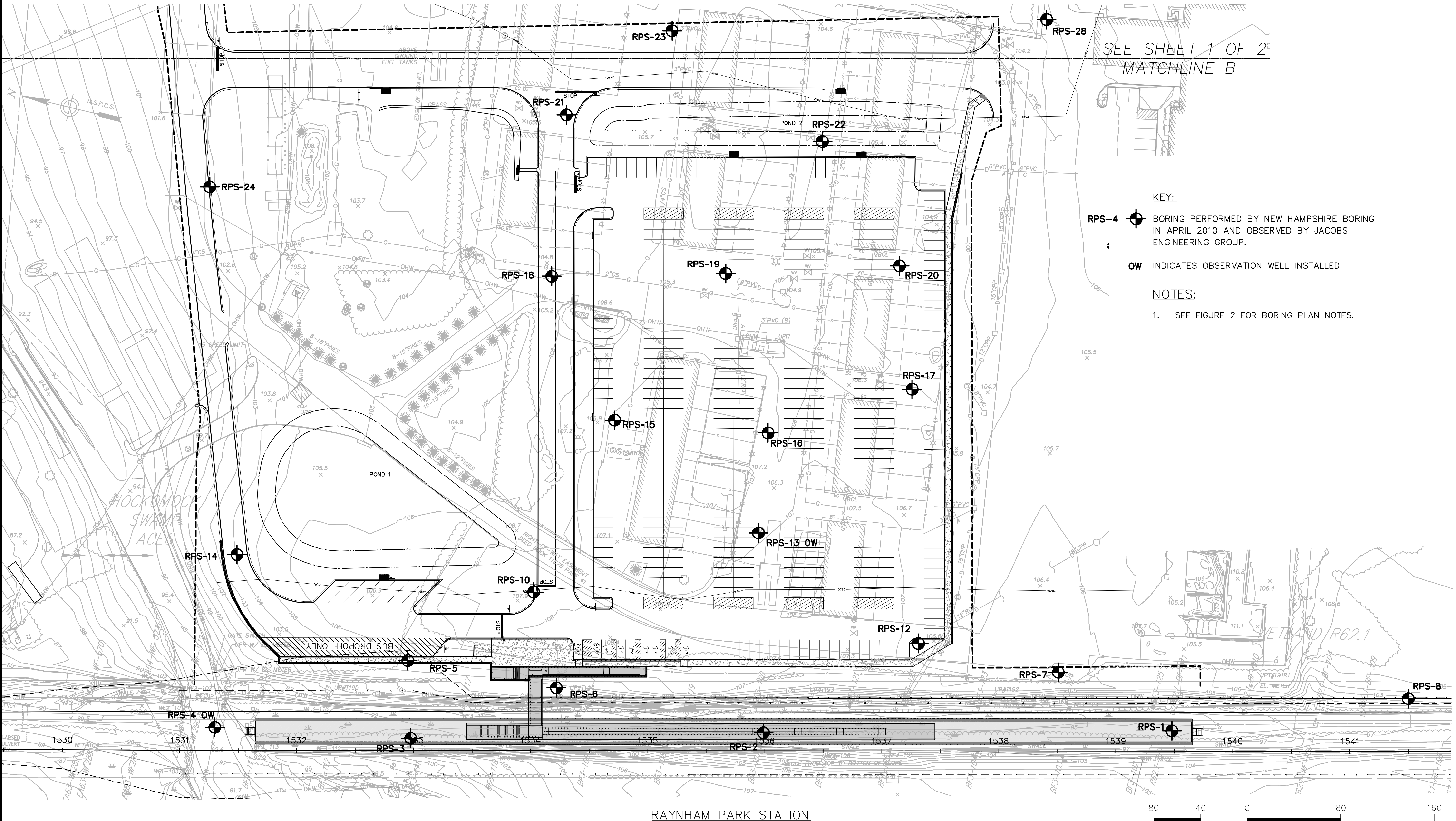
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242–9222

RAYNHAM PARK STATION
RAYNHAM, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: FEBRUARY 2012

FIGURE NO: 2



KEY:

RPS-4 ⊕	BORING PERFORMED BY NEW HAMPSHIRE BORING IN APRIL 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
OW	INDICATES OBSERVATION WELL INSTALLED

NOTES:

1. SEE FIGURE 2 FOR BORING PLAN NOTES.

RAYNHAM PARK STATION
BORING LOCATION PLAN
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_RaynhamPark.dwg Feb 24, 2012

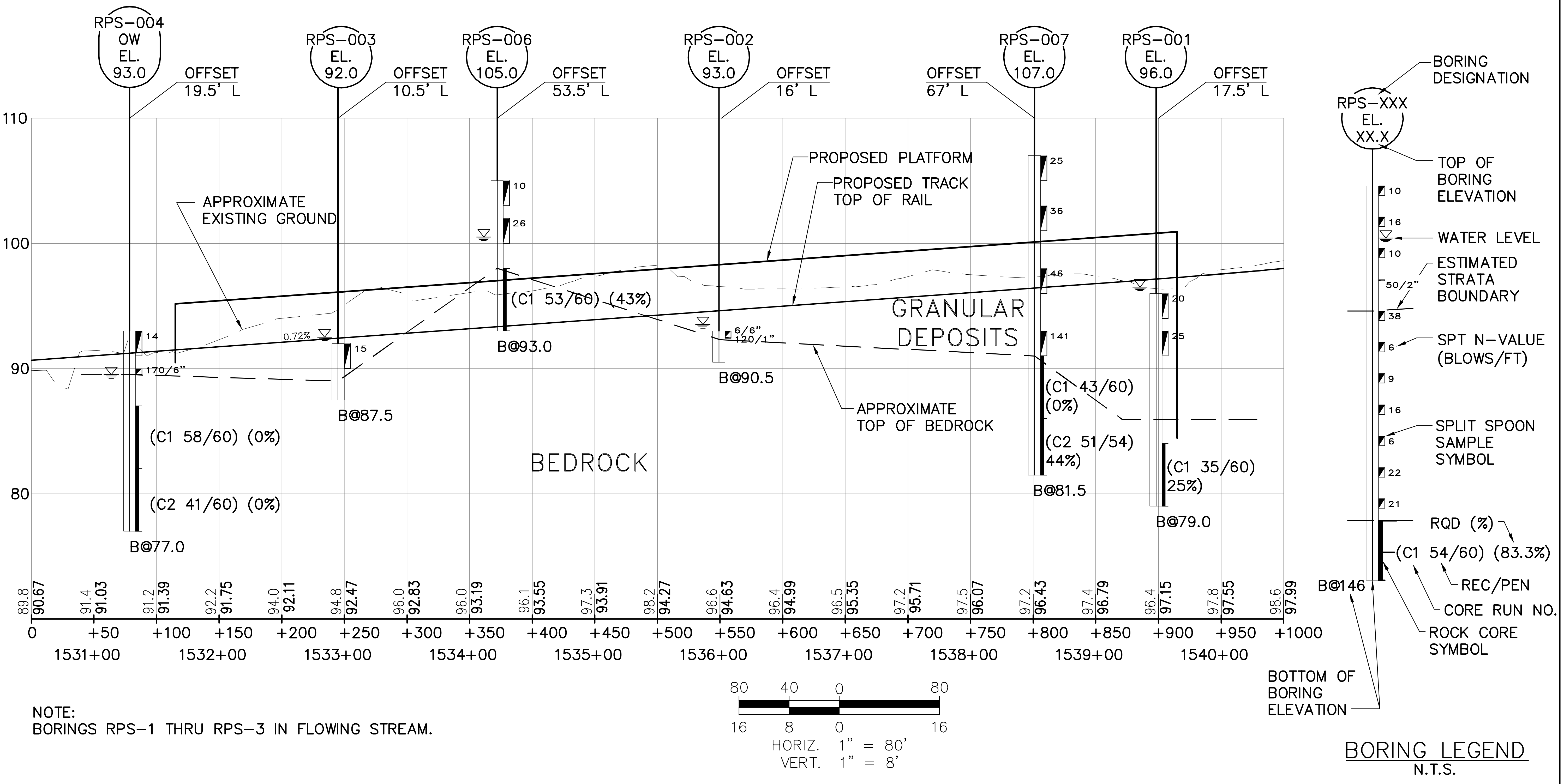
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

RAYNHAM PARK STATION
RAYNHAM, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: FEBRUARY 2012

FIGURE NO: 3



NOTE:
BORINGS RPS-1 THRU RPS-3 IN FLOWING STREAM.

BORING LEGEND
N.T.S.

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Raynham Park-profile.dwg Feb 29, 2012

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

RAYNHAM PARK STATION
RAYNHAM, MASSACHUSETTS
SUBSURFACE PROFILE A-A

DATE: FEBRUARY 2012

FIGURE NO: 4

APPENDIX A: BORING LOGS

RPS-1 TO RPS-8
RPS-10
RPS-12 TO RPS-26
RPS-28

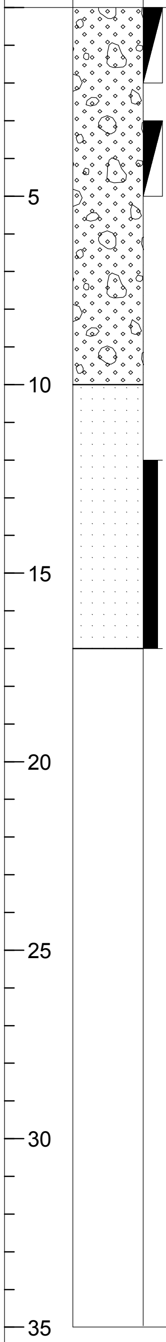
LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 001
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	96
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29

METHOD OF DRILLING		GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS				
0	Wash Boring w/Casing				SPT HAMMER 140 lb Auto	GRID COORD	N	2817411
12	NX Rock Core	4/8/2010	-0.5	In stream.			E	771692
17	Terminated					DATE START		4/8/10
						DATE END		4/8/10



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	9 10 10 11	S1	0 - 2	12		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, little fine to coarse gravel, brown, wet.
3	12 12 13 12	S2	3 - 5	15		SIMILAR TO S1; some gravel, trace silt.
10					86.0	Top of bedrock at ~10 ft, roller bit to 12 ft.
12	RQD=25	C1	12 - 17	35		SANDSTONE; fine grained, severe jointing and joint weathering, joints spaced 0 - 5 inches, joints angled at ~0 - 60 degrees, soft, gray.
17					79.0	Bottom of Hole at 17'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 001

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 002
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	93
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID N	2817750
2.5	Terminated	4/8/2010	-0.5	In stream.		COORD E	771609
						DATE START	4/8/10
						DATE END	4/8/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 120/1"	S1	0 - 0.58		92.3	WELL GRADED GRAVEL WITH SAND (GW); fine to coarse gravel up to 1.5", some fine to coarse sand, trace silt, grayish brown, wet.
						90.5	Top of apparent bedrock at ~8 in. Roller bit to 2.5 ft.
5							Bottom of Hole at 2.5'. Boring located in small stream.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

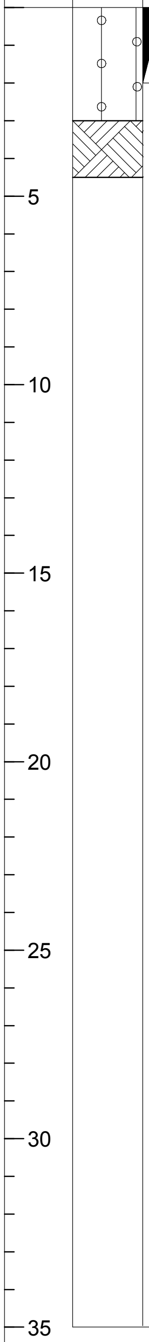
BORING NO. RPS - 002

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 003
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	92
				DRILL RIG	ATV CME - 550	DATUM	NGVD 29
				SPT HAMMER	140 lb Auto		

METHOD OF DRILLING		GROUNDWATER READINGS					
		DATE/TIME	DEPTH(ft)	REMARKS			
0	Wash Boring w/Casing				GRID	N	2818042
4.5	Terminated	4/8/2010	-0.5	In stream.	COORD	E	771534
					DATE START		4/8/10
					DATE END		4/8/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		WOR 12 3 10	S1	0 - 2	6		SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some non-plastic silt, little fine gravel, dark brown, leaves, wet.
						89.0	Top of apparent bedrock at ~3 ft. Roller bit to 4.5 ft.
						87.5	Bottom of Hole at 4.5'. Boring located in small stream.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	⊠ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

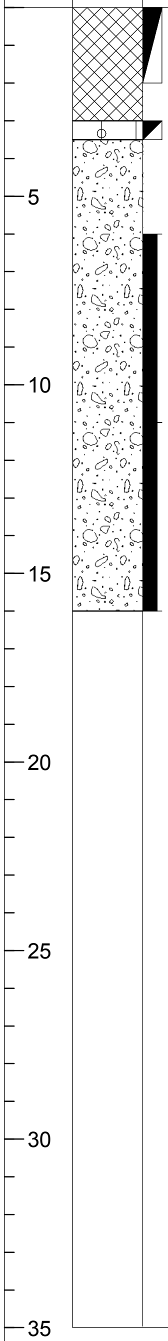
BORING NO. RPS - 003

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	RPS - 004 OW
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION 93
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER 140 lb Auto	GRID COORD		
0	Wash Boring w/Casing					GRID	N	2818207
6	NX Rock Core	7/7/2010	3.5	Monitoring Well Reading		COORD	E	771504
16	Terminated					DATE START		4/9/10
						DATE END		4/12/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 4 10 12	S1	0 - 2	10		WELL GRADED GRAVEL WITH SAND (GW); fine to coarse gravel up to 1.5", little fine to coarse sand, dark brown, wet, FILL.
		50 120/0"	S2	3 - 3.5	6	90.0 89.5	SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some fine to medium gravel, little silt, weathered rock, gray, wet. Top of bedrock at ~ 3.5 ft, roller bit to 6 ft.
		RQD=0	C1	6 - 11	58		CONGLOMERATE; highly jointed, moderate weathering, joints spaced <1 to 3", joints generally angled at 0 to 10 degrees from horizontal, gray.
		RQD=0	C2	11 - 16	41		SIMILAR TO C1.
						77.0	Bottom of Hole at 16'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	▮	◤	▯	⧗	⊠
Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 004 OW

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 005
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	S. Bolduc	ELEVATION		106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2818060
4	NX Rock Core	4/7/2010	2	Upon Completion (In Casing)			COORD	E	771598
21	Terminated						DATE START		4/6/10
							DATE END		4/7/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		5 7 11 14	S1	0 - 2	15		POORLY GRADED SAND WITH GRAVEL (SP); mostly fine sand, little fine gravel, trace silt, brown, moist.
						103.0	Top of bedrock at 3 ft, roller bit to 4 ft.
5		RQD=0	C1	4 - 9	14		CONGLOMERATE; highly fractured, gray.
10		RQD=0	C2	9 - 11	12		CONGLOMERATE; moderate weathering, highly fractured.
		RQD=22	C3	11 - 16	48		CONGLOMERATE; joints spaced 2 - 8", joints angled at ~15 degrees from horizontal, moderate joint weathering, clasts up to 1.5" in size, gray.
15		RQD=47	C4	16 - 21	57		SIMILAR TO C3.
20						85.0	
							Bottom of Hole at 21'.
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 005

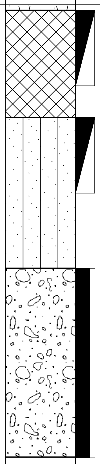
LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	RPS - 006
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	105
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2817931
						GRID COORD E	771605
						DATE START	4/7/10
						DATE END	4/7/10

METHOD OF DRILLING	
0	Wash Boring w/Casing
7	NX Rock Core
12	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH(ft)	REMARKS
4/7/2010	4.5	Upon Completion (In Casing)



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 4 6 7	S1	0.16 - 2.16	14	104.8	Top 2" Topsoil. WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, trace silt, light brown, moist, FILL.
5		3 6 20 22	S2	3 - 5	10	102.0	SILT WITH SAND (ML); non-plastic silt, some fine sand, light brown, wet.
10		RQD=43	C1	7 - 12	53	98.0	Top of bedrock at 7 ft. GRAYWACKE; joints spaced 1 - 8", joints angled at ~0-45 degrees from horizontal, moderate weathering and discoleration of joint surfaces, clasts up to 1", gray.
15						93.0	Bottom of Hole at 12'. Boring Offset ~30 ft East.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)
▮	Rock Core (RC) and RQD (%) REC (%)
◣	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
▯	Undisturbed (U)-Shelby Tube, (P)-Piston
⧗	Jar Sample (JS)
☒	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 006

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 007
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	107
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2817517
16	NX Rock Core						COORD E	771718
25.5	Terminated						DATE START	4/9/10
							DATE END	4/9/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		10 15 10 5	S1	0 - 2	10		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, dark brown, moist, FILL.
						104.0	
5		12 17 19 19	S2	4 - 6	14		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, some non-plastic silt, trace fine gravel, light brown, moist.
						99.0	
10		3 19 27 15	S3	9 - 11	9		SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little gravel, gray, wet, possible TILL.
						93.0	
15		67 44 97 53	S4	14 - 16	4		WEATHERED ROCK
						91.0	
		RQD=0	C1	16 - 21	43		SANDSTONE; fine grained, severe jointing and joint weathering, joints spaced 0 - 2 inches, joints angled at ~0 - 60 degrees, soft, gray, at 20'6" rock becomes black and less fractured, partial loss of drill water.
20							
		RQD=44	C2	21 - 25.5	51		(21 - 24') SANDSTONE; fine grained, moderate jointing and joint weathering, joints spaced 1 - 8 inches, joints angled at ~0 - 60 degrees, soft, gray, loss of drill water.
						83.0	
							(24 - 25') SILTSTONE; joints spaced 1 - 8", soft, gray.
25						81.5	
							Bottom of Hole at 25.5'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

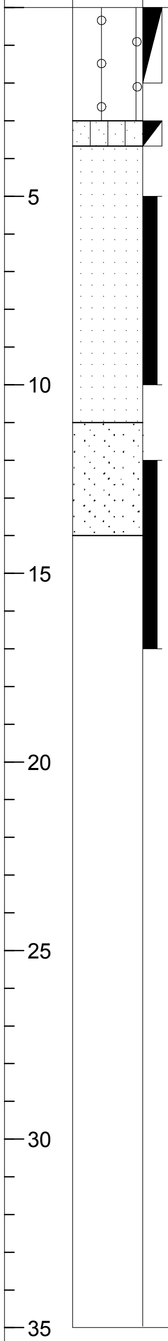
REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 007

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 008
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2817221
5	NX Rock Core						COORD	E	771766
17	Terminated						DATE START		4/8/10
							DATE END		4/8/10



SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
1 10 10 19	S1	0 - 2	19		SILTY SAND (SM); mostly fine sand, some non-plastic silt, trace fine gravel, brown, moist.
22 120/2"	S2	3 - 3.67	6	103.0 102.3	SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little fine gravel, gray, wet, fractured rock in tip of spoon. Top of bedrock at 3.67 ft.
RQD=30	C1	5 - 10	58		SANDSTONE; medium grained, hard, highly fractured, joints spaced 0 - 6", joints angled at ~15 degrees from horizontal, sand seams, gray.
RQD=7	C2	12 - 17	16	95.0	SILTSTONE; fine grained, soft, highly fractured, vertical fractures, loss of water, gray.
				92.0	
					Bottom of Hole at 17'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 008

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	RPS - 010
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	S. Bolduc	ELEVATION	108
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

0	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2817969
10	Terminated	4/6/2010	7.5	Upon Completion (In Augers)			GRID COORD E	771680
							DATE START	4/6/10
							DATE END	4/6/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 5 13 17	S1	0 - 2	19		POORLY GRADED SAND (SP); mostly fine sand, trace fine gravel, brown, FILL.
		24 44 66 90	S2	4 - 6	16		(4 - 5') SIMILAR TO S1; some non-plastic silt, moist.
5						103.0	(5 - 6') WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some mostly fine gravel, trace silt, cobble encountered, light brown, moist.
						100.0	
		120/2"	S3	9 - 9.16	2	98.5	SANDY SILT (ML); non-plastic silt, some fine sand, trace fine gravel, light brown, wet.
10						98.0	Top of apparent bedrock at ~ 9.5 ft.
							Bottom of Hole at 10'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	⊠ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 010

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 012
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	103
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N 2817639
16	Terminated					COORD E	771714
						DATE START	4/9/10
						DATE END	4/9/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		8 8 8 7	S1	0.33 - 2.33	0	102.7	Top 4" Asphaltic Concrete NO RECOVERY; FILL based on cuttings.
5		10 25 66 50	S2	4 - 6	8	99.0	POORLY GRADED SAND (SP); mostly fine sand, trace silt, light brown, moist.
10		7 12 30 33	S3	9 - 11	10	94.0	SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little fine to coarse gravel, grayish brown, wet.
15		21 36 22 35	S4	14 - 16	6	89.0	WEATHERED ROCK; completely weathered rock, gray, wet.
						87.0	
20							
25							Bottom of Hole at 26'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 012

LOG OF TEST BORING

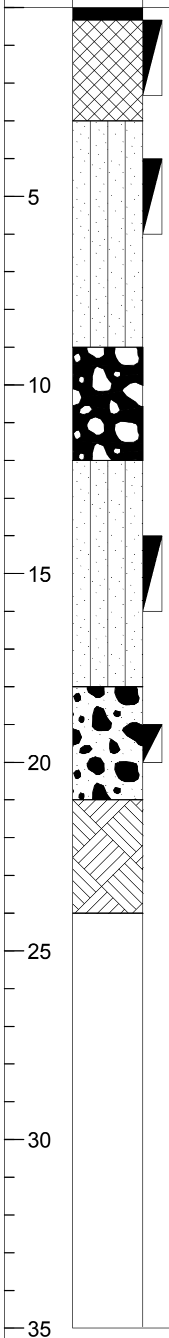
JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 013 OW
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	107
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2817794
						E	771774
						DATE START	4/8/10
						DATE END	4/8/10

METHOD OF DRILLING	
0	Wash Boring w/Casing
24	Terminated

GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS
7/7/2010	7.5	Monitoring Well Reading
9/12/2011	4.7	Monitoring Well Reading



SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
				106.7	Top 4" Asphaltic Concrete.
9 6 7 9	S1	0.33 - 2.33	9		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, little fine gravel, light brown, moist, FILL.
				104.0	
18 23 21 17	S2	4 - 6	6		WELL GRADED SAND WITH SILT (SW - SM); fine to coarse sand, little non-plastic silt, trace fine gravel, grayish brown, moist.
				98.0	Boulder encountered from 9 to 12 ft.
				95.0	
23 21 16 15	S3	14 - 16	5		SILTY SAND WITH GRAVEL (SM); mostly fine sand, some non-plastic silt, little fine gravel, grayish brown, wet.
				89.0	
32 120/6"	S4	19 - 20	3		WELL GRADED GRAVEL WITH SAND (GW); fine to coarse gravel up to 1.5", some fine to coarse sand, trace silt, gray, wet, weathered rock.
				86.0	Top of apparent bedrock at 21 ft. Roller bit to 24 ft.
				83.0	
					Bottom of Hole at 24'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)
▮	Rock Core (RC) and RQD (%) REC (%)
◣	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
▯	Undisturbed (U)-Shelby Tube, (P)-Piston
⧗	Jar Sample (JS)
☒	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 013 OW

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 014
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	S. Bolduc	ELEVATION		104
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
0	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2818223
5.42	Terminated						COORD	E	771652
							DATE START		4/6/10
							DATE END		4/6/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		4 8 10 12	S1	0 - 2	14		SILTY SAND (SM); mostly fine sand, some non-plastic silt, trace gravel, brown, moist.
5		120/5"	S2	5 - 5.42	2	99.0 98.6	WEATHERED ROCK
							Bottom of Hole at 5.42'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 014

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	RPS - 015
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	107
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2817936
9	Terminated						COORD E	771839
							DATE START	4/7/10
							DATE END	4/7/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						106.7	Top 4" Asphaltic Concrete
		7 11 12 13	S1	0.33 - 2.33	16		POORLY GRADED SAND (SP); mostly fine sand, trace fine gravel, light brown, moist, FILL.
						104.0	
5		4 4 25 120/2"	S2	4 - 5.83	12		SILT WITH SAND (ML); non-plastic silt, some fine sand, gray with brown, wet.
						101.0	Top of apparent bedrock at 6 ft, roller bit to 9 ft.
						98.0	
10							Bottom of Hole at 9'.
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)
Rock Core (RC) and RQD (%) REC (%)
Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
Undisturbed (U)-Shelby Tube, (P)-Piston
Jar Sample (JS)
Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 015

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 016
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION		107
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2817806
16	Terminated						COORD	E	771859
							DATE START		4/7/10
							DATE END		4/8/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						106.7	Top 4" Asphaltic Concrete
		10 10 8 7	S1	0.33 - 2.33	16		POORLY GRADED SAND (SP); mostly fine sand, grayish brown, moist, FILL.
						103.0	
5		6 13 19 17	S2	4 - 6	16		POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, trace fine gravel, grayish brown, wet.
10		10 15 15 19	S3	9 - 11	16		SILTY SAND (SM); mostly fine sand, little non-plastic silt, grayish brown, wet.
						95.0	
15		12 9 11 15	S4	14 - 16	7		SANDY SILT (ML); non-plastic silt, some fine to coarse sand, trace fine gravel, grayish brown, wet.
						91.0	
							Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 016

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 017
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2817695
16	Terminated						COORD E	771924
							DATE START	4/8/10
							DATE END	4/8/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						105.7	Top 4" Asphaltic Concrete.
		4 9 12 23	S1	0.33 - 2.33	4		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, grayish brown, moist, FILL.
						103.0	
5		9 16 18 21	S2	4 - 6	8		SILTY SAND (SM); fine to coarse sand, some non-plastic silt, trace fine gravel, brown, wet.
						98.0	
10		15 15 16 22	S3	9 - 11	14		SILT WITH SAND (ML); non-plastic sile, little fine to coarse sand, gray, wet.
15		14 17 23 40	S4	14 - 16	16		SILT WITH SAND (ML); non-plastic silt, little fine to coarse sand, dark gray, wet.
						90.0	
							Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

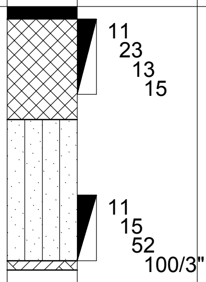
BORING NO. RPS - 017

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 018
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	105
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Hollow Stem Auger	DATE/TIME	DEPTH(ft) / REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2818017
7	Terminated					E	771946
						DATE START	4/6/10
						DATE END	4/6/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						104.7	Top 4" Asphaltic Concrete.
		11 23 13 15	S1	0.33 - 2.33	18		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, grayish brown, moist, FILL.
						102.0	
5		11 15 52 100/3"	S2	5 - 6.75	12		SILT WITH SAND (ML); non-plastic silt, some fine sand, gray, wet.
						98.3 98.0	Top of apparent bedrock at 6.75 ft.
							Bottom of Hole at 7'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 018

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO. RPS - 019
	LOCATION	Raynham, MA	
	OWNER	Mass.Bay Transportation Authority	
	JOB NUMBER	E2347101	SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2817873
16	Terminated	4/6/2010	8	Upon Completion (In Augers)			E	771983
							DATE START	4/6/10
							DATE END	4/6/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		11 23 15 15	S1	0.33 - 2.33	18	105.7	Top 4" Asphaltic Concrete. POORLY GRADED SAND (SP); mostly fine sand, trace silt, light brown, moist, FILL.
5		10 14 16 19	S2	5 - 7	20		SIMILAR TO S1.
		10 15 66 30	S3	9 - 11	20		(9 - 11') POORLY GRADED SAND (SP); mostly fine sand, trace silt, brown, wet.
10						96.0	(10 - 11') WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, trace silt, grayish brown, wet.
						93.0	
15		15 18 20 28	S4	14 - 16	22		SANDY SILT (ML); non-plastic silt, some fine sand, trace fine gravel, grayish brown, wet.
						90.0	Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

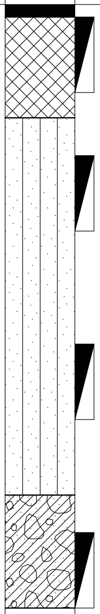
REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 019

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 020
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION		106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2817730
16	Terminated						COORD	E	772024
							DATE START		4/9/10
							DATE END		4/9/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						105.7	Top 4" Asphaltic Concrete.
		8 10 8 15	S1	0.33 - 2.33	10		WELL GRADED SAND (SW); fine to coarse sand, brown, moist, FILL.
						103.0	
5		7 11 13 21	S2	4 - 6	16		SANDY SILT (ML); non-plastic silt, some fine sand, light brown, moist.
10		10 9 10 21	S3	9 - 11	16		SANDY SILT (ML); non-plastic silt, some fine sand, gray, wet.
						93.0	
15		32 48 52 72	S4	14 - 16	8		SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some non-plastic silt, little fine gravel, gray, wet, possible GLACIAL TILL.
						90.0	
							Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ☐ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 020

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 021
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	105
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29

0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2818037
17	Terminated	4/7/2010	6	Upon Completion (In Casing)			COORD E	772083
							DATE START	4/7/10
							DATE END	4/7/10

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
					104.7	Top 4" Asphaltic Concrete.
	4 7 9 14	S1	0.33 - 2.33	12		POORLY GRADED SAND (SP); mostly fine sand, grayish-brown, moist, FILL.
					102.0	
5	14 23 25 25	S2	4 - 6	18		SANDY SILT (ML); non-plastic silt, some fine to coarse sand, trace fine gravel, gray with brown, moist.
					97.0	
10	8 25 35 40	S3	9 - 11	6		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, trace silt, brown, wet.
					91.0	
15	100/5"	S4	14 - 14.52	0		NO RECOVERY; top of apparent bedrock, roller bit to 17 ft.
					88.0	
20						Bottom of Hole at 17'.
25						
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)

Rock Core (RC) and RQD (%) REC (%)

Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)

Undisturbed (U)-Shelby Tube, (P)-Piston

Jar Sample (JS)

Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 021

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 022
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION		105
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2817819
24	Terminated	4/6/2010	5	Upon Completion (In Casing)			COORD	E	772112
							DATE START		4/6/10
							DATE END		4/6/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	■					104.7	Top 4" Asphaltic Concrete.
	▨	14 10 10 8	S1	0.33 - 2.33	12		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, trace coarse gravel, brown, moist, FILL.
5	⁘	7 11 14 16	S2	4 - 6	8	102.0	POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, grayish-brown, wet.
10	▥	5 5 5 6	S3	8 - 10	12	97.0	SANDY SILT (ML); slightly plastic silt, some fine sand, trace gravel, gray, wet.
15	▨	16 31 120/4"	S4	13 - 14.33	12	92.0	SILT WITH SAND (ML); non-plastic silt, some fine to coarse sand, trace fine gravel, gray, wet, possible GLACIAL TILL.
20	▨	21 20 30 32	S5	18 - 20	10		SILT (ML); non-plastic silt, trace fine gravel, gray, wet, completely weathered rock in tip of spoon, GLACIAL TILL.
	▧					84.0	Top of apparent bedrock at 21 ft. Roller bit to 24 ft.
25						81.0	Bottom of Hole at 24'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

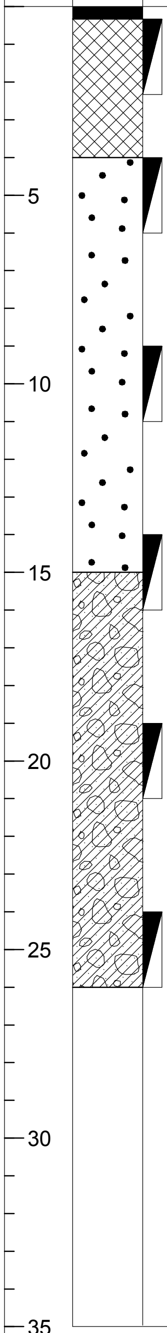
BORING NO. RPS - 022

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 023
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	106
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2817966
26	Terminated						COORD E	772174
							DATE START	4/7/10
							DATE END	4/7/10



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	7 6 5 7	S1	0.33 - 2.33	12	105.7	Top 4" Asphaltic Concrete. POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, little non-plastic silt, trace fine gravel, grayish-brown, moist, FILL.
5	7 10 14 16	S2	4 - 6	18	102.0	POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, reddish-brown, moist.
10	14 14 15 17	S3	9 - 11	16		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, little non-plastic silt, brown, moist.
15	13 16 25 40	S4	14 - 16	22		(14 - 15') POORLY GRADED SAND (SP); mostly fine sand, gray, wet.
					91.0	(15 - 16') SILT WITH SAND (ML); non-plastic silt, some fine to medium sand, trace fine gravel, gray, wet, possible GLACIAL TILL.
20	17 25 31 33	S5	19 - 21	14		SILT WITH SAND (ML); non-plastic silt, some fine to coarse sand, trace fine gravel, gray, wet, GLACIAL TILL.
25	16 30 42 33	S6	24 - 26	8		SILTY SAND (SM); mostly fine sand, some non-plastic silt, trace fine gravel, gray, wet, rock fragments in tip of spoon, GLACIAL TILL.
					80.0	Bottom of Hole at 26'.
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 023

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	RPS - 024
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	103
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD	N 2818319 E 771952
						DATE START	4/6/10
						DATE END	4/6/10

METHOD OF DRILLING	
0	Hollow Stem Auger
2.5	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH(ft)	REMARKS
4/6/2010	2	Upon Completion (In Augers)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						102.7	Top 4" Asphaltic Concrete.
		8 8 8 120/2"	S1	0.5 - 2.16	8		WELL GRADED SAND WITH SILT AND GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, little non-plastic silt, brown, moist, some weathered rock in tip of spoon, FILL.
						101.0	
						100.5	Top of apparent bedrock at ~ 2 ft, roller bit to 2.5 ft.
5							Bottom of Hole at 2.5'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 024

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	RPS - 025
	LOCATION	Raynham, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha
				DRILL RIG	TR CME 75
				SPT HAMMER	140 lb Safety

ELEVATION		103
DATUM		NGVD 29
GRID COORD	N	2818408
	E	772236
DATE START		4/6/10
DATE END		4/6/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
0	Hollow Stem Auger			
4.5	Terminated			

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Top 6" Asphaltic Concrete.
		9 9 5 6	S1	0.5 - 2.5	6	102.5	POORLY GRADED SAND (SP); mostly fine sand, brown, dry, FILL.
		120/0"	S2	4 - 4	0	99.0 98.5	NO RECOVERY; top of apparent bedrock at ~ 4 ft, roller bit to 4.5 ft.
5							Bottom of Hole at 4.5'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)	▮	Rock Core (RC) and RQD (%) REC (%)	◣	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯	Undisturbed (U)-Shelby Tube, (P)-Piston	⧗	Jar Sample (JS)	☒	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 025

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 026
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	104
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto		
0	Wash Boring w/Casing					GRID	N	2818157
6.5	Terminated					COORD	E	772216
						DATE START		4/9/10
						DATE END		4/9/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		1 1 2 2	S1	0 - 2	18		SILT (ML); non-plastic silt, light brown, moist, pieces of wood.
		2 3 1 28	S2	3 - 5	12	101.0	POORLY GRADED SAND (SP); mostly medium sand, trace fine gravel, weathered rock in tip of spoon, grayish brown, wet.
5						99.0	Top of apparent bedrock at ~ 5ft, roller bit to 6.5 ft.
						98.0	
							Bottom of Hole at 6.5'.
10							
15							
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ⊠ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

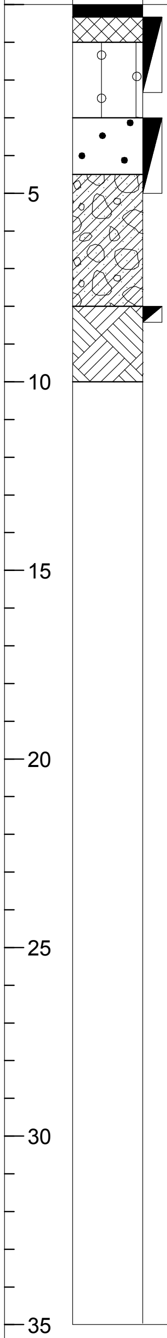
BORING NO. RPS - 026

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	RPS - 028
LOCATION	Raynham, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	105
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft) / REMARKS	SPT HAMMER	140 lb Auto	GRID N	2817657
10	Terminated					COORD E	772258
						DATE START	4/9/10
						DATE END	4/9/10



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	16 19 16 13	S1	0.33 - 2.33	20	104.7	Top 4" Asphaltic Concrete.
					104.0	(0.33 - 1') WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brick fragments, dark brown, FILL. (1 - 2') SILTY SAND (SM); fine to coarse sand, some non-plactic silt, dark brown, moist.
	15 21 27 23	S2	3 - 5	16	102.0	(3 - 4.5') POORLY GRADED SAND (SP); mostly fine sand, light brown, moist.
5					100.5	(4.5 - 5') SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some non-plastic silt, little fine gravel, gray, wet, possible GLACIAL TILL.
	120/5"	S3	8 - 8.42	4	97.0	WEATHERED ROCK; top of apparent bedrock at ~8 ft, roller bit to 10 ft.
10					95.0	Bottom of Hole at 10'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. RPS - 028

APPENDIX B: LABORATORY DATA

Table C.1 - Summary of Laboratory Soil Test Data
South Coast Rail Project

Sample Identification				Test Results								Soil Classification
Boring Number	Sample Number	Sample Depth	Sample Elevation	Moisture Content	% Gravel	% Sand	% Fines	Organic Content	Liquid Limit	Plastic Limit	Plasticity Index	Unified Soil Classification System (ASTM D-2487)
BCS - 01	S3	4.0	15.9	0.2	57.3	33.1	9.6					Well Graded Gravel w/ Sand (GW)
	S9	38.0	-18.1	17.5	7.1	8.8	84.1					Silt (ML)
BCS - 02	S5	18.0	9.7		29.3	47.3	23.4					Silty Sand w/ Gravel (SM)
ECC - 02	S4	13.0	89.0	10					23	15	8	Clay (CL)
EVS - 02	S4	11.0	132.0	24.3	0.6	46.2	53.2					Sandy Silt (ML)
EVS - 03	S5	18.0	126.0		0.0	28.0	72.0					Silt w/ Sand (ML)
FRD - 01	S2	4.0	34.0	6.5	47.7	41.1	11.2					Gravel w/ Silt + Sand (GW-GM)
FRD - 03	S4	13.0	24.0	12.3	17.6	68.4	14.0					Silty Sand w/ Gravel (SM)
FRD - 06	S2	4.0	22.0	7.2	44.4	47.1	8.5					Sand w/ Silt + Gravel (SW-SM)
	S7	29.0	-3.0	20.1	0.0	88.0	12.0					Silty Sand (SM)
FTS - 04	S2	4.0	63.6	42.4				4.7				Silt (ML)
FTS - 11	S1	0.0	56.0	24	0	48.1	51.9					Sandy Silt (ML)
FTS - 13	S2	3.0	35.6	23.8	0	1	99					Silt (ML)
KHS - 02	S3	8.0	82.8		27.0	47.9	25.1					Silty Sand w/ Gravel (SM)
NES - 04	S4	14.0	144.0	23.6	0.0	1.9	98.1					Silty Clay (CL)
NES - 05	S2	4.0	154.0	1.1	13.3	68.3	18.4					Silty Sand (SM)
NES - 14	S2	4.0	162.0		32.7	51.3	16.0					Silty Sand w/ Gravel (SM)
NES - 21	S2	4.0	158.0		56.9	34.1	9.0					Gravel w/ Silt + Sand (GW-GM)
RPS - 04	S2	3.0	90.0		37.7	45.2	17.1					Silty Sand w/ Gravel (SM)
RPS - 13	S3	14.0	93.0	6.2	16.0	49.6	34.4					Silty Sand w/ Gravel (SM)
RPS - 16	S3	9.0	95.0	11.6	4.9	74.8	20.3					Silty Sand (SM)
RPS - 19	S4	14.0	92.0	2.7	6.0	44.4	49.6					Sandy Silt (ML)
RPS - 22	S3	8.0	97.0	14.5	6.0	40.0	54.0					Sandy Silt (ML)
TD - 05	S2	3.0	33.9		3.1	64.7	32.2					Silty Sand (SM)
TS - 02	S3	9.0	9.0	32								Clay (CL)
	S4	14.0	4.0	37	0	1.1	98.9		26	22	4	Silt (ML)
TS - 03	S3	9.0	8.0	37.7								Clay (CL)
TS - 07	S3	8.0	8.0	36.5	0	6.1	93.9		32	21	11	Clay (CL)
	S4	13.0	3.0	32.8								Clay (CL)
TS - 11	S2	3.0	14.0	26.1				7.8				Silt (ML)
TS - 20	S3	8.0	6.0	41.4	0	5.6	94.4		33	24	9	Silt (ML)
TS - 23	S3	8.0	5.0	35.8								Clay (CL)
TS - 24	S3	8.0	6.0	32.4								Clay (CL)
WTS - 05	S4	14.0	-5.6	23.5				1.4				Silt (ML)
WTS - 09	S5	20.0	-12.1	65.1					77	43	34	Silt (ML)
WTS - 11	S6	20.0	-11.7	285.8				62.4				Organics (OL)
WTS - 12	S4	10.0	-1.4	45.4				3				Silt (ML)
	S5	15.0	-6.4	55.4					73	31	42	Clay (CL)

Notes:

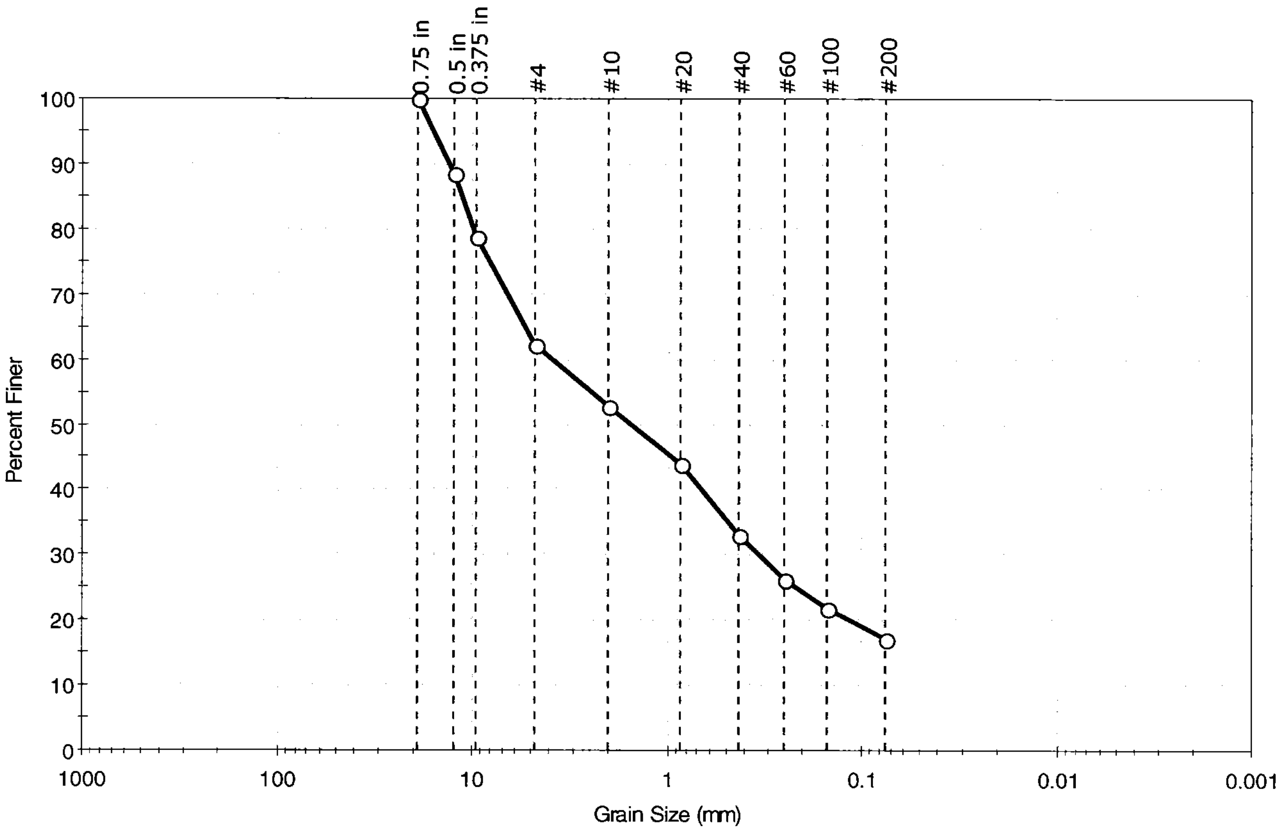
1) Refer to the boring logs for the original sample descriptions based on visual-manual procedure (ASTM D-2488). For samples where no laboratory Atterberg Limit tests were performed, determinations of the type of fines was based on the visual-manual procedure.

GeoTesting
express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	RPS-4	Sample Type:	jar	Tested By:	jbr
Sample ID:	S-2	Test Date:	07/14/10	Checked By:	jdt
Depth :	3-5 ft	Test Id:	185197		

Test Comment: ---
Sample Description: Moist, light olive gray silty sand with gravel
Sample Comment: sample jar received broken

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	37.7	45.2	17.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	89		
0.375 in	9.50	79		
#4	4.75	62		
#10	2.00	53		
#20	0.85	44		
#40	0.42	33		
#60	0.25	26		
#100	0.15	22		
#200	0.075	17		

Coefficients

D_{85} =11.2986 mm	D_{30} =0.3356 mm
D_{60} =3.8752 mm	D_{15} =N/A
D_{50} =1.5297 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

<u>ASTM</u> N/A

<u>AASHTO</u> Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

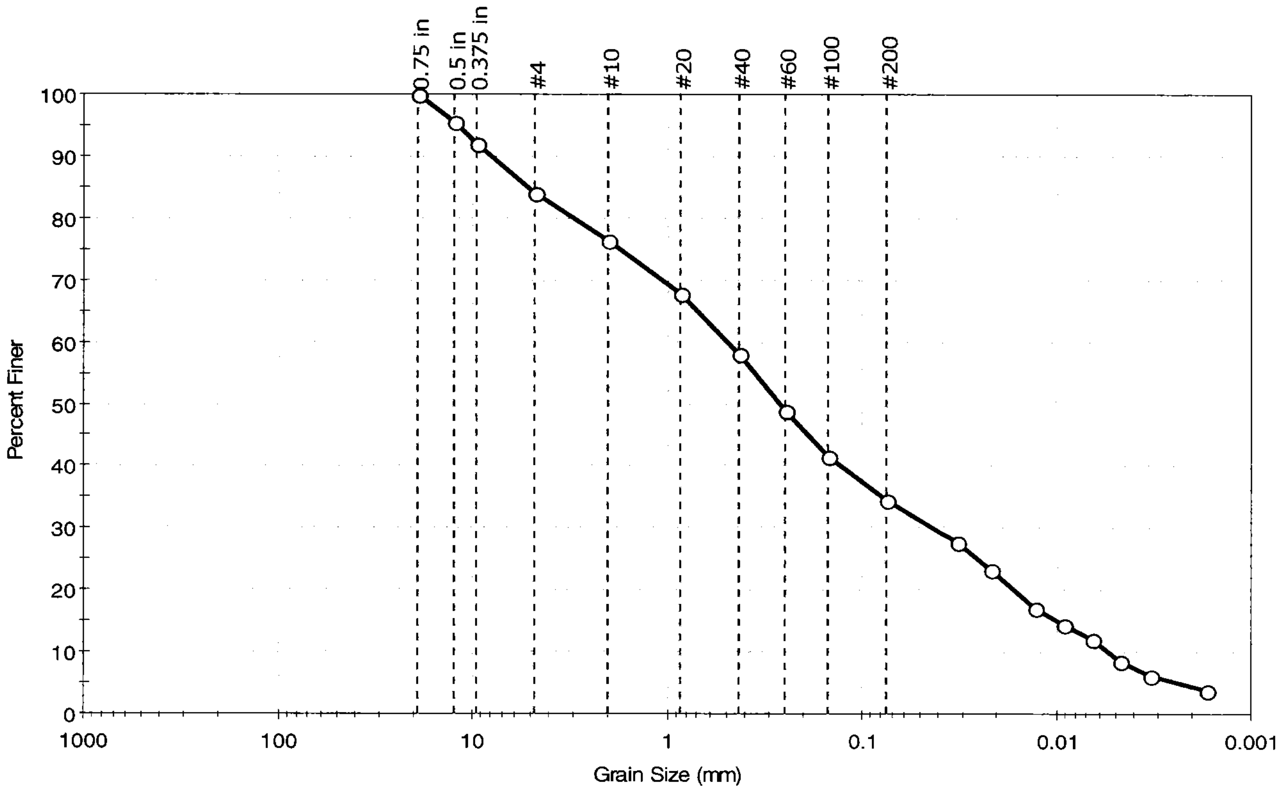
Sand/Gravel Hardness : HARD

printed 7/20/2010 9:52:32 AM

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: RPS-13
Sample Type: jar
Tested By: jbr
Sample ID:S-3
Test Date: 07/21/10
Checked By: jdt
Depth : 14-16 ft
Test Id: 185186
Test Comment: ---
Sample Description: Moist, olive gray silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	16.0	49.6	34.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	96		
0.375 in	9.50	92		
#4	4.75	84		
#10	2.00	77		
#20	0.85	68		
#40	0.42	58		
#60	0.25	49		
#100	0.15	41		
#200	0.075	34		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0328	28		
---	0.0216	23		
---	0.0128	17		
---	0.0092	15		
---	0.0066	12		
---	0.0047	9		
---	0.0033	6		
---	0.0017	4		

Coefficients

D_{85} =5.1894 mm
D_{30} =0.0439 mm
D_{60} =0.4899 mm
D_{15} =0.0097 mm
D_{50} =0.2641 mm
D_{10} =0.0053 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

printed 7/21/2010 12:29:08 PM

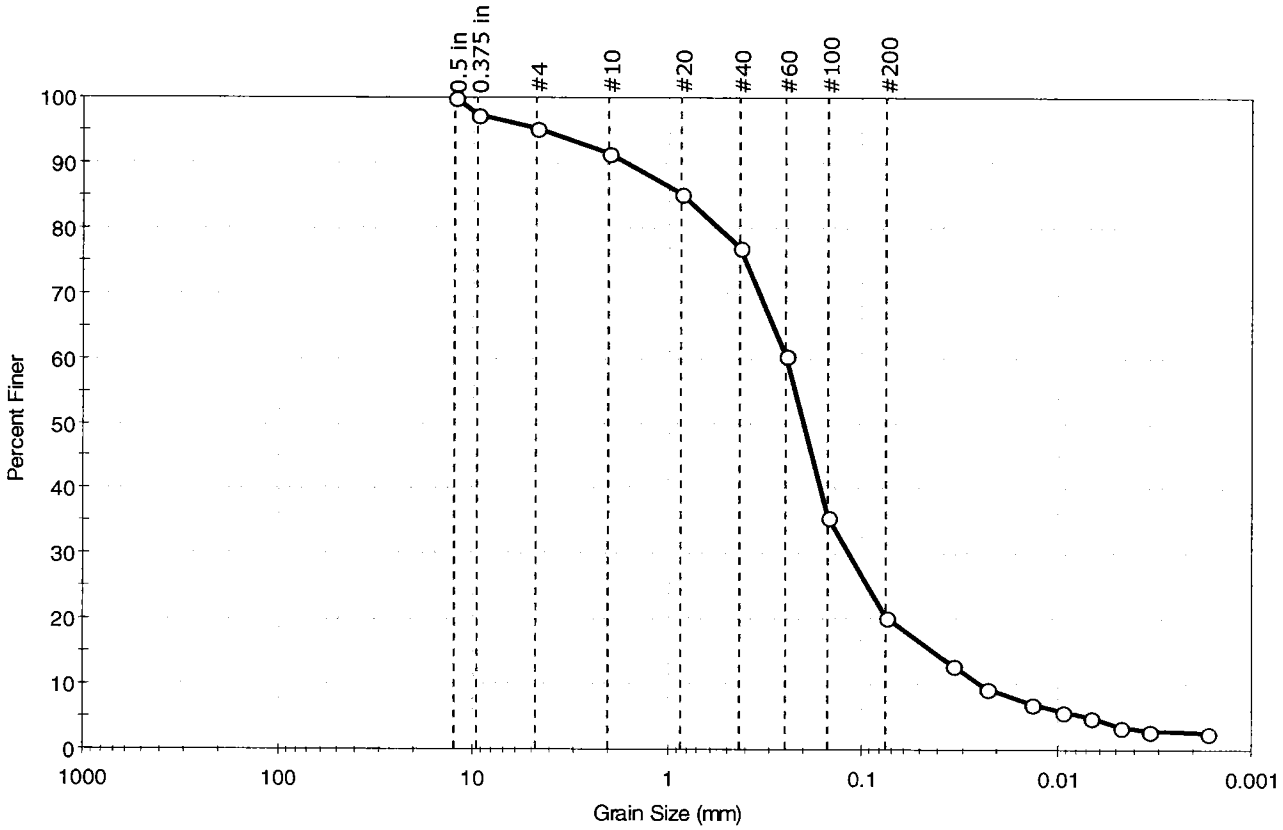
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764

Boring ID: RPS-16
Sample ID:S-3
Depth : 9-11 ft
Sample Type: jar
Test Date: 07/21/10
Test Id: 185185
Tested By: jbr
Checked By: jdt

Test Comment: ---
Sample Description: Moist, olive silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	4.9	74.8	20.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	97		
#4	4.75	95		
#10	2.00	91		
#20	0.85	85		
#40	0.42	77		
#60	0.25	60		
#100	0.15	36		
#200	0.075	20		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0342	13		
---	0.0226	9		
---	0.0134	7		
---	0.0094	6		
---	0.0067	5		
---	0.0047	4		
---	0.0033	3		
---	0.0017	3		

Coefficients

D_{85} =0.8261 mm	D_{30} =0.1157 mm
D_{60} =0.2479 mm	D_{15} =0.0423 mm
D_{50} =0.2015 mm	D_{10} =0.0242 mm
C_u =N/A	C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

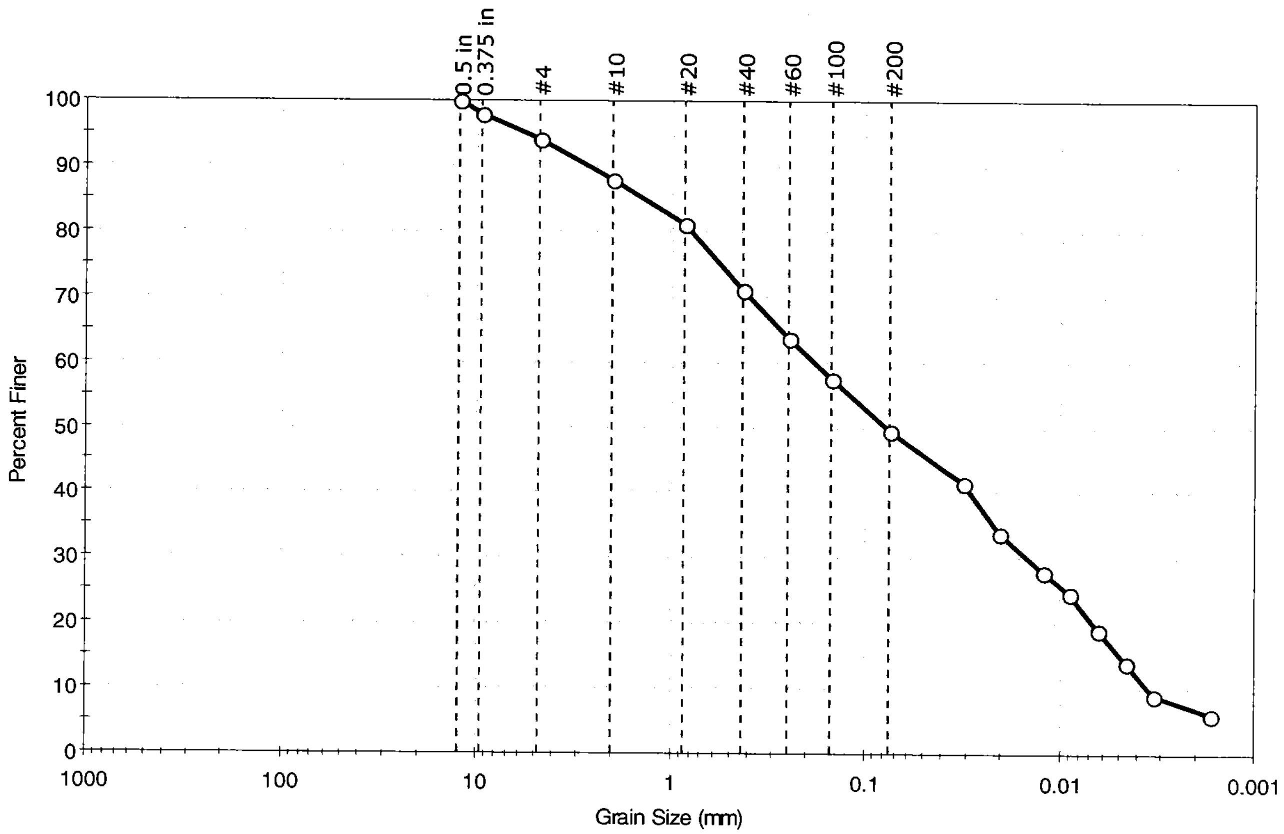
Sand/Gravel Hardness : HARD

printed 7/21/2010 12:28:39 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: RPS-19
Sample Type: jar
Tested By: jbr
Sample ID:S-4
Test Date: 07/21/10
Checked By: jdt
Depth : 14-16 ft
Test Id: 185187
Test Comment: ---
Sample Description: Moist, olive sandy silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	6.0	44.4	49.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	98		
#4	4.75	94		
#10	2.00	88		
#20	0.85	81		
#40	0.42	71		
#60	0.25	64		
#100	0.15	57		
#200	0.075	50		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0320	42		
---	0.0207	34		
---	0.0123	28		
---	0.0089	25		
---	0.0064	19		
---	0.0046	14		
---	0.0033	9		
---	0.0017	6		

Coefficients

D_{85} =1.3895 mm
D_{30} =0.0145 mm
D_{60} =0.1857 mm
D_{15} =0.0048 mm
D_{50} =0.0777 mm
D_{10} =0.0035 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

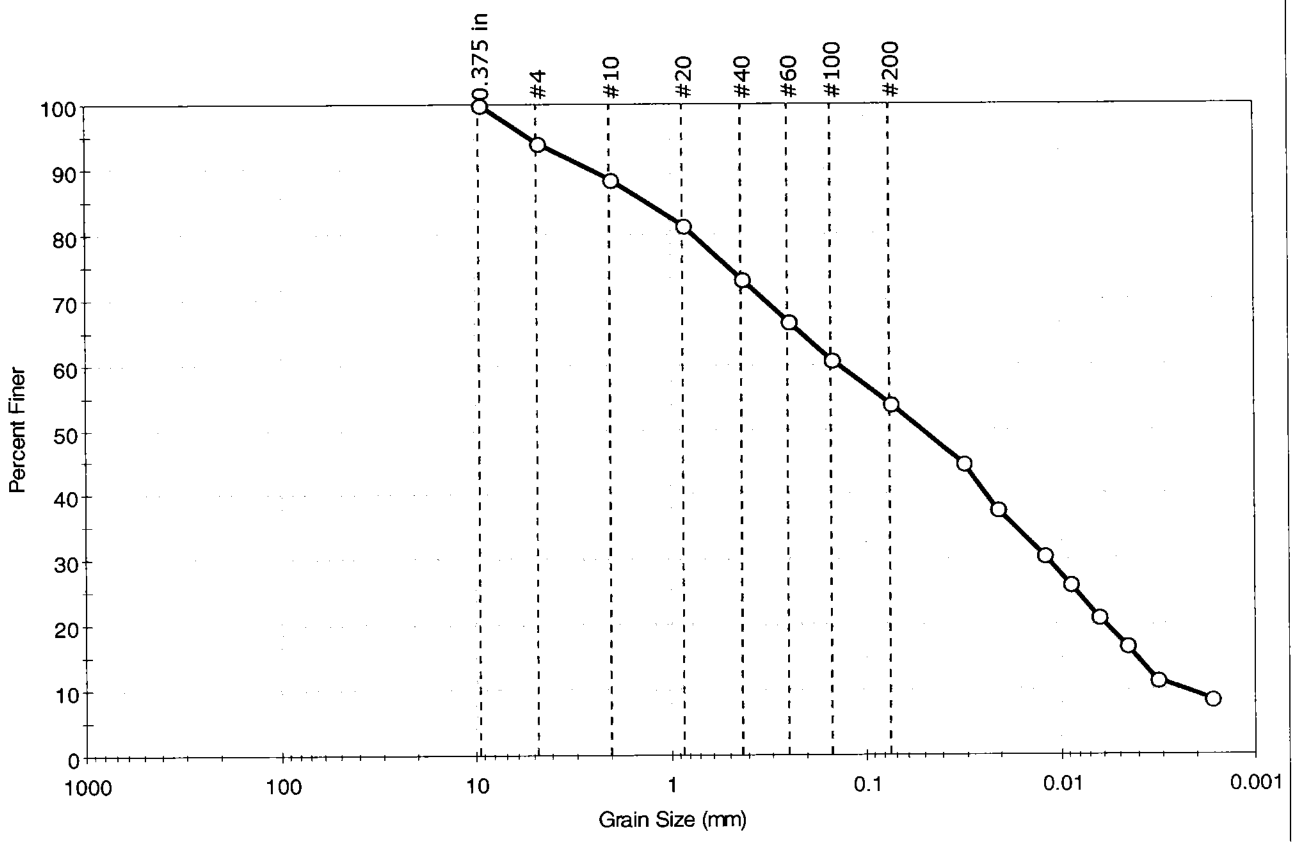
Sand/Gravel Hardness : HARD

printed 7/21/2010 12:29:27 PM

GeoTesting
express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: RPS-22
Sample Type: jar
Tested By: jbr
Sample ID:S-3
Test Date: 07/21/10
Checked By: jdt
Depth : 8-10 ft
Test Id: 185184
Test Comment: ---
Sample Description: Moist, dark olive gray sandy silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	6.0	40.0	54.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	94		
#10	2.00	88		
#20	0.85	81		
#40	0.42	73		
#60	0.25	67		
#100	0.15	61		
#200	0.075	54		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0318	45		
---	0.0210	38		
---	0.0123	31		
---	0.0089	26		
---	0.0064	21		
---	0.0046	17		
---	0.0033	12		
---	0.0017	8		

Coefficients

D_{85} =1.3120 mm
D_{30} =0.0116 mm
D_{60} =0.1368 mm
D_{15} =0.0041 mm
D_{50} =0.0512 mm
D_{10} =0.0024 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

printed 7/21/2010 12:28:01 PM

APPENDIX C: GEOTECHNICAL CALCULATIONS

- Allowable Bearing Capacity and Estimated Settlement
- Seismic Site Class Evaluation

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

CALCULATION WORKSHEET

JOB MBTA South Coast Rail
SUBJECT Raynham Park Station
CALCULATED BY DH **DATE** 2/20/2012
CHECKED BY AH/PJM **DATE** 2/29/2012

PURPOSE: Evaluate bearing resistance for platform shallow foundations.

REFERENCE: AASHTO LRFD Bridge Design Specifications, 2010

ASSUMPTIONS:

- Platform footing is 4 ft wide by 10 ft long.
- Bearing surface is compacted Gravel Borrow overlying sand or gravel.
- Footing embedment is at least 4 feet below final ground surface.
- Groundwater level is at 3 feet below surface.
- Footing eccentricity is assumed to be zero.
- Estimated soil properties (experience, geotech literature, Table 10.4.6.2.4-1):

	γ (pcf)	ϕ
Gravel Borrow:	125	34

BEARING CAPACITY FACTORS (Table 10.6.3.1.2a-1):

	ϕ	N_c	N_q	N_γ
Gravel Borrow:	34	42.2	29.4	41.1

CALCULATE EFFECTIVE FOOTING WIDTH (B'):

$e < B/4$ (Section 10.6.3.3)

where: B = footing width (ft) = 3
e = eccentricity (ft)

Assume no footing eccentricity, thus, e = 0

B' = B-2e 3

NOMINAL BEARING RESISTANCE (q_n):

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$$ (Eqn. 10.6.3.1.2a-1)

where: c = cohesion = 0
γ = total unit weight 125
D_f = depth of footing (ft) = 4 Assumed
B' = effective width of footing (ft) = 3
L = length of footing (ft) = 10
B'/L = 0.30
D_f /B' = 1.33
L/B' = 3.33
C_{wq} $C_{w\gamma}$ = groundwater correction factors (using B')
C_{wq} = 0.7 (Table 10.6.3.1.2a-2)
$C_{w\gamma}$ = 0.5 (Table 10.6.3.1.2a-2)

N_{cm} N_{qm} $N_{\gamma m}$ = bearing capacity factors

$N_{qm} = N_q s_q d_q i_q$ (Eqn. 10.6.3.1.2a-3)

s_q = 1.20 (Table 10.6.3.1.2a-3)

d_q = 1.23 (Table 10.6.3.1.2a-4)

i_q = 1.0 (see AASHTO p. 10-62)

N_{qm} = 43.5

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

s_γ = 0.88 (Table 10.6.3.1.2a-3)

i_γ = 1 (see AASHTO p. 10-62)

$N_{\gamma m}$ = 36.2

q_n = 18,609 psf

ALLOWABLE BEARING RESISTANCE (q_a):

$q_a = q_n/FOS$

where: FOS = factor of safety = 2.5 for sand

q_a = 7,443 psf

use

$\boxed{q_a = 7.44 \text{ ksf}}$ strength limit value

Note: Based on the anticipated light loads and potentially small footing sizes, an allowable bearing capacity of 6 ksf is recommended.

Elastic Settlement Calculations:

$$S_e = \frac{\left(q_o\,(1 - \nu^2)\sqrt{A'}\right)}{144 E_s \beta_z}$$ eqn. 10.6.2.4.2-1

where:
q_o = applied vert. stress (ksf)
v = Poisson's Ratio
E_s = Young's Modulus (ksi)
β_z = Shape/Rigidity Factor

v = Poisson's Ratio = 0.30 (Table C10.4.6.3-1)
E_s = Young's Modulus (ksi) = 6.00 (Table C10.4.6.3-1)
β_z = Shape/Rigidity Factor = 1.15 (Table 10.6.2.4.2-1)

where:
B' = eff. width of footing (ft) = 3 (from bearing resistance calcs)
L = length of footing (ft): 10 (from bearing resistance calcs)
A' =(B'xL) = footing area (ft^2): 30 ft^2

Settlement (S_e) for a given q_o:

q_o = applied vertical stress (ksf) = 6.00 ksf (assumed)

Se (inches) = 0.36 inches

Raynham Park Station Seismic Site Class Evaluation

Based on the platform boring with the deepest soil overburden and lowest average blow counts (worst case)

Boring No.	Sample No.	N Value	Di	D_i/N_i	N_{bar}
RPS-1	S-1	20	3	0.15	
	S-2	25	7	0.28	**75**
	Bedrock	100	90	0.90	
	Total Depth =	100			
	Depth to Bedrock =	10	Sum	1.33	

Approx. Project Coordinates

Lat	41.981442
Long	-71.075919

Seismic Coefficients

$S_S =$ 0.24 (Table 1604.10*)

$S_1 =$ 0.062 (Table 1604.10*)

For Site Class C

$F_A =$ 1.2 (See Table 9.4.1.2.4a*)

$F_V =$ 1.7 (See Table 9.4.1.2.4b*)

Design Spectral Response Parameters

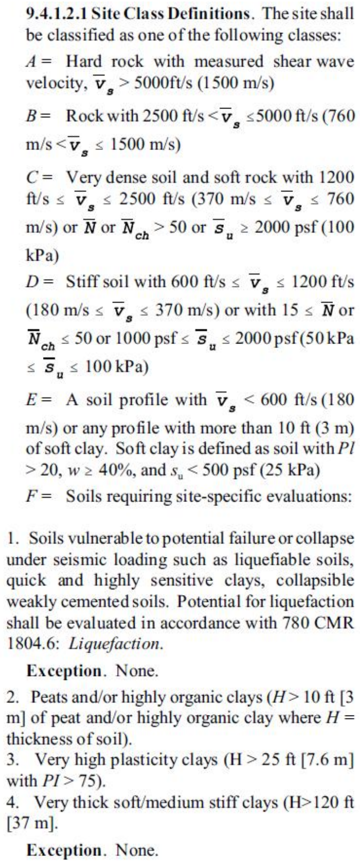
$S_{MS} = Ss \times F_A =$ 0.288

$S_{M1} = S_1 \times F_V =$ 0.105

$S_{DS} = 2/3 \times S_{MS} =$ 0.192

$S_{D1} = 2/3 \times S_{M1} =$ 0.070

Per 9.4.1.2.1, $N_{bar} > 50$, Site Class C



9.4.1.2.1 Site Class Definitions. The site shall be classified as one of the following classes:

A = Hard rock with measured shear wave velocity, $\bar{v}_s > 5000$ft/s (1500 m/s)

B = Rock with 2500 ft/s $< \bar{v}_s \le 5000$ ft/s (760 m/s $< \bar{v}_s \le$ 1500 m/s)

C = Very dense soil and soft rock with 1200 ft/s $\le \bar{v}_s \le$ 2500 ft/s (370 m/s $\le \bar{v}_s \le$ 760 m/s) or $\bar{N}$ or $\bar{N}_{ch} > 50$ or $\bar{s}_u \ge 2000$ psf (100 kPa)

D = Stiff soil with 600 ft/s $\le \bar{v}_s \le$ 1200 ft/s (180 m/s $\le \bar{v}_s \le$ 370 m/s) or with $15 \le \bar{N}$ or $\bar{N}_{ch} \le 50$ or 1000 psf $\le \bar{s}_u \le$ 2000 psf (50 kPa $\le \bar{s}_u \le$ 100 kPa)

E = A soil profile with $\bar{v}_s < 600$ ft/s (180 m/s) or any profile with more than 10 ft (3 m) of soft clay. Soft clay is defined as soil with $PI > 20$, $w \ge 40\%$, and $s_u < 500$ psf (25 kPa)

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. Potential for liquefaction shall be evaluated in accordance with 780 CMR 1804.6: *Liquefaction.*

Exception. None.

2. Peats and/or highly organic clays ($H > 10$ ft [3 m] of peat and/or highly organic clay where H = thickness of soil).
3. Very high plasticity clays (H > 25 ft [7.6 m] with $PI > 75$).
4. Very thick soft/medium stiff clays (H>120 ft [37 m].

Exception. None.

Notes: * The Massachusetts State Building Code, 8th Edition (2010)

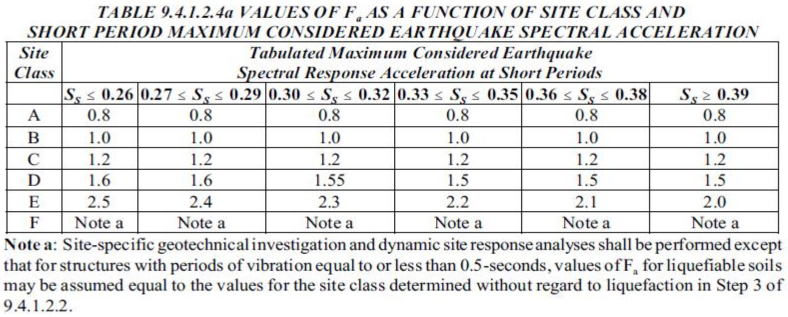


TABLE 9.4.1.2.4a VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods*					
	$S_S \le 0.26$	$0.27 \le S_S \le 0.29$	$0.30 \le S_S \le 0.32$	$0.33 \le S_S \le 0.35$	$0.36 \le S_S \le 0.38$	$S_S \ge 0.39$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5	1.5	1.5
E	2.5	2.4	2.3	2.2	2.1	2.0
F	Note a	Note a	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

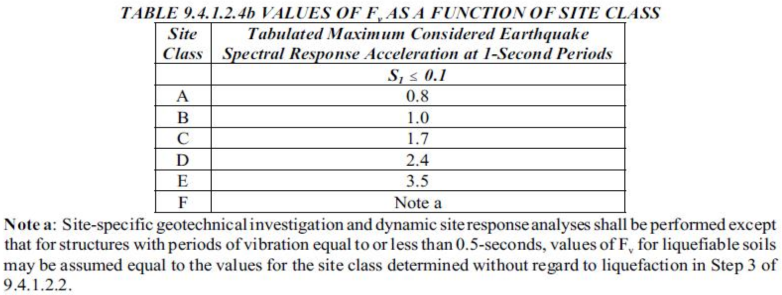


TABLE 9.4.1.2.4b VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods*
	$S_1 \le 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

TABLE 1604.10 GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

(For R-3 of three stories or less one- and two-family stand alone buildings, see 780 CMR 53.00 for snow and wind loads)

City/Town	Ground Snow Load $p_{g,}$ psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Needham	55	100	0.27	0.067
New Ashford	65	90	0.22	0.068
New Bedford	45	110	0.23	0.058
New Braintree	55	100	0.23	0.067
New Marlborough	65	90	0.23	0.066
New Salem	65	100	0.24	0.068
Newbury	55	110	0.35	0.076
Newburyport	55	110	0.35	0.077
Newton	55	105	0.27	0.068
Norfolk	55	100	0.25	0.065
North Adams	65	90	0.22	0.069
North Andover	55	110	0.33	0.075
North Attleborough	55	110	0.24	0.063
North Brookfield	55	100	0.23	0.066
North Reading	55	105	0.32	0.073
Northampton	55	100	0.22	0.066
Northborough	55	100	0.25	0.067
Northbridge	55	100	0.24	0.065
Northfield	65	100	0.24	0.070
Norton	55	110	0.24	0.063
Norwell	45	110	0.26	0.064
Norwood	55	100	0.26	0.065
Oak Bluffs	35	120	0.18	0.051
Oakham	55	100	0.24	0.067
Orange	65	100	0.24	0.070
Orleans	35	120	0.18	0.051
Otis	65	90	0.23	0.066
Oxford	55	100	0.23	0.065
Palmer	55	100	0.23	0.066
Paxton	55	100	0.24	0.067
Peabody	45	110	0.31	0.072
Pelham	55	100	0.23	0.067
Pembroke	45	110	0.25	0.063
Pepperell	65	100	0.30	0.073
Peru	65	90	0.22	0.067
Petersham	65	100	0.24	0.068
Phillipston	65	100	0.24	0.069
Pittsfield	65	90	0.22	0.067
Plainfield	65	100	0.22	0.068
Plainville	55	100	0.24	0.063
Plymouth	45	110	0.24	0.060
Pympton	45	110	0.24	0.061
Princeton	65	100	0.25	0.069
Provincetown	35	120	0.22	0.058
Quincy	45	105	0.27	0.067
Randolph	45	105	0.26	0.065
Raynham	55	110	0.24	0.062
Reading	55	105	0.31	0.072
Rehoboth	55	110	0.24	0.062
Revere	45	105	0.30	0.070
Richmond	65	90	0.22	0.067

Stormwater Report

Taunton Station

City of Taunton,
Massachusetts

Prepared for

massDOT
Massachusetts Department of Transportation
10 Park Plaza
Boston, Massachusetts

Prepared by

VHB **/Vanasse Hangen Brustlin, Inc.**
Transportation, Land Development, Environmental Services
99 High Street
Boston, Massachusetts 02110
617 728 7777

June 2012

Table of Contents

List of Figures

List of Tables

Appendices

Checklist for Stormwater Report

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☒ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☒ Use of “country drainage” versus curb and gutter conveyance and pipe

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☐ Other (describe): ______________________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☒ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

---

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

  ☒ The ½" or 1" Water Quality Volume or

  ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☒ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☐ Name of the stormwater management system owners;
- ☐ Party responsible for operation and maintenance;
- ☐ Schedule for implementation of routine and non-routine maintenance tasks;
- ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Water Quality Certification Regulations (314 CMR 9.00).

Project Description

The Applicant, MassDOT, is proposing to construct a train station in Taunton, Massachusetts near the intersection of Arlington Street and the Belmont Street Extension (the Project). As proposed, the Project consists of a parking lot with 210 spaces, access driveway, a bus drop off area, a side platform, sidewalks, stairs and ramps associated with access from the parking lot to the train platform, bicycle parking facilities, a bioretention basin, and ancillary landscape improvements including the removal of the existing concrete building pads and existing broken pavement.

The site is not considered a Land Use with Higher Potential Pollutant Loads (LUHPPL) as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Site Description

The Project Site is a 12 acre parcel of land (the Site) located at the intersection of Arlington and the Belmont Street Extension in Taunton, Massachusetts. The Site lies within the surface watershed of Taunton River and is bounded by undeveloped land to the north, by Arlington Street to the south, a large wetland to the west, and the MBTA railroad ROW to the east (see Figure 1, Site Locus Map and Figure 2, Site Aerial). The site is previously developed, however the existing buildings have burned down, leaving only building foundations and paved driveways. Stormwater runoff currently sheet flows untreated, to the existing wetland.

One wetland Resource Area on the Site, shown on Figures 3 and 4, is described in Table 1. For additional information regarding the wetland resource area T41 present on the site see the Abbreviated Notice of Resource Area Delineation (ANRAD) prepared by VHB dated May 2011.

Table 1
Wetland Resource Areas

Name	*Critical Area*	*Zone 1 or Zone A*	*ORW or SRW*	*Zone II or IWPA*	*Description*
Wetland T41	No	No	No	No	PFO

Notes: Wetland Classifications: PFO = Palustrine Forested

According to the National Resources Conservation Service (NRCS), surface soils on the Site are classified as Urban land. On-site soils are classified as fill. Based on the soil evaluation performed by Jacobs Engineering, included in Appendix C, the Site is not considered to be within an area of rapid infiltration (soils with a saturated hydraulic conductivity greater than 2.4 inches per hour). Soil vary at the upper fill levels and are poor (silty/clay), HSG D soils at levels just below the surface.

The project is located within an area of 0.2% chance of flood as shown on the FEMA Floodway Map, Town of Taunton, Massachusetts Bristol County, Community Panel Number 25005C0162F and 25005CO164F dated July 7, 2009. These maps are included in Appendix B.

Existing Drainage Conditions

Under existing conditions, the 12 acre Site is developed with predominantly impervious surfaces with small areas of intermixed pervious ground, and generally has a flat topography with 8.7 acres developed area, and the remainder generally the wetland area to the west. This drainage area is described below.

Drainage Area 1 - This 8.7-acre developed area of the site consist of concrete building foundations, paved driveways and parking areas, and small and large patches of pervious surfaces. This entire area sheet flows, untreated, to wetland T41 west of the site.

Figure 3 illustrates the existing drainage patterns on the Site. The Site was evaluated as a single drainage area because stormwater runoff flows to one Design Point. Table 2 below provides a summary of the existing conditions hydrologic data.

Table 2
Existing Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland T41	1	8.7	93	16.1

Proposed Drainage Conditions

Figure 4 illustrates the proposed "post construction" drainage conditions for the project. As shown, the Site would be divided into three sub-drainage areas that will discharge treated stormwater to the one existing Design Point. Existing grading and drainage patterns were maintained to the maximum extent possible in the proposed conditions. The existing building foundations and broken paved areas would be removed in the proposed conditions, and replaced with landscaping, or paved parking areas as shown on Figure 4. All runoff from impervious surfaces would sheet flow to a grassed swale and then be conveyed to a bioretention area for further treatment. Low impact development stormwater management techniques have been incorporated into the design. These practices are focused on decentralizing stormwater management techniques into the design that will reduce peak runoff rates, maximize groundwater recharge and treat for water quality. The following is a summary of each drainage area.

Drainage Area 1 – This 3.0-acre area consists of almost entirely pervious area that would sheet flow to Wetland T41. The existing building foundations and paved areas would be completely removed in the proposed conditions.

Drainage Area 2 – This 4.1-acre area consists of both paved parking and drive aisle areas and landscaped islands. This area would sheet flow from the impervious surfaces into a grassed channel or a sediment forebay and then be conveyed to a bioretention area for treatment before it overflows to Wetland T41.

Drainage Area 3 – This 1.8-acre area consist of almost entirely pervious surfaces that would sheet flow onto Arlington Street, as it does under existing conditions, before it is captured by a catch basin located in the street and connected to an existing culvert.

Table 3 below provides a summary of the proposed conditions hydrologic data.

Table 3
Proposed Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland T41	1	3.03	84	12.8
2	Wetland T41	1	4.05	93	13.3
3	Wetland T41	1	1.83	85	5.6

The site has been designed with a comprehensive stormwater management system that has been developed in accordance with the Massachusetts Stormwater Handbook. The proposed stormwater management system has been designed to treat the 0.5 inch Water Quality Volume.

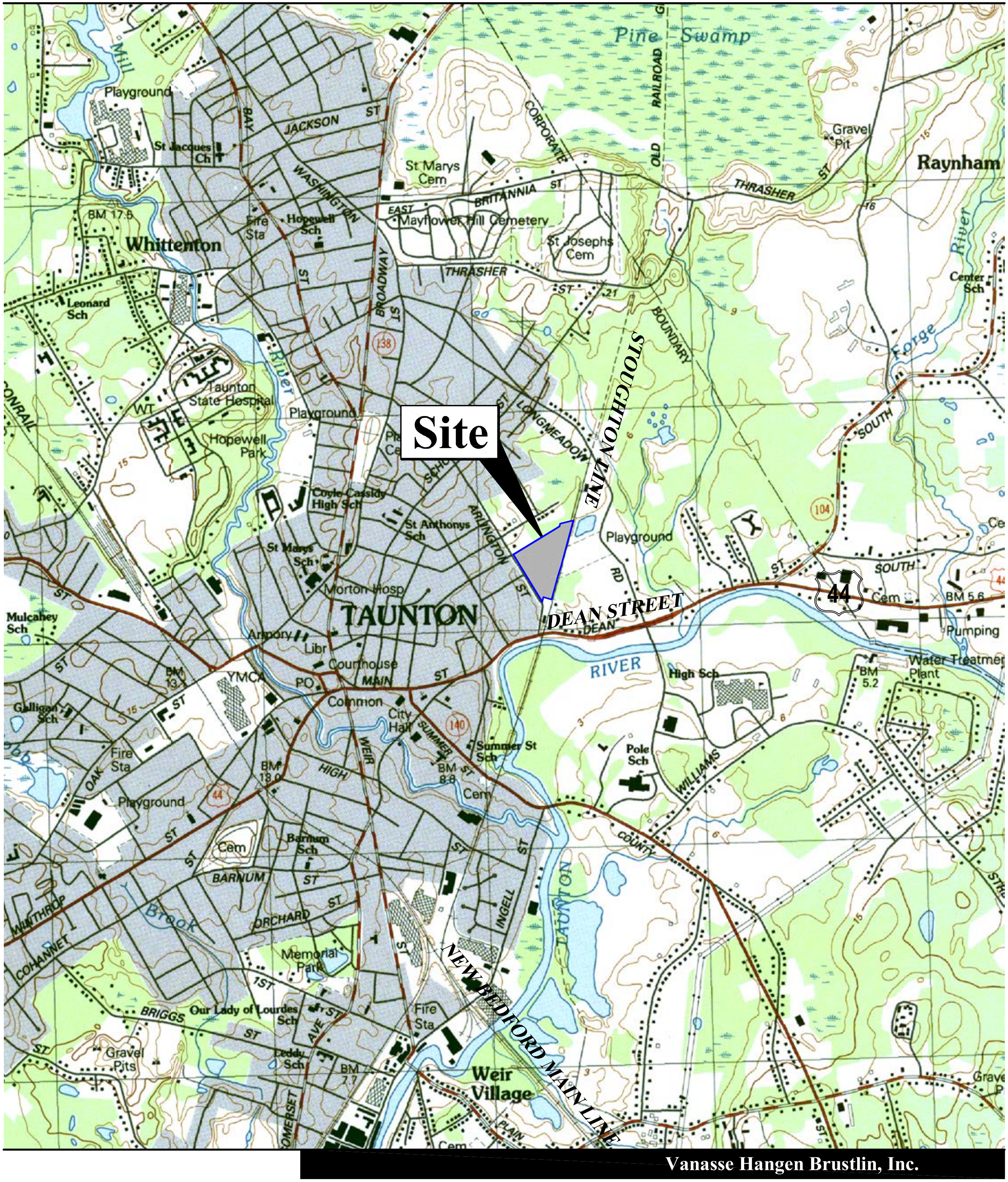
Environmentally Sensitive and Low Impact Development (LID) Techniques

Low Impact Development (LID) techniques and stormwater Best Management Practices (BMPs) implemented into the site design include:

- Reduction in impervious area of 2.9 acres
- Grassed swale
- Bioretention basin
- Light colored pavement sidewalks

In general, stormwater from the proposed impervious surfaces will sheet flow into a grassed swale and conveyed to a large bioretention area for treatment and discharge to Wetland T41. Under existing conditions stormwater sheet flows from impervious surfaces, untreated, to the wetland.

\\MABOS\projects\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Taunton Dean\Stormwater Figures\Figure1-SiteLocus\Figure 1-Site Locus.dwg



Vanasse Hangen Brustlin, Inc.

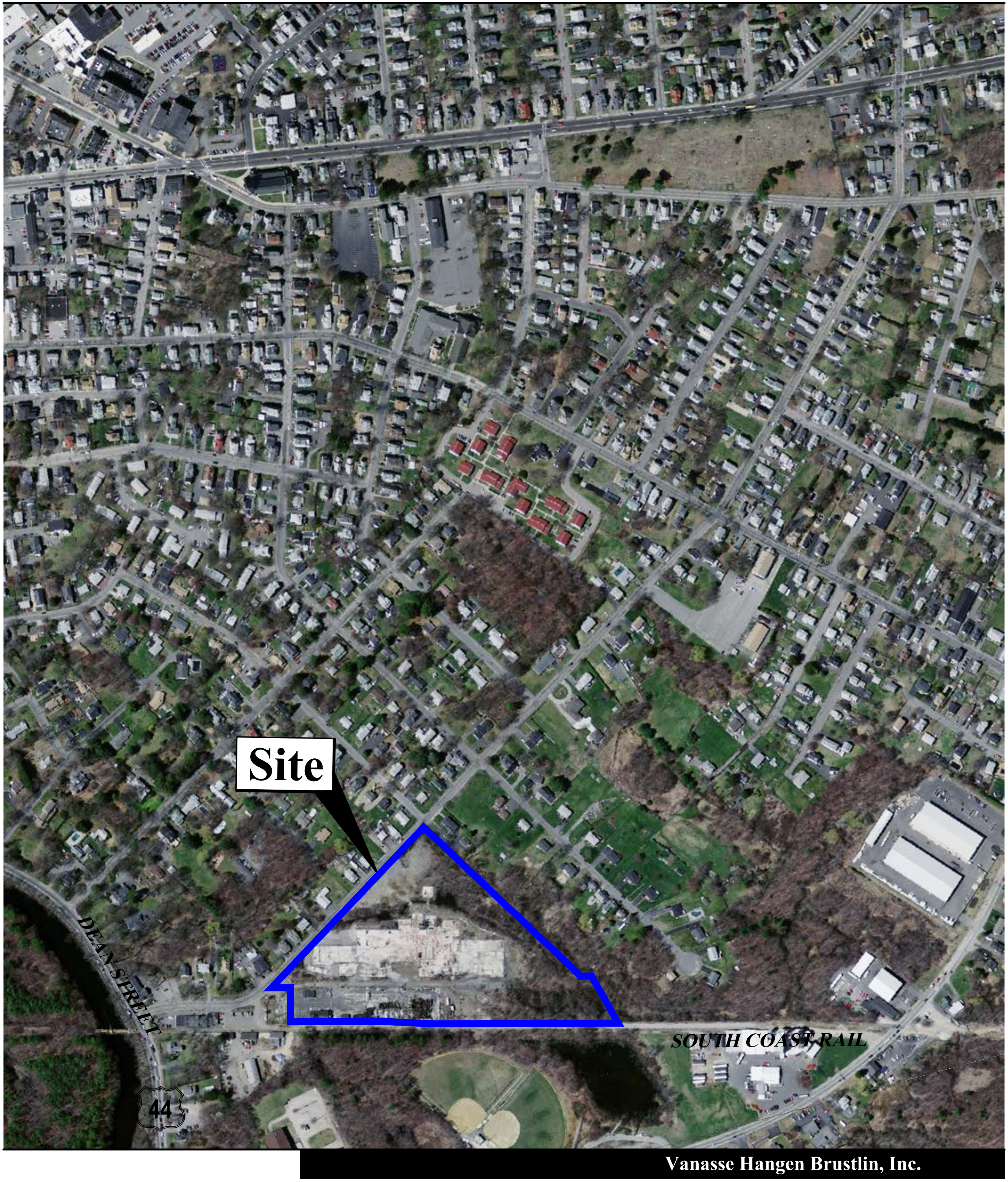
USGS Locus Map

Proposed Taunton Station
South Coast Rail
Taunton, Massachusets

Figure 1
May 2012

↑

0 1000 2000 Feet

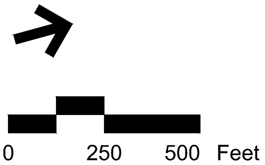


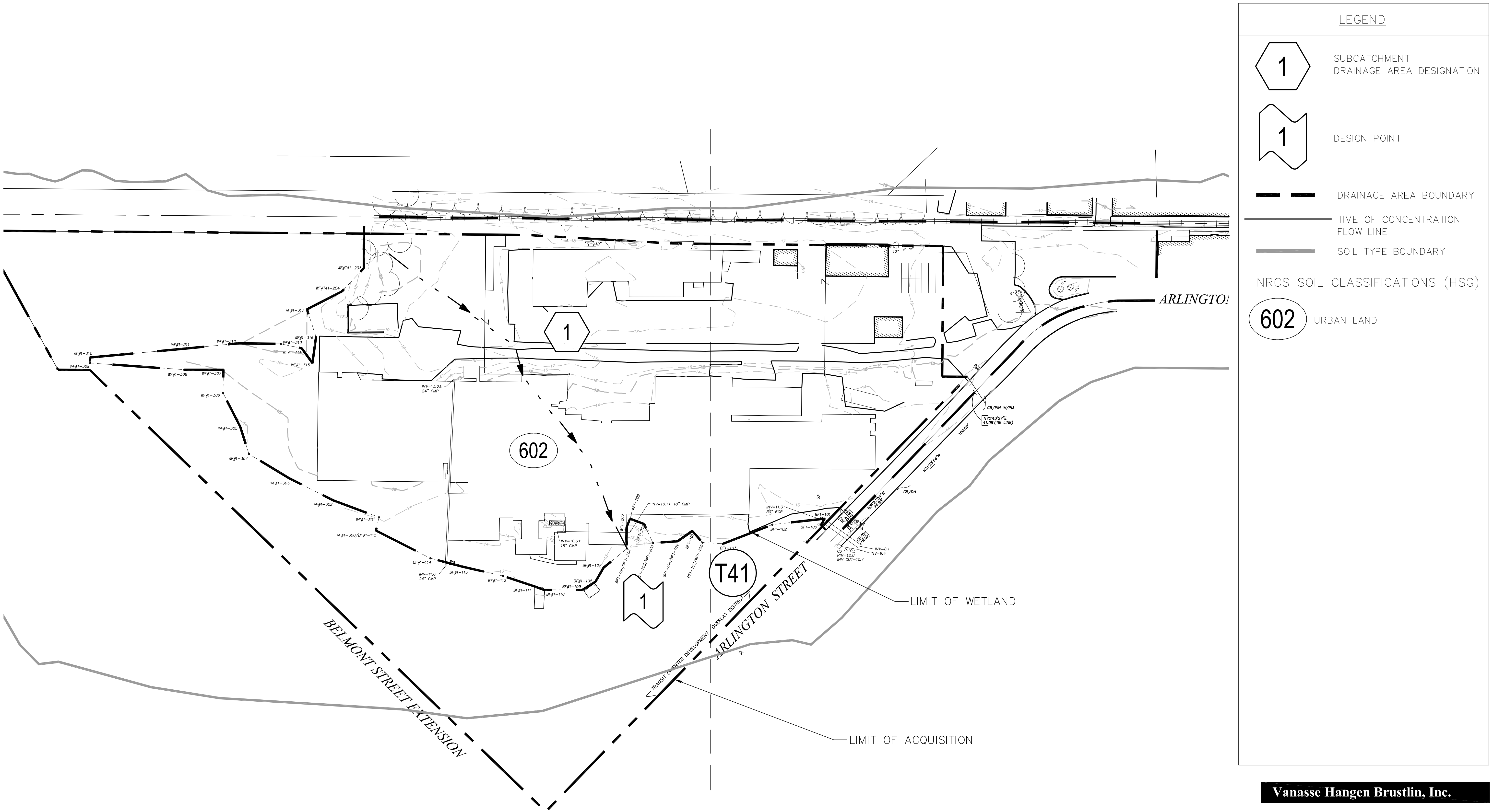
Vanasse Hangen Brustlin, Inc.

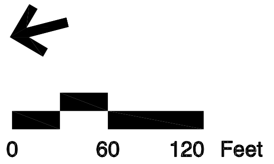
Site Aerial Map

Figure 2
May 2012

Taunton Station
South Coast Rail
Taunton, Massachusets







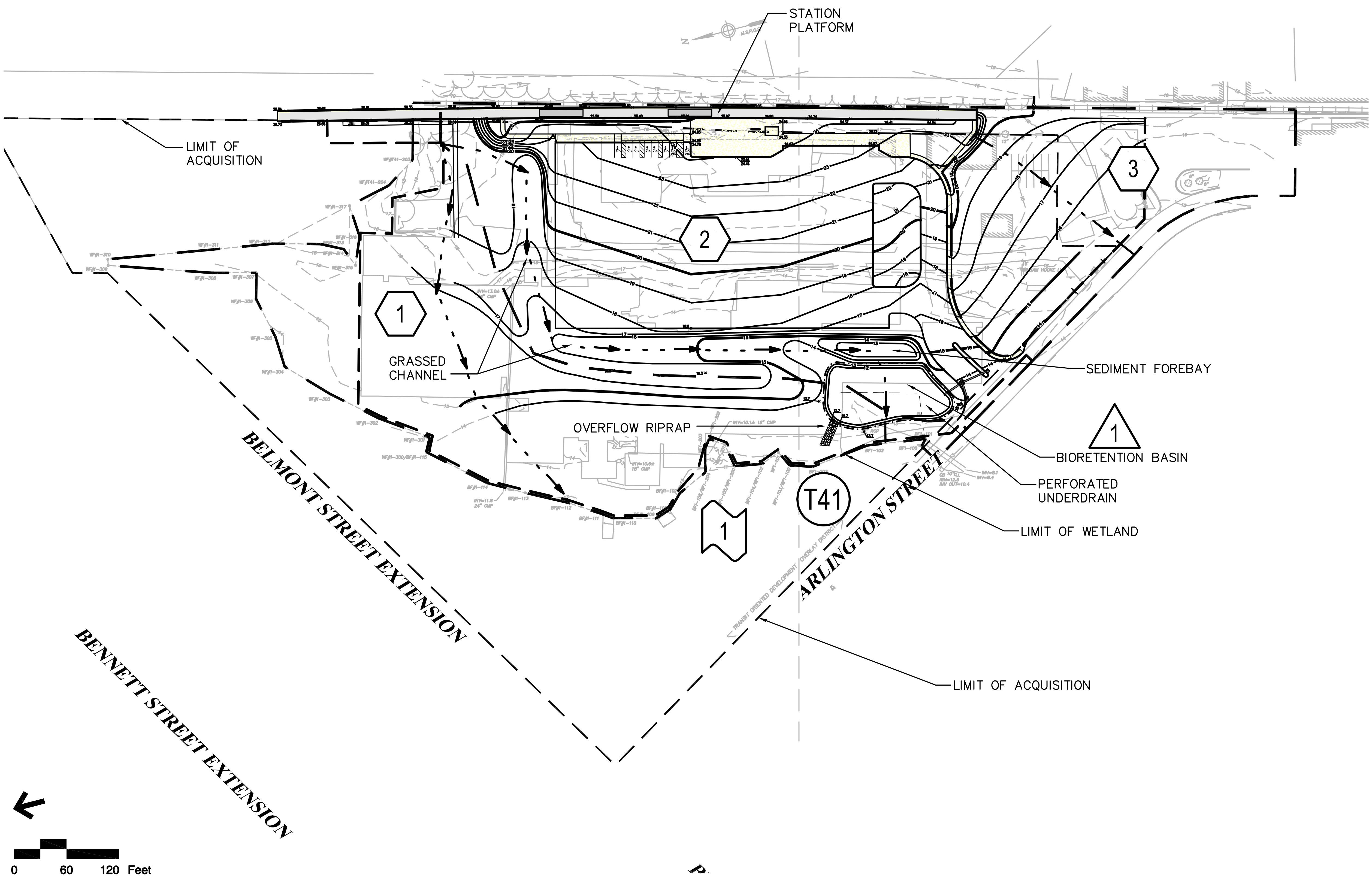
Vanasse Hangen Brustlin, Inc.

Figure 3 May 2012

Existing Conditions Drainage Areas

South Coast Rail
Taunton, Massachusetts

\\Vhb\proj\Boston\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Taunton Dean\Stormwater Figures\Figure4-ProposedConditions\Taunton Proposed Conditions.dwg



LEGEND

⬡ 1 SUBCATCHMENT DRAINAGE AREA DESIGNATION

△ 1 POND/BIORETENTION AREA

1 DESIGN POINT

▬ ▬ DRAINAGE AREA BOUNDARY

- · - · → TIME OF CONCENTRATION FLOW LINE

Vanasse Hangen Brustlin, Inc.

Figure 4 May 2012

Proposed Conditions Drainage Areas

South Coast Rail
Taunton, Massachusetts

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards at 310 CMR 10.05.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

All proposed Project stormwater outlets and conveyances have been designed to not cause erosion or scour to wetlands or receiving waters. Outlets from closed drainage systems have been designed with flared end sections and stone protection to dissipate discharge velocities. Overflows from BMPs that impound stormwater have been designed with stone rip rap to protect down-gradient areas from erosion.

Computations and supporting information for the sizing and selection of materials used to protect from scour and erosion are included in Appendix A.

Standard 2: Peak Rate Attenuation

The Project has been designed to fully comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, and 100-years. The results of the analysis, as summarized in Table 4 below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions.

Computations and supporting information regarding the hydrologic modeling are included in Appendix B.

Table 4
Peak Discharge Rates (cfs*)

Design Point	*2-year*	*10-year*	*100-year*
Design Point: Wetland T41			
Existing	19.1	28.4	42.8
Proposed	13.9	23.0	37.1

Standard 3: Stormwater Recharge

Due to the fact that the development portion of the site is comprised of fill, underlain by poorly draining soils, the project has been designed to promote infiltration of the required recharge volume only to the maximum extent practicable. The addition of pervious area in the proposed conditions will reduce runoff from the site as a whole. Currently the site runs off to the adjacent wetland and groundwater recharge is insignificant under existing conditions. If assuming there could be some infiltration, in the HSG D lower soils, according to the Stormwater Handbook, the Required Recharge Volume for the Project would be 970 cubic feet, a relatively small amount. . Approximately 1,263 cubic feet of recharge is provided in the bioretention area.

This volume of storage has been provided through the use of a bioretention basin, which has been sized using the static method. It is hoped that the bioretention basin will promote some recharge and infiltrate, however it has been designed to drain completely within 72 hours by the incorporation of perforated underdrain. This is necessary due to the inconsistent and poor draining qualities of the subsurface soil conditions. A Geotechnical Report that describes subsurface soil conditions is included as an appendix to this report.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum of 80% TSS removal for stormwater runoff from all proposed impervious surfaces.

Computations and supporting information are included in Appendix D.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a LUHPPL as defined in 310 CMR 10.04 and 314 CMR 9.02 because it is not parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Standard 6: Critical Areas

The Project will not discharge stormwater near or to a critical area.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is a redevelopment, but has still been designed to fully comply with all ten of the Stormwater Management Standards.

Refer directly to each Standard for applicable computations and supporting information demonstrating compliance with each.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Controls

The Project would disturb approximately 8.9 acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) would be developed and a Notice of Intent for the CGP would be submitted at least 14 days before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls were discussed in the DEIR/S. Appropriate controls will be prepared and implemented by the contractor and MassDOT (MBTA) during construction in accordance with the final design and NPDES SWPPP.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan will be developed by the MBTA during final design for the Project.

Standard 10: Prohibition of Illicit Discharges

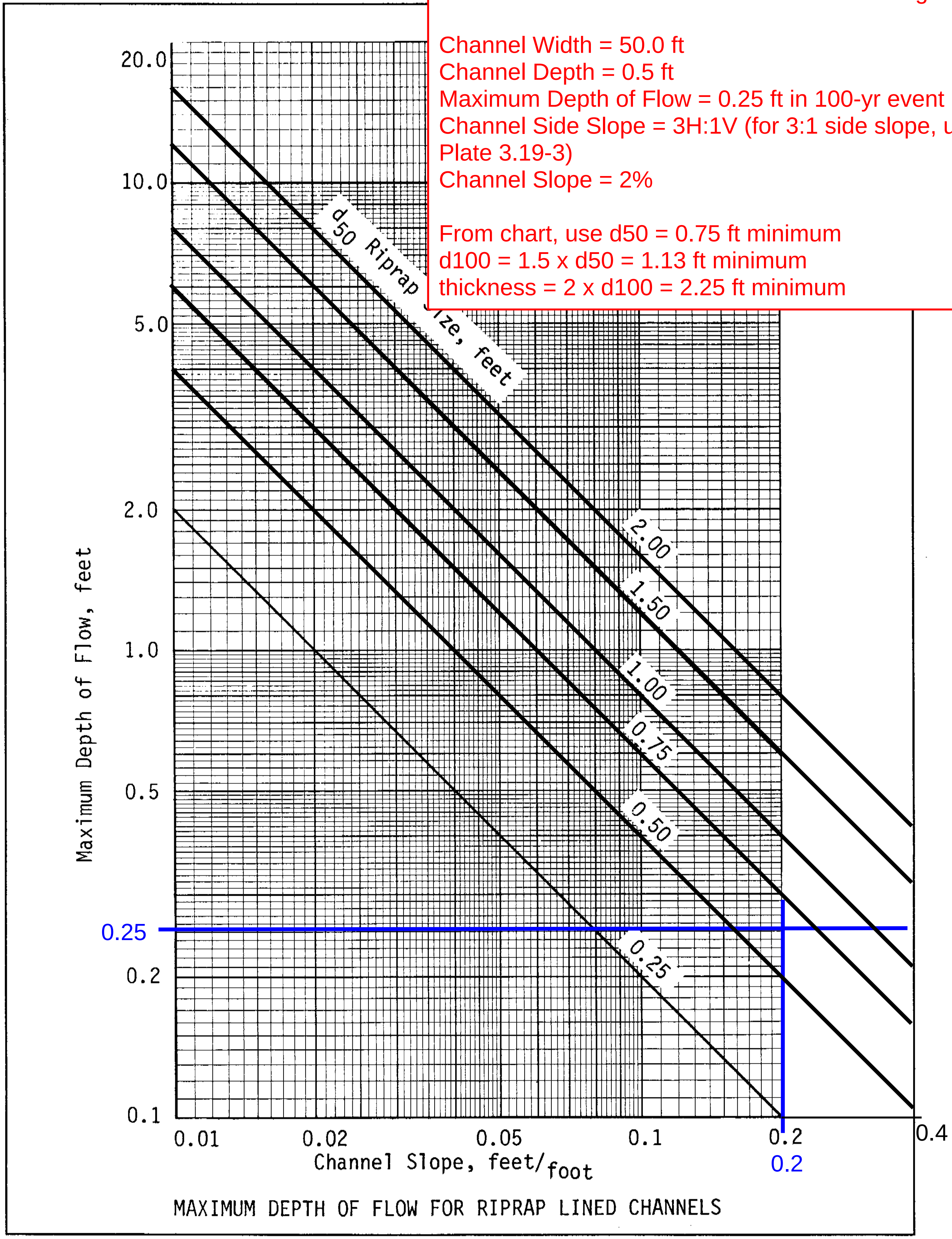
Storm drainage structures remaining from the previous development which are part of the redevelopment area will be removed. The design plans submitted with this report have been designed so that the components included therein are in full compliance with current standards. No statement is made with regard to the drainage system in portions of the site not included in the redevelopment project area. The Long-Term Pollution Prevention Plan will include measures to prevent illicit discharges.

Appendix A
Standard 1 Computations and Supporting Information

Project No: 10111
Project Name: SCR
Date: April 2012
Location: Taunton, MA
Calculated By: DAG
Re: Bioretention Basin 1 Overflow Stone Sizing

Channel Width = 50.0 ft
Channel Depth = 0.5 ft
Maximum Depth of Flow = 0.25 ft in 100-yr event
Channel Side Slope = 3H:1V (for 3:1 side slope, use Plate 3.19-3)
Channel Slope = 2%

From chart, use d50 = 0.75 ft minimum
d100 = 1.5 x d50 = 1.13 ft minimum
thickness = 2 x d100 = 2.25 ft minimum



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

Source: VDOT Drainage Manual

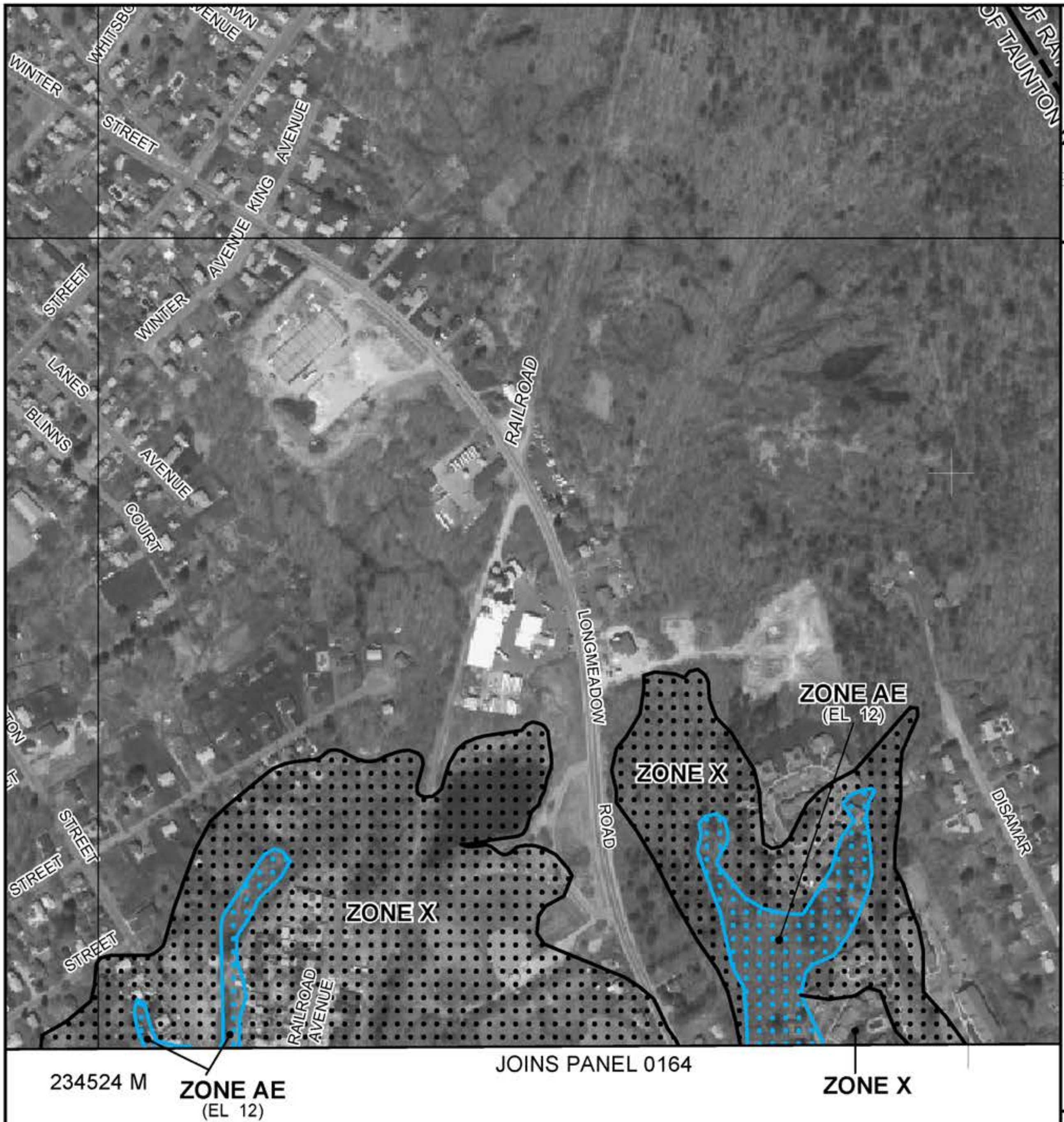
Plate 3.19-3

*Sizing calculations represent minimum stone size. Larger stone may be required per detail plans.

Appendix B
Standard 2 Computations and Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Bristol County. Runoff coefficients for the existing and proposed conditions, as previously shown in Tables 1 and 2 respectively, were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

FEMA Flood Map



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METE

NFIP

PANEL 0162F

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 162 OF 550

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
RAYNHAM, TOWN OF	250061	0162	F
TAUNTON, CITY OF	250066	0162	F

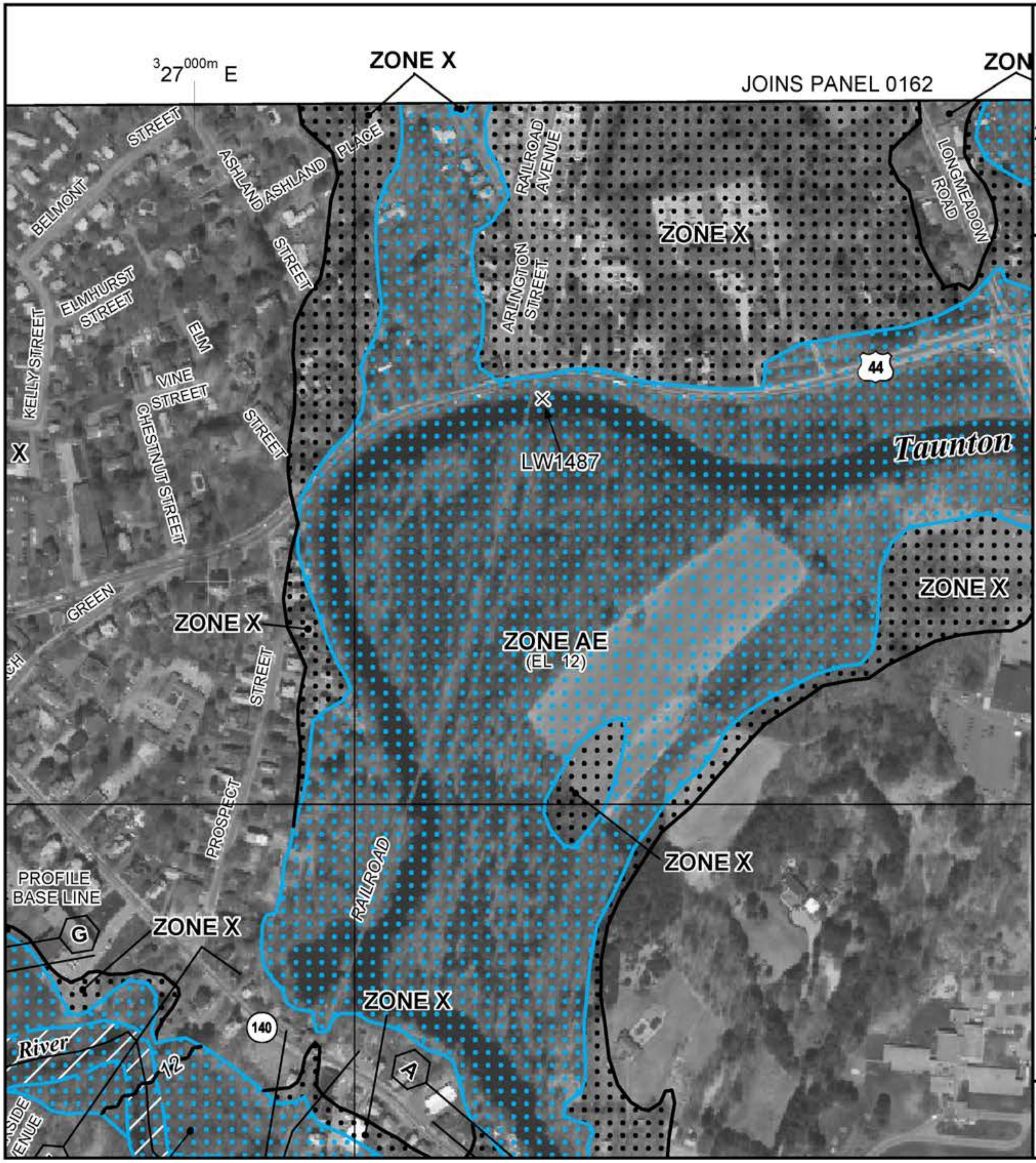
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

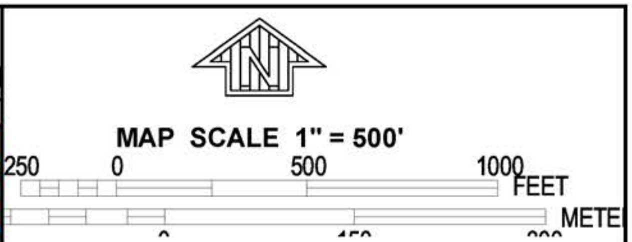
MAP NUMBER
25005C0162F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov





NATIONAL FLOOD INSURANCE PROGRAM

NFIP

PANEL 0164F

FIRM
FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 164 OF 550

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
RAYNHAM, TOWN OF	250061	0164	F
TAUNTON, CITY OF	250066	0164	F

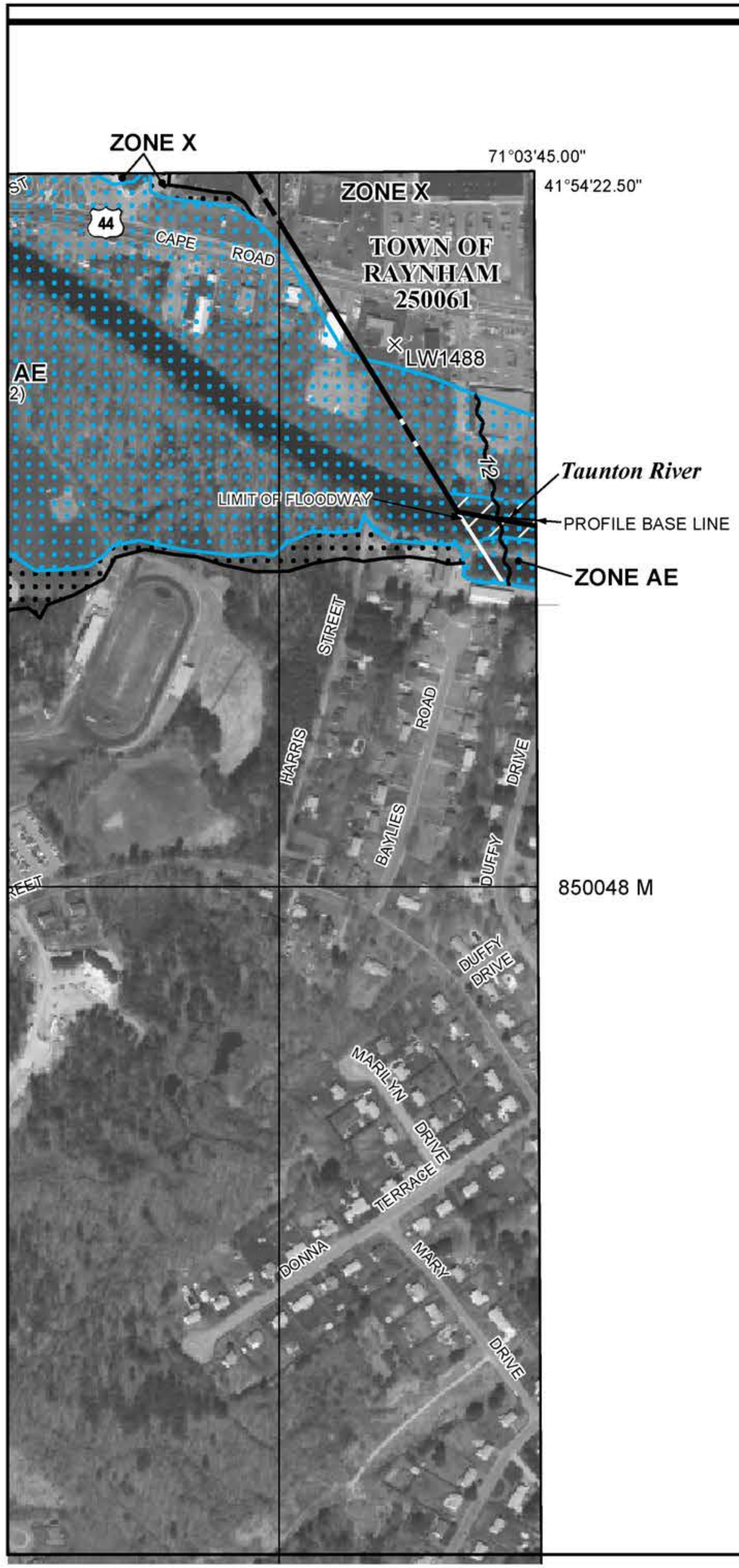
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25005C0164F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



LEGEND

░ **SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

▨ **FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

▒ **OTHER FLOOD AREAS**

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

☐ **OTHER AREAS**

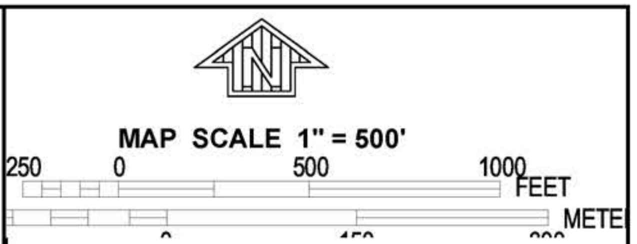
ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

▧ **COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**

▧ **OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

———	1% annual chance floodplain boundary
———	0.2% annual chance floodplain boundary
— — —	Floodway boundary
– ——— ——— –	Zone D boundary
●●●●●●●●●●●●●●●●	CBRS and OPA boundary
░ ←	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*



PANEL 0164F

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 164 OF 550
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
RAYNHAM, TOWN OF	250061	0164	F
TAUNTON, CITY OF	250066	0164	F

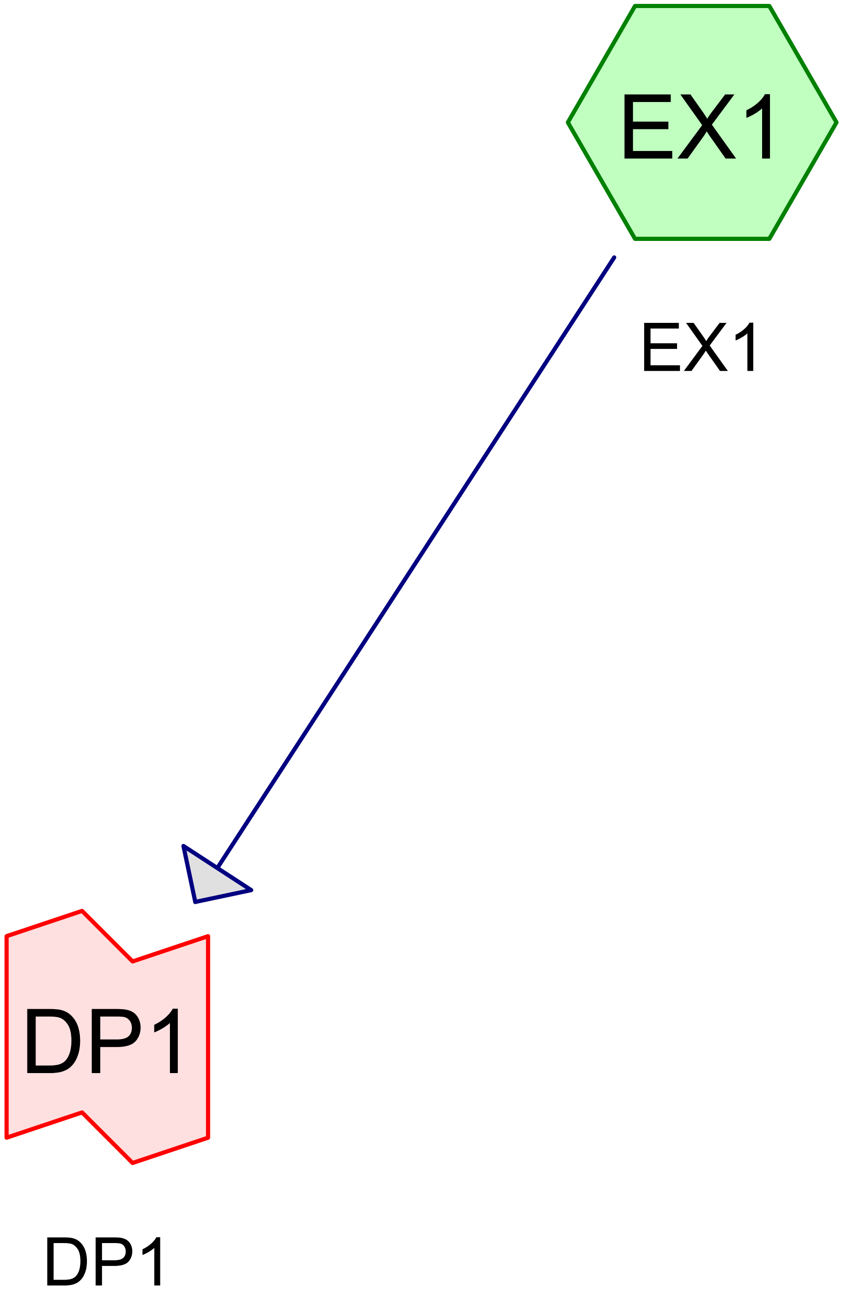
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

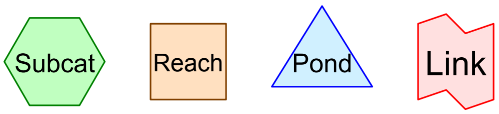
MAP NUMBER
25005C0164F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

HydroCAD Analysis: Existing Conditions





Routing Diagram for Taunton Dean-EX
Prepared by Vanasse Hangen Brustlin, Printed 5/21/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.249	84	50-75% Grass cover, Fair, HSG D (EX1)
5.324	98	Paved parking, HSG D (EX1)
0.112	98	Roofs, HSG D (EX1)
8.685	**93**	**TOTAL AREA**

2-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=8.685 ac 62.59% Impervious Runoff Depth>2.63"
Flow Length=597' Tc=16.1 min CN=93 Runoff=19.13 cfs 1.905 af

Link DP1: DP1 Inflow=19.13 cfs 1.905 af
Primary=19.13 cfs 1.905 af

Total Runoff Area = 8.685 ac Runoff Volume = 1.905 af Average Runoff Depth = 2.63"
37.41% Pervious = 3.249 ac 62.59% Impervious = 5.436 ac

Summary for Subcatchment EX1: EX1

Runoff = 19.13 cfs @ 12.21 hrs, Volume= 1.905 af, Depth> 2.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
3.249	84	50-75% Grass cover, Fair, HSG D
5.324	98	Paved parking, HSG D
0.112	98	Roofs, HSG D
8.685	93	Weighted Average
3.249		37.41% Pervious Area
5.436		62.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
3.0	147	0.0140	0.83		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	38	0.0974	6.34		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.6	142	0.0056	1.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.8	130	0.0008	0.57		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	90	0.0089	1.92		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
16.1	597	Total			

Summary for Link DP1: DP1

Inflow Area = 8.685 ac, 62.59% Impervious, Inflow Depth > 2.63" for 2-Year event
Inflow = 19.13 cfs @ 12.21 hrs, Volume= 1.905 af
Primary = 19.13 cfs @ 12.21 hrs, Volume= 1.905 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

10-Year Storm Event - Existing

```
                 Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
                     Runoff by SCS TR-20 method, UH=SCS
     Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentEX1: EX1            Runoff Area=8.685 ac   62.59% Impervious   Runoff Depth>3.99"
                          Flow Length=597'   Tc=16.1 min   CN=93   Runoff=28.40 cfs  2.890 af

Link DP1: DP1                                                    Inflow=28.40 cfs  2.890 af
                                                                Primary=28.40 cfs  2.890 af

          Total Runoff Area = 8.685 ac   Runoff Volume = 2.890 af   Average Runoff Depth = 3.99"
                                    37.41% Pervious = 3.249 ac     62.59% Impervious = 5.436 ac
```

Summary for Subcatchment EX1: EX1

Runoff = 28.40 cfs @ 12.21 hrs, Volume= 2.890 af, Depth> 3.99"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
3.249	84	50-75% Grass cover, Fair, HSG D
5.324	98	Paved parking, HSG D
0.112	98	Roofs, HSG D
8.685	93	Weighted Average
3.249		37.41% Pervious Area
5.436		62.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
3.0	147	0.0140	0.83		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	38	0.0974	6.34		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.6	142	0.0056	1.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.8	130	0.0008	0.57		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	90	0.0089	1.92		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
16.1	597	Total			

Summary for Link DP1: DP1

Inflow Area = 8.685 ac, 62.59% Impervious, Inflow Depth > 3.99" for 10-Year event
Inflow = 28.40 cfs @ 12.21 hrs, Volume= 2.890 af
Primary = 28.40 cfs @ 12.21 hrs, Volume= 2.890 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

100-Year Storm Event - Existing

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=8.685 ac 62.59% Impervious Runoff Depth>6.16"
Flow Length=597' Tc=16.1 min CN=93 Runoff=42.79 cfs 4.457 af

Link DP1: DP1 Inflow=42.79 cfs 4.457 af
Primary=42.79 cfs 4.457 af

Total Runoff Area = 8.685 ac Runoff Volume = 4.457 af Average Runoff Depth = 6.16"
37.41% Pervious = 3.249 ac 62.59% Impervious = 5.436 ac

Summary for Subcatchment EX1: EX1

Runoff = 42.79 cfs @ 12.21 hrs, Volume= 4.457 af, Depth> 6.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
3.249	84	50-75% Grass cover, Fair, HSG D
5.324	98	Paved parking, HSG D
0.112	98	Roofs, HSG D
8.685	93	Weighted Average
3.249		37.41% Pervious Area
5.436		62.59% Impervious Area

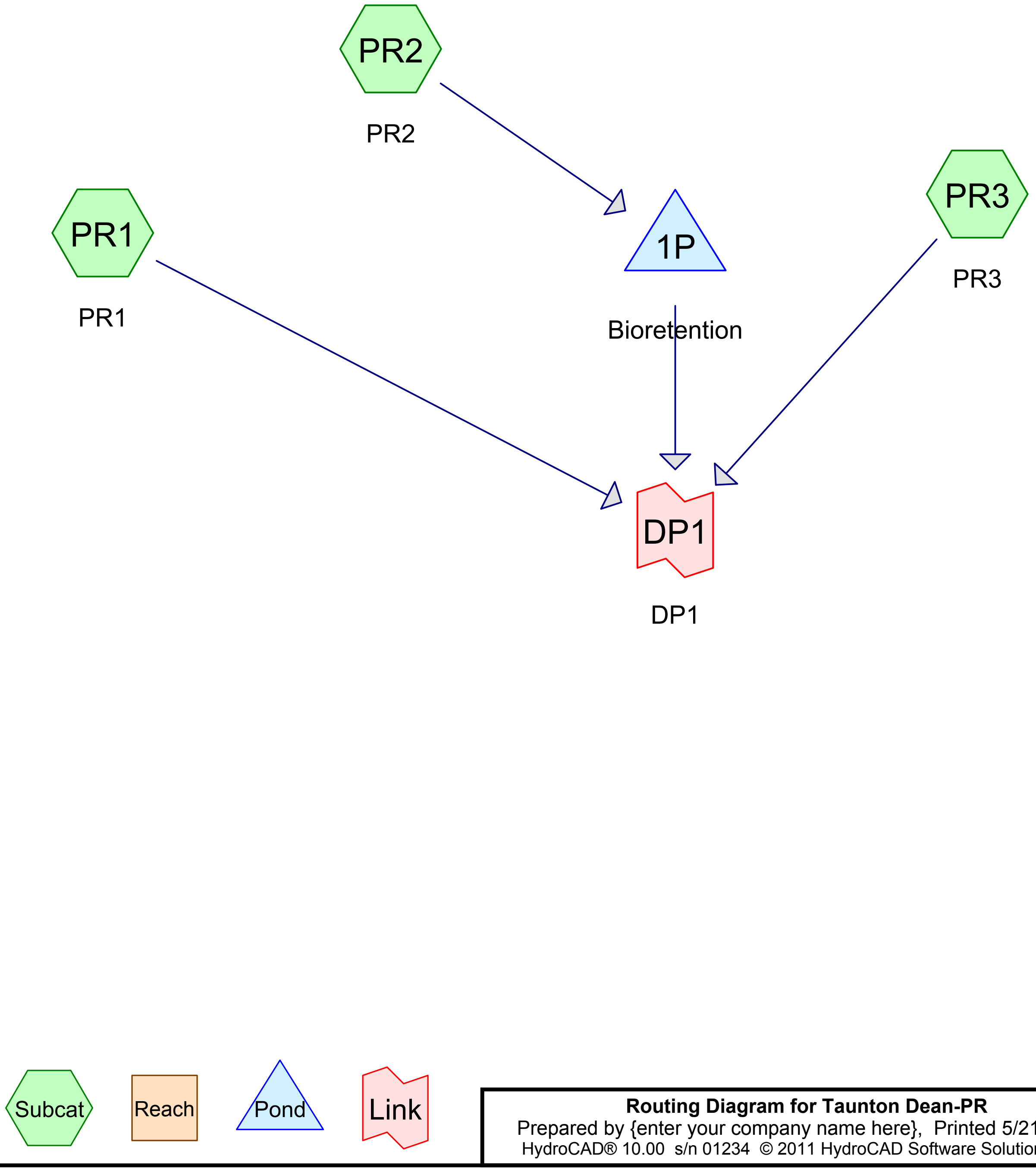
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
3.0	147	0.0140	0.83		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	38	0.0974	6.34		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.6	142	0.0056	1.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
3.8	130	0.0008	0.57		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.8	90	0.0089	1.92		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
16.1	597	Total			

Summary for Link DP1: DP1

Inflow Area = 8.685 ac, 62.59% Impervious, Inflow Depth > 6.16" for 100-Year event
Inflow = 42.79 cfs @ 12.21 hrs, Volume= 4.457 af
Primary = 42.79 cfs @ 12.21 hrs, Volume= 4.457 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

HydroCAD Analysis: Proposed Conditions



Routing Diagram for Taunton Dean-PR
Prepared by {enter your company name here}, Printed 5/21/2012
HydroCAD® 10.00 s/n 01234 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
6.121	80	>75% Grass cover, Good, HSG D (PR1, PR2, PR3)
2.579	98	Paved parking, HSG D (PR1, PR2)
0.092	98	Paved roads w/curbs & sewers, HSG D (PR3)
0.119	98	Water Surface, HSG D (PR2)
8.911	**86**	**TOTAL AREA**

2-Year Storm Event - Proposed

```
                         Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
                              Runoff by SCS TR-20 method, UH=SCS
              Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentPR1: PR1                  Runoff Area=3.025 ac   1.72% Impervious   Runoff Depth>1.55"
                                 Flow Length=461'   Tc=12.8 min   CN=80   Runoff=4.35 cfs  0.392 af

SubcatchmentPR2: PR2                 Runoff Area=4.053 ac   65.28% Impervious   Runoff Depth>2.54"
                                 Flow Length=670'   Tc=13.3 min   CN=92   Runoff=9.25 cfs  0.857 af

SubcatchmentPR3: PR3                  Runoff Area=1.833 ac   5.02% Impervious   Runoff Depth>1.63"
                                  Flow Length=208'   Tc=5.6 min   CN=81   Runoff=3.45 cfs  0.248 af

Pond 1P: Bioretention                   Peak Elev=13.16'  Storage=9,345 cf   Inflow=9.25 cfs  0.857 af
                  Discarded=0.02 cfs  0.025 af   Primary=8.03 cfs  0.701 af   Outflow=8.04 cfs  0.726 af

Link DP1: DP1                                                                Inflow=13.87 cfs  1.341 af
                                                                            Primary=13.87 cfs  1.341 af
```

Total Runoff Area = 8.911 ac Runoff Volume = 1.497 af Average Runoff Depth = 2.02"
68.69% Pervious = 6.121 ac 31.31% Impervious = 2.790 ac

Summary for Subcatchment PR1: PR1

Runoff = 4.35 cfs @ 12.18 hrs, Volume= 0.392 af, Depth> 1.55"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.052	98	Paved parking, HSG D
2.973	80	>75% Grass cover, Good, HSG D
3.025	80	Weighted Average
2.973		98.28% Pervious Area
0.052		1.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	50	0.0140	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
1.6	119	0.0327	1.27		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	134	0.0075	0.61		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.1	158	0.1266	2.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
12.8	461	Total			

Summary for Subcatchment PR2: PR2

Runoff = 9.25 cfs @ 12.18 hrs, Volume= 0.857 af, Depth> 2.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
2.527	98	Paved parking, HSG D
1.407	80	>75% Grass cover, Good, HSG D
0.119	98	Water Surface, HSG D
4.053	92	Weighted Average
1.407		34.72% Pervious Area
2.646		65.28% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.0160	0.14		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
0.9	55	0.0236	1.08		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.1	80	0.0063	1.19		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
1.0	91	0.0109	1.57		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.3	31	0.0129	1.70		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.7	64	0.0094	1.45		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.3	299	0.0100	1.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
13.3	670	Total			

Summary for Subcatchment PR3: PR3

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.45 cfs @ 12.09 hrs, Volume= 0.248 af, Depth> 1.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (ac)	CN	Description
0.092	98	Paved roads w/curbs & sewers, HSG D
1.741	80	>75% Grass cover, Good, HSG D
1.833	81	Weighted Average
1.741		94.98% Pervious Area
0.092		5.02% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.2	50	0.0800	0.26		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
2.4	158	0.0253	1.11		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.6	208	Total			

Summary for Pond 1P: Bioretention

Inflow Area = 4.053 ac, 65.28% Impervious, Inflow Depth > 2.54" for 2-Year event
Inflow = 9.25 cfs @ 12.18 hrs, Volume= 0.857 af
Outflow = 8.04 cfs @ 12.26 hrs, Volume= 0.726 af, Atten= 13%, Lag= 5.0 min
Discarded = 0.02 cfs @ 12.26 hrs, Volume= 0.025 af
Primary = 8.03 cfs @ 12.26 hrs, Volume= 0.701 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.16' @ 12.26 hrs Surf.Area= 8,698 sf Storage= 9,345 cf

Plug-Flow detention time= 106.8 min calculated for 0.726 af (85% of inflow)
Center-of-Mass det. time= 43.3 min (844.4 - 801.1)

Volume	Invert	Avail.Storage	Storage Description
#1	12.00'	14,203 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
12.00	7,420	356.0	0	0	7,420
12.70	8,181	369.0	5,458	5,458	8,212
13.00	8,517	375.0	2,505	7,963	8,584
13.70	9,318	388.0	6,240	14,203	9,417

Device	Routing	Invert	Outlet Devices
#1	Primary	12.70'	**10.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Discarded	12.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.02 cfs @ 12.26 hrs HW=13.16' (Free Discharge)
⮤**2=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=7.95 cfs @ 12.26 hrs HW=13.16' (Free Discharge)
⮤**1=Broad-Crested Rectangular Weir** (Weir Controls 7.95 cfs @ 1.74 fps)

Summary for Link DP1: DP1

Inflow Area = 8.911 ac, 31.31% Impervious, Inflow Depth > 1.81" for 2-Year event
Inflow = 13.87 cfs @ 12.22 hrs, Volume= 1.341 af
Primary = 13.87 cfs @ 12.22 hrs, Volume= 1.341 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

10-Year Storm Event- Proposed

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentPR1: PR1 Runoff Area=3.025 ac 1.72% Impervious Runoff Depth>2.71"
Flow Length=461' Tc=12.8 min CN=80 Runoff=7.66 cfs 0.684 af

SubcatchmentPR2: PR2 Runoff Area=4.053 ac 65.28% Impervious Runoff Depth>3.89"
Flow Length=670' Tc=13.3 min CN=92 Runoff=13.88 cfs 1.313 af

SubcatchmentPR3: PR3 Runoff Area=1.833 ac 5.02% Impervious Runoff Depth>2.81"
Flow Length=208' Tc=5.6 min CN=81 Runoff=5.96 cfs 0.429 af

Pond 1P: Bioretention Peak Elev=13.30' Storage=10,554 cf Inflow=13.88 cfs 1.313 af
Discarded=0.02 cfs 0.027 af Primary=12.48 cfs 1.154 af Outflow=12.49 cfs 1.181 af

Link DP1: DP1 Inflow=22.99 cfs 2.267 af
Primary=22.99 cfs 2.267 af

Total Runoff Area = 8.911 ac Runoff Volume = 2.425 af Average Runoff Depth = 3.27"
68.69% Pervious = 6.121 ac 31.31% Impervious = 2.790 ac

Summary for Subcatchment PR1: PR1

Runoff = 7.66 cfs @ 12.18 hrs, Volume= 0.684 af, Depth> 2.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
0.052	98	Paved parking, HSG D
2.973	80	>75% Grass cover, Good, HSG D
3.025	80	Weighted Average
2.973		98.28% Pervious Area
0.052		1.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	50	0.0140	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
1.6	119	0.0327	1.27		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	134	0.0075	0.61		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.1	158	0.1266	2.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
12.8	461	Total			

Summary for Subcatchment PR2: PR2

Runoff = 13.88 cfs @ 12.18 hrs, Volume= 1.313 af, Depth> 3.89"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.80"

Area (ac)	CN	Description
2.527	98	Paved parking, HSG D
1.407	80	>75% Grass cover, Good, HSG D
0.119	98	Water Surface, HSG D
4.053	92	Weighted Average
1.407		34.72% Pervious Area
2.646		65.28% Impervious Area

```
   Tc  Length   Slope  Velocity  Capacity  Description
(min)  (feet)  (ft/ft)  (ft/sec)     (cfs)
  6.0      50  0.0160      0.14            Sheet Flow,
                                           Grass: Short   n= 0.150   P2= 3.32"
  0.9      55  0.0236      1.08            Shallow Concentrated Flow,
                                           Short Grass Pasture   Kv= 7.0 fps
  1.1      80  0.0063      1.19            Shallow Concentrated Flow,
                                           Grassed Waterway   Kv= 15.0 fps
  1.0      91  0.0109      1.57            Shallow Concentrated Flow,
                                           Grassed Waterway   Kv= 15.0 fps
  0.3      31  0.0129      1.70            Shallow Concentrated Flow,
                                           Grassed Waterway   Kv= 15.0 fps
  0.7      64  0.0094      1.45            Shallow Concentrated Flow,
                                           Grassed Waterway   Kv= 15.0 fps
  3.3     299  0.0100      1.50            Shallow Concentrated Flow,
                                           Grassed Waterway   Kv= 15.0 fps
 13.3     670  Total
```

Summary for Subcatchment PR3: PR3

```
[49] Hint: Tc<2dt may require smaller dt

Runoff      =        5.96 cfs @   12.09 hrs,  Volume=          0.429 af,  Depth>  2.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr  10-Year Rainfall=4.80"

   Area (ac)   CN  Description
       0.092   98  Paved roads w/curbs & sewers, HSG D
       1.741   80  >75% Grass cover, Good, HSG D
       1.833   81  Weighted Average
       1.741       94.98% Pervious Area
       0.092       5.02% Impervious Area

   Tc  Length   Slope  Velocity  Capacity  Description
(min)  (feet)  (ft/ft)  (ft/sec)     (cfs)
  3.2      50  0.0800      0.26            Sheet Flow,
                                           Grass: Short   n= 0.150   P2= 3.32"
  2.4     158  0.0253      1.11            Shallow Concentrated Flow,
                                           Short Grass Pasture   Kv= 7.0 fps
  5.6     208  Total
```

Summary for Pond 1P: Bioretention

```
Inflow Area =        4.053 ac,  65.28% Impervious,  Inflow Depth >   3.89"    for  10-Year event
Inflow      =       13.88 cfs @   12.18 hrs,  Volume=          1.313 af
Outflow     =       12.49 cfs @   12.25 hrs,  Volume=          1.181 af,  Atten= 10%,  Lag= 4.2 min
Discarded   =        0.02 cfs @   12.25 hrs,  Volume=          0.027 af
Primary     =       12.48 cfs @   12.25 hrs,  Volume=          1.154 af
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.30' @ 12.25 hrs Surf.Area= 8,854 sf Storage= 10,554 cf

Plug-Flow detention time= 85.1 min calculated for 1.181 af (90% of inflow)
Center-of-Mass det. time= 36.9 min (826.5 - 789.5)

Volume	Invert	Avail.Storage	Storage Description
#1	12.00'	14,203 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
12.00	7,420	356.0	0	0	7,420
12.70	8,181	369.0	5,458	5,458	8,212
13.00	8,517	375.0	2,505	7,963	8,584
13.70	9,318	388.0	6,240	14,203	9,417

Device	Routing	Invert	Outlet Devices
#1	Primary	12.70'	**10.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Discarded	12.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.02 cfs @ 12.25 hrs HW=13.30' (Free Discharge)
└─**2=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=12.48 cfs @ 12.25 hrs HW=13.30' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 12.48 cfs @ 2.09 fps)

Summary for Link DP1: DP1

Inflow Area = 8.911 ac, 31.31% Impervious, Inflow Depth > 3.05" for 10-Year event
Inflow = 22.99 cfs @ 12.20 hrs, Volume= 2.267 af
Primary = 22.99 cfs @ 12.20 hrs, Volume= 2.267 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

100-Year Storm Event – Proposed

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentPR1: PR1 Runoff Area=3.025 ac 1.72% Impervious Runoff Depth>4.68"
Flow Length=461' Tc=12.8 min CN=80 Runoff=13.18 cfs 1.181 af

SubcatchmentPR2: PR2 Runoff Area=4.053 ac 65.28% Impervious Runoff Depth>6.04"
Flow Length=670' Tc=13.3 min CN=92 Runoff=21.07 cfs 2.041 af

SubcatchmentPR3: PR3 Runoff Area=1.833 ac 5.02% Impervious Runoff Depth>4.80"
Flow Length=208' Tc=5.6 min CN=81 Runoff=10.06 cfs 0.733 af

Pond 1P: Bioretention Peak Elev=13.50' Storage=12,328 cf Inflow=21.07 cfs 2.041 af
Discarded=0.02 cfs 0.029 af Primary=19.04 cfs 1.878 af Outflow=19.06 cfs 1.907 af

Link DP1: DP1 Inflow=37.13 cfs 3.793 af
Primary=37.13 cfs 3.793 af

Total Runoff Area = 8.911 ac Runoff Volume = 3.956 af Average Runoff Depth = 5.33"
68.69% Pervious = 6.121 ac 31.31% Impervious = 2.790 ac

Summary for Subcatchment PR1: PR1

Runoff = 13.18 cfs @ 12.17 hrs, Volume= 1.181 af, Depth> 4.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.052	98	Paved parking, HSG D
2.973	80	>75% Grass cover, Good, HSG D
3.025	80	Weighted Average
2.973		98.28% Pervious Area
0.052		1.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	50	0.0140	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
1.6	119	0.0327	1.27		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	134	0.0075	0.61		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.1	158	0.1266	2.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
12.8	461	Total			

Summary for Subcatchment PR2: PR2

Runoff = 21.07 cfs @ 12.18 hrs, Volume= 2.041 af, Depth> 6.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
2.527	98	Paved parking, HSG D
1.407	80	>75% Grass cover, Good, HSG D
0.119	98	Water Surface, HSG D
4.053	92	Weighted Average
1.407		34.72% Pervious Area
2.646		65.28% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.0160	0.14		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
0.9	55	0.0236	1.08		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.1	80	0.0063	1.19		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
1.0	91	0.0109	1.57		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.3	31	0.0129	1.70		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.7	64	0.0094	1.45		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.3	299	0.0100	1.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
13.3	670	Total			

Summary for Subcatchment PR3: PR3

[49] Hint: Tc<2dt may require smaller dt

Runoff = 10.06 cfs @ 12.08 hrs, Volume= 0.733 af, Depth> 4.80"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (ac)	CN	Description
0.092	98	Paved roads w/curbs & sewers, HSG D
1.741	80	>75% Grass cover, Good, HSG D
1.833	81	Weighted Average
1.741		94.98% Pervious Area
0.092		5.02% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.2	50	0.0800	0.26		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.32"
2.4	158	0.0253	1.11		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.6	208	Total			

Summary for Pond 1P: Bioretention

Inflow Area = 4.053 ac, 65.28% Impervious, Inflow Depth > 6.04" for 100-Year event
Inflow = 21.07 cfs @ 12.18 hrs, Volume= 2.041 af
Outflow = 19.06 cfs @ 12.24 hrs, Volume= 1.907 af, Atten= 10%, Lag= 4.1 min
Discarded = 0.02 cfs @ 12.24 hrs, Volume= 0.029 af
Primary = 19.04 cfs @ 12.24 hrs, Volume= 1.878 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 13.50' @ 12.24 hrs Surf.Area= 9,081 sf Storage= 12,328 cf

Plug-Flow detention time= 65.8 min calculated for 1.903 af (93% of inflow)
Center-of-Mass det. time= 31.1 min (809.4 - 778.3)

Volume	Invert	Avail.Storage	Storage Description
#1	12.00'	14,203 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
12.00	7,420	356.0	0	0	7,420
12.70	8,181	369.0	5,458	5,458	8,212
13.00	8,517	375.0	2,505	7,963	8,584
13.70	9,318	388.0	6,240	14,203	9,417

Device	Routing	Invert	Outlet Devices
#1	Primary	12.70'	**10.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83
#2	Discarded	12.00'	**0.090 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.02 cfs @ 12.24 hrs HW=13.49' (Free Discharge)
↰**2=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=18.97 cfs @ 12.24 hrs HW=13.49' (Free Discharge)
↰**1=Broad-Crested Rectangular Weir** (Weir Controls 18.97 cfs @ 2.39 fps)

Summary for Link DP1: DP1

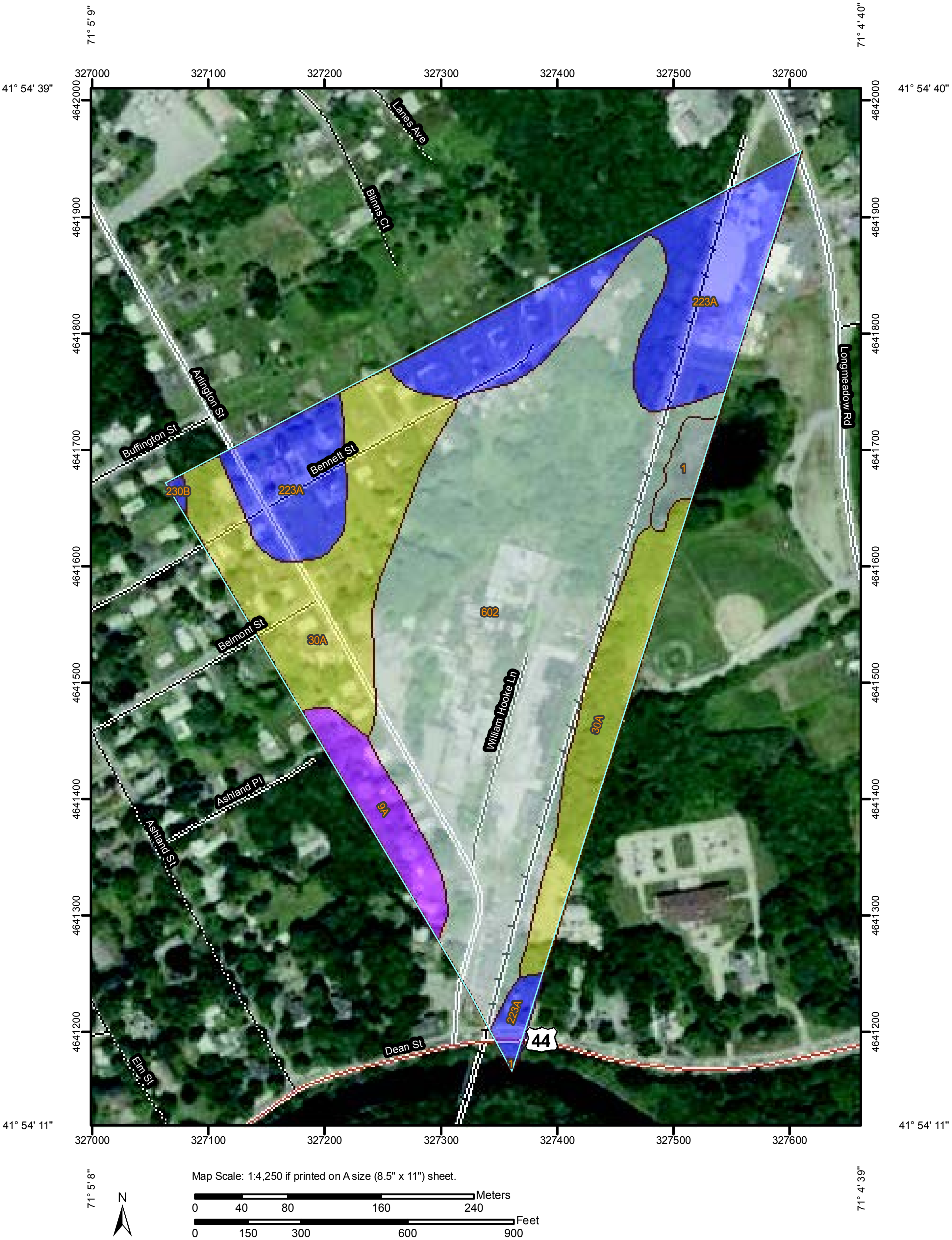
Inflow Area = 8.911 ac, 31.31% Impervious, Inflow Depth > 5.11" for 100-Year event
Inflow = 37.13 cfs @ 12.19 hrs, Volume= 3.793 af
Primary = 37.13 cfs @ 12.19 hrs, Volume= 3.793 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Appendix C
Standard 3 Computations and Supporting Information

Soil Evaluation and Analysis

Hydrologic Soil Group—Bristol County, Massachusetts, Northern Part



MAP LEGEND

Area of Interest (AOI)

☐ Area of Interest (AOI)

Soils

☐ Soil Map Units

Soil Ratings

■ A

■ A/D

■ B

■ B/D

■ C

■ C/D

■ D

■ Not rated or not available

Political Features

● Cities

Water Features

∿ Streams and Canals

Transportation

┼ Rails

∿ Interstate Highways

∿ US Routes

∿ Major Roads

∿ Local Roads

MAP INFORMATION

Map Scale: 1:4,250 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bristol County, Massachusetts, Northern Part
Survey Area Data: Version 5, Jul 27, 2010

Date(s) aerial images were photographed: 7/10/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Northern Part (MA602)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
1	Water		0.6	1.4%
9A	Birdsall silt loam, 0 to 3 percent slopes	D	1.7	3.8%
30A	Raynham silt loam, 0 to 3 percent slopes	C	10.2	22.9%
223A	Scio silt loam, 0 to 3 percent slopes	B	9.5	21.4%
230B	Unadilla very fine sandy loam, 3 to 8 percent slopes	B	0.1	0.2%
602	Urban land		22.3	50.3%
Totals for Area of Interest			**44.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Required and Provided Recharge Volumes

Recharge Calculations

Project Name: Taunton Station **Proj. No.:** 10111.00
Project Location: Taunton, MA **Date:** 21-May-2012
Calculated by: DAG
Checked by: EJM

Proposed Impervious Surface Summary

Net Proposed Impervious Areas by Hydrologic Soil Group (HSG) in acres

Subcatchment	HSG A	HSG B	HSG C	HSG D	Total Area
1	0.0	0.0	0.0	0.1	0.1
2	0.0	0.0	0.0	2.5	2.5
3	0.0	0.0	0.0	0.1	0.1
TOTAL	**0.0**	**0.0**	**0.0**	**2.7**	**2.7**

Required Recharge Volume (Cubic Feet)

HSG	Area (acres)	Recharge Depth * (in.)	Volume (c.f.)
A	0.0	0.60	0
B	0.0	0.35	0
C	0.0	0.25	0
D	2.7	0.10	970
TOTAL			**970**

* Per 2008 Massachusetts DEP Recharge Requirement

Provided Recharge Volume (Cubic Feet)

Infiltration Volumes Provided in Infiltration Basins (below lowest overflow outlet)

Basin 1	1,263	
Total	**1,263**	c.f.

\\mabosdata\PROJECTS\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Taunton Dean\Appendices\Appendix C_Standard 3 Support\Recharge Requirement.xls

72-hour Drawdown Analysis

Drawdown Calculations

Project Name:	Taunton Station	**Proj. No.:**	10111.00
		Date:	5/18/2012
Project Location:	Taunton, MA	**Calculated by:**	PAC
		Check by:	EJM

Bioretention Basin - 1

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
12.00	7,420	0
12.70	8,181	5,460
TOTAL		**5,460**

Assumptions:

Recharge Rate: 1.00 in/hr* * Bioretention Basin Soil Media Infiltration Rate

Drawdown Time: 8.8 hours

Appendix D
Standard 4 Computations and Supporting Information

Water Quality Volume Calculations

Water Quality Volume Calculations

Project Name: Taunton Station **Proj. No.:** 10111.00
Project Location: Taunton, MA **Date:** 4/24/2012
Calculated by: DAG

Bioretention Basin 1P
(runoff from Area PR 2)

Total Impervious Area = 2.79 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	1,013
Water Quality Volume	0.5	5,064

Provided:

	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
Bioretention Basin 1 P			
	12.0	7,420	0
	12.7	8,181	5,460

TSS Removal Worksheets

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Taunton Station**
Project Number: **10111.00**
Location: **Taunton, MA**
Discharge Point: **1**
Drainage Area(s): **1**

Sheet: **1 of 1**
Date: **24-Apr-2012**
Computed by: **DAG**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area with Grass Swale or sediment forebay Pretreatment	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol.
** Equals remaining load from previous BMP (E)

Treatment Train TSS Removal = **90%**

Appendix E
Geotechnical Report

JACOBS
343 Congress Street
Boston, MA 02210

Design Memorandum

Date	February 17, 2012
To	Rick Carey, Natasha Velickovic - VHB
From	Paul Murphy, Da Ha, Peter Chou - Jacobs
Subject	MBTA South Coast Rail (New Bedford/Fall River Commuter Rail Extension) Taunton Station Geotechnical Design Memorandum Taunton, MA
Project No.	E2347101

INTRODUCTION

The South Coast Rail project will restore passenger rail transportation from South Station in Boston to the cities of Fall River and New Bedford along an existing rail freight corridor running south from Taunton to Fall River and New Bedford. The project will include the construction of several existing and new passenger stations and two terminal layover facilities. This geotechnical design memorandum presents the foundation design considerations for the new station platform at the proposed Taunton Station in Taunton, Massachusetts. The design recommendations presented in this report are based on the results of subsurface investigation performed by Jacobs in 2010.

Existing Conditions

The proposed Taunton Station, located off Arlington Street, is an approximately 3.8 acre site to the east of downtown Taunton (Figure 1). The site is a formerly developed parcel now containing vacant buildings and other derelict areas as a result of fire. Existing grades at the platform location range from approximately elevations 16 to 19 feet (NGVD29 Datum), generally sloping downward from north to south. A 20-inch diameter water main pipe is located along the proposed platform alignment and will need to be relocated. The remains of the buildings and their foundations will also have to be removed.

Proposed Construction

Current station plans are to construct an 800 foot long, 12 foot wide high level platform adjacent to the existing tracks, a new parking area and a new drop-off area. In addition, some track relocation is required. Access to the platform will be from a ramp/stair structure along the west side of the planned platform. Two 50-ft long platform canopies are also planned. The details of new track layout (including grading), associated sidewalks, ramps of the proposed station are still under development at the time of this report preparation. However, we anticipate that about 3 to 5 feet of fill will be placed at the site to raise the grade at the track level and platform area. This report focuses on the geotechnical design and recommendation for the platform only.

SCOPE OF WORK

This memorandum was prepared by Jacobs in accordance with the scope of work under the contract between Jacobs and VHB for work on the New Bedford/Fall River Commuter Rail Line Extension Project for Massachusetts Bay Transportation Authority (MBTA). The geotechnical work included the following tasks:

- Perform a geotechnical exploration and laboratory testing program;
- Report and interpret the results of the exploration and laboratory testing program; and
- Provide geotechnical recommendations for design and construction of the platform foundations.

The Jacobs scope of work did not include environmental assessment of the potential presence of any hazardous materials at the project site. However, please note that potential contamination was observed in borings TS-5 (samples S2 and S3) from a depth of about 3 to 10 feet and TS-19 (samples S2 and S3) from a depth of about 3 to 10 feet (refer to boring logs in Appendix A).

LOCAL GEOLOGY

The site is located in the Narragansett Basin of southeastern Massachusetts. The rocks in the Narragansett Basin consist mostly of lightly metamorphosed shale and sandstone of Pennsylvanian and Permian age. The Taunton Station is located in the area of the Rhode Island Formation. The rocks encountered in the borings included coarse, weathered sandstone, dark gray shale, and dark gray siltstone. The weathered sandstone was sampled by Standard Penetration Tests with high blow counts. The shale and siltstone were cored but only partially recovered due to weathered seams. The rock contains joints oriented parallel to bedding, which typically dipped about 30 degrees. Based on the borings, the top of rock is likely to be between elevation -12 feet and elevation -30 feet over the site.

GEOTECHNICAL EXPLORATIONS

Jacobs planned the subsurface exploration program and retained the drilling contractor to perform the exploration. The geotechnical data report was submitted in 2010. Five borings (TS-1 to TS-5) were conducted along the proposed station platform and fourteen borings (TS-7, TS-9, TS-11, TS-13, TS-15, TS-17, and TS-19 to TS-26) were drilled in the general vicinity of the proposed parking lot and the access roads. Boring locations are shown on the Subsurface Exploration Plan (Figure 2).

The borings were drilled by New Hampshire Boring using either a CME-550 or D-50 ATV mounted drill rig, or a CME-75 truck mounted drill rig. The borings were advanced through the soil by wash boring methods using a 4-inch casing and roller bit with water. Standard penetration tests (SPT), consisting of a 140-pound hammer dropping 30 inches on a standard 2-inch-diameter (OD) split-spoon sampler, were performed with a safety hammer or an automatic hammer to establish the consistency of the subsurface soils. The SPT's were typically performed at five foot intervals of depth. The obtained samples were sealed in glass jars to retain their natural moisture. Bedrock was encountered and cored in some of the borings around the proposed platform area.

The borings were observed by a representative from Jacobs. The soil samples were classified in the field in accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) by Jacobs' representative, and appropriate stratum breaks were interpolated from drilling and sampling observations. The boring logs were prepared by Jacobs based on the field classifications and laboratory testing, and are presented in Appendix A.

LABORATORY TESTING

The results of the laboratory testing were previously submitted to VHB in report entitled "South Coast Rail, Jacobs Geotechnical Data Report", dated November 2010.

Grain size distribution analyses were performed to evaluate the gradation of the natural granular soils for potential reuse as backfill, if needed, and to classify the soils. The graduation analyses are summarized in Table 1 below and are presented in Appendix B.

Table 1: Laboratory Soil Classification Summary

BORING NO.	SAMPLE NO.	ELEVATION (FEET)	USCS SOIL CLASSIFICATION	W (%)	ATTERBERG LIMITS		GRAVEL (%)	SAND (%)	FINES (%)	ORGANIC CONTENT (%)
					LL	PI				
TS-2	S3	9.0	Clay (CL)	32	NT	NT	NT	NT	NT	NT
	S4	4.0	Silt (ML)	37	26	4	0	1.1	98.9	NT
TS-3	S3	8.0	Clay (CL)	38	NT	NT	NT	NT	NT	NT
TS-7	S3	8.0	Clay (CL)	37	32	11	0	6.1	93.9	NT
	S4	3.0	Clay (CL)	33	NT	NT	NT	NT	NT	NT
TS-11	S2	14.0	Silt (ML)	26	NT	NT	NT	NT	NT	7.8
TS-20	S3	6.0	Silt (ML)	41	33	9	0	5.6	94.4	NT
TS-24	S3	6.0	Clay (CL)	32	NT	NT	NT	NT	NT	NT

Where: w = natural moisture content, LL = Liquid Limit, PI = Plasticity Index, NT = Not Tested

SUBSURFACE CONDITIONS

The subsurface conditions at the site were inferred from the boring data collected for the South Coast Rail project, with some interpretations. The subsurface conditions encountered at the station platform generally consist of a layer of granular fill of up to 4-feet thickness, underlain by an intermittent sand layer, and a clayey silt layer with thickness ranging from about 20 feet to 30 feet overlying glacial till and weathered bedrock. A 5 to 10 feet thick lean clay layer was encountered within the clayey silt layer in borings TS-2 and TS-3. Weathered bedrock was encountered at a depth of about 28 to 38 feet in the platform area, corresponding to approximately elevations -12 to -21 feet.

Fill materials with thicknesses varying from 0.3 to 7 feet were also encountered in the vicinity of the proposed parking lot area. Bedrock was not encountered in this area due to shallow boring depths.

Subsurface soil conditions are summarized in Table 2 and discussed below.

Table 2: Summary of Subsurface Conditions at Borings

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Platform Borings							
TS-1	19.0	3	16.0	-18.0	-26.0	11.0	
TS-2	18.0	4	14.0	NE	-9.5	NE	
TS-3	17.0	4	13.0	-21.0	-23.0	14.0	
TS-4	16.0	4	12.0	-12.0	-32.5	5.0	
TS-5 OW	16.0	4	12.0	-21.0	-27.0	5.0	Potential Contamination encountered, Well screened from 33 to 43 ft
BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Site Borings							
TS-7	16.0	3	13.0	NE	1.0	13.0	
TS-9	18.0	3	15.0	NE	3.0	15.0	
TS-11	17.0	3	14.0	NE	2.0	NE	
TS-13	17.0	3	14.0	NE	2.0	13.0	
TS-15	15.0	7	8.0	NE	0.0	NE	
TS-17	13.0	0.3 (Concrete Slab)	12.7	NE	-2.0	13.0	
TS-19	14.0	3	11.0	NE	-1.0	NE	Potential Contamination encountered
TS-20 OW	14.0	1	13.0	NE	-11.0	12.0	Well screened from 15 to 20 ft
TS-21	15.0	3	12.0	NE	-10.0	12.0	
TS-22	14.0	3	11.0	NE	-11.0	NE	
TS-23	13.0	4	9.0	NE	-12.0	12.0	
TS-24	14.0	0.3 (Asphalt Concrete)	13.7	NE	-11.0	10.0	
TS-25	14.0	0.3 (Concrete Slab)	13.7	NE	-11.0	12.0	Boring offset ~8 ft SE
TS-26	14.0	1	13.0	NE	-11.0	12.0	Boring offset ~10 ft E

NE: Not encountered at the boring during drilling.

Soil conditions in the platform area generally consisted of the following:

Fill: The fill layer typically consists of mostly granular, loose to medium dense sand with up to about 15% silt and 15% gravel. The fill layer is generally about 3 to 4 feet thick in the area of the platform.

Sand: Below the fill, an intermittent sand layer consisting of predominantly fine sand with up to about 40% silt was encountered. These deposits are medium dense with Standard Penetration Test (SPT) N-values ranging between 11 and 23 blows per foot (bpf).

Clayey Silt: The clayey silt layer generally consists of silt with up to about 20% clay. This layer is typically soft to very stiff with SPT N-value ranging between 2 and 26 bpf.

An approximately 5 to 10 feet thick medium stiff to stiff lean clay layer was encountered in borings TS-2 and TS-3 from about 8 to 19 feet below ground surface, corresponding to elevations 10 to -2 feet.

Glacial Till: A thin layer of medium dense to dense glacial till was encountered in borings TS-3 and TS-5 overlying weathered bedrock.

Weathered Bedrock: Weathered bedrock was encountered in the platform area at depth of about 28 to 38 feet below existing ground surface, corresponding to approximately elevations -12 to -21 feet. The bedrock was generally weathered shale or slightly weathered soft siltstone.

Groundwater: Groundwater levels were measured in the test borings using a weighted tape during and at completion of drilling. The data indicated the groundwater level ranged from approximate elevations 16 to 19 feet along the platform alignment, and from elevations 13 to 18 feet in the general area of the proposed parking lot. The use of wash boring techniques for all soil borings may have artificially increased the water level readings due to the addition of water to the borings. Trapped/perched water is also commonly seen at a higher elevation within existing fill and silty materials. The longer term water level readings taken at Boring TS–05 OW on July 7, 2010 and September 12, 2011 indicated the water at a depth of about 22.5 feet (Elevation -6.5 feet) and 11.3 feet (Elevation 4.7 feet). The longer term water level readings taken at Boring TS–20 OW on July 7, 2010 and September 12, 2011 indicated the water at a depth of about 5.5 feet (Elevation 8.5 feet) and 2.0 feet (Elevation 12.0 feet). Based upon these short-term observations and readings from the observation wells, it is anticipated that the groundwater could be at approximately elevation 10 to 12 feet at the site.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. Local and periodic variations of ground water elevations may also be influenced by local subsurface drainage, leaking water or sewer pipes, and precipitation.

GEOTECHNICAL RECOMMENDATIONS

Based on our review of available subsurface conditions, the proposed station platforms can be supported on shallow spread footings bearing directly on competent natural soil or structural fill placed above suitable natural soils. Platform and canopy design loads were not available at the time of this report preparation. However, it is anticipated that the station platform will be lightly (axially) loaded with limited horizontal forces from wind and seismic loads.

The following paragraphs provide project specific geotechnical recommendations for foundation soil preparation, structural fill/backfill placement, and design and construction of platform foundations.

Platform Foundations

Spread footings are recommended for the platform foundations, bearing on compacted structural fill or natural granular deposits. The bottom of footing elevation should be at least 4 feet below final grades for frost protection. Due to proposed site filling, bottom of footing is anticipated to be at approximately elevations 16 to 18 feet. The existing fill is not suitable for support of the spread footings and should be removed within the zone of influence of the footings, defined by a line extending one foot horizontally from the bottom edge of footing and then down and away at a 1H:1V slope until natural soils are encountered.

The recommended allowable design bearing capacity for spread footings bearing on at least medium dense structural fill or natural sandy soil is 3 ksf, provided that subgrades are prepared as described herein. This provides an adequate factor of safety against bearing failure and limits the total estimated settlement to about 1.5 inches due to consolidation of the underlying clayey silt layer and the differential settlement to about 3/4 inch. It is recommended that footings should be at least 7 feet wide to limit bearing pressure and settlement impacts. Due to site filling to raise the track grade, we anticipate the track and platform will settle similarly over time. However, if these estimated settlements are not acceptable, alternative means of supporting the platform, such as drilled minipiles, can be developed.

The structural fill material, if needed, should be free from organics and other deleterious substances and should conform to the requirements listed in the MBTA Standard Specification Section 02200 - Earthwork for Type B Gravel Borrow. The structural fill should be compacted to 95% of the maximum dry density as determined by the Modified Proctor compaction test (ASTM D1557).

All temporary open cuts required for footing construction should be in accordance with the related OSHA regulations and should have side slopes of no steeper than 1.5H:1V.

Seismic Consideration

The seismic design should comply with the requirements of the most current Massachusetts State Building Code 780 CMR and other relevant project design codes such as AREMA and AASHTO. Modification of the peak acceleration by the soils overlying bedrock depends upon the type of soil at the site. For the subsurface conditions encountered, the station site is classified as Seismic Site Class D soil profile in accordance with 780 CMR Chapter 1614.0 Section 9.4 Site Ground Motion. The structure could be designed for the total lateral seismic force using the equations specified in the code, or by the response spectrum method using the design spectra presented in the code. The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods (Ss) and at 1-sec (S_1) obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4.

For Site Class D Soils at the location of this station:

$S_{MS} = 0.384$ and $S_{M1} = 0.149$

$S_{DS} = 0.256$ and $S_{D1} = 0.099$

where:

- S_{MS} is the maximum consider earthquake spectral response acceleration for short periods adjusted for site class
- S_{M1} is the maximum consider earthquake spectral response acceleration at 1-sec adjusted for site class
- S_{DS} is the design earthquake spectral response acceleration for short periods adjusted for site class
- S_{D1} is the design earthquake spectral response acceleration at 1-sec adjusted for site class

The building code also requires that the soil be evaluated for the following potential hazards: slope instability, soil liquefaction, or surface rupture due to faulting or lateral spreading. The proposed grading is relatively flat and we are not aware of any pre-existing slope instability in this area. The existing overburden soils do not appear to be subject to surface rupture due to faulting or lateral spreading.

Liquefaction

Based on the observed subsurface conditions, recorded water levels, percentage of fine contents and sample relative densities the existing soils underlying the site are judged not susceptible to liquefaction.

CONSTRUCTION CONSIDERATIONS

Foundation Installation - Spread Footings

The existing fill, as well as any former building foundations should be stripped off and removed from within the zone of influence of the platform and any walkway areas down to natural soil deposits using a smooth edge excavation bucket, and replaced by compacted granular soils.

Following excavation to the top of the natural soil deposits, the exposed surface should be observed by an on-site representative of the project geotechnical engineer and be proof-compacted with at least 10 passes of a large vibratory drum roller. Any yielding areas should be observed by geotechnical personnel to assess if localized undercutting is necessary. Footing subgrade observations should include hand auger probes by the geotechnical personnel to check for soft/weak zones. The need for undercutting and backfilling with structural fill should be closely evaluated in the field based on encountered conditions.

In areas where seepage is encountered within footing excavations, the need for placing a 3” thick lean concrete mud mat or a layer of ¾-inch crushed stone to protect the bearing surface should be evaluated in the field. Crushed stone thicker than 4 inches shall be wrapped by non-woven filter fabric.

Following observation of the bearing soils by geotechnical personnel, reinforcing steel and concrete can be placed in the excavation. It is recommended that footing reinforcing steel and concrete be placed the same day as the footing excavation is made, where possible, to avoid significant moisture content changes in the bearing soils. No water should be allowed to pond within excavations and drainage should be maintained away from foundations both during and after construction. The footing excavation should be free of loose debris at the time of footing concrete placement.

Subgrade Preparation

Prior to performing any required grading operations and excavations in the proposed structure footprints, walkway and paved areas, these areas should be stripped of topsoil, vegetation, fill, organic silt, former building foundations and existing pavement, if present. The topsoil should be placed in a designated area for reuse during final grading. Following site clearing and stripping, the exposed subgrade should be proof compacted with 10 passes of a large vibratory drum roller (minimum 10,000 pound static weight). Any pockets of excessively soft, wet or disturbed soil or unsuitable soils should be removed and replaced with properly compacted fill materials. Where subgrade soils are close to the existing groundwater level or where silty subgrade soils are encountered, proof-compaction using non-vibratory methods may be considered by the geotechnical engineer.

If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches but not exceeding eighteen inches, aerated, re-compacted, and retested to provide uniform compaction. Following satisfactory compaction of the subgrade, controlled compacted fill material should be placed to bring the site to the required grade.

Fill should not be placed over frozen soil. Soil subgrades should be protected against frost both during and after construction.

Proper drainage of construction areas should be provided to protect the subgrades from the detrimental effects of weather conditions. Excavations should be made with as few passes of the backhoe bucket as possible to reduce disturbance of the subgrade. A backhoe bucket fitted with a smooth blade should be used during the final subgrade preparation, where necessary. The exposed base should be kept free of standing water at all times. The site should be graded to carry any surface runoff away from the work areas. Construction traffic should be controlled to prevent excessive stresses and disturbance to the subgrade.

If pavements are not constructed immediately after grading, the subgrade should be shaped so as to prevent ponding. If there is a substantial lapse in time between grading and paving, or if the subgrade is disturbed, it should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during proof-rolling or initial construction should be removed and replaced with compacted granular fill.

Within the proposed paved areas, and extending a distance of five feet beyond the edge on all sides, excavate existing granular fill soils to a depth of two feet below existing site grades. It may be possible to reuse the existing granular fill, depending on the suitability of the material, as described herein.

Fill Placement and Compaction

Fill materials most likely will be obtained by importing granular fill materials from off-site borrow sources. However, it may be possible to reuse existing site granular fill material provided that it can be properly placed and compacted. The gradation shall be in accordance with MBTA Standard Specification Section 02200-Earthwork for Type B Gravel Borrow.

All structural fill should be free of organics, demolition debris or other deleterious substances. The fill material should have a plasticity index (PI) less than 4 and a liquid limit (LL) less than 10, and contain fragments less than 4 inches in maximum dimension. Each lift should be compacted to the specified density prior to placing any subsequent lift. All materials to be used as structural fill should be tested in the laboratory to determine their project suitability and compaction characteristics.

The fill should be systematically compacted to the following percentages of the maximum dry density:

Table 3: Fill Compaction Requirements

DESCRIPTION	MINIMUM PERCENT COMPACTION (ASTM D-1557)
General Site Fills, Structural Fill (Below Footings and Slabs)	95
Behind Retaining Walls	92
Landscape Area	90

Soils which exhibit a well-defined moisture content–dry density relationship should be compacted to within plus or minus two percentage points of the optimum moisture content as determined by the Modified Proctor test (ASTM D-1557).

Where fill materials are placed against an existing embankment slope, the slope should be benched as the fill is brought up in layers. Benching should be of a sufficient width to permit placing and compaction of fill material upon the existing embankment materials. Typically, benches are between four to eight feet wide. Each bench cut should begin at the intersection of the existing embankment and the vertical side of the previous bench. Trench backfills over pipelines or utility structures should be performed so as not to adversely impact the underlying utilities. In fill areas, the backfill material, compaction method, and degree of compaction requirements should be similar to that for the fill adjacent to the trench.

Construction Dewatering

All excavations should be performed in the dry condition. Discharge of pumped water should be performed in accordance with all federal, state and/or local regulations which may require a discharge permit and possible filtration and chemical testing of the water prior to discharge.

Permanent Slopes

Permanent slopes with loamed and seeded surfaces should not be steeper than 2-1/2 horizontal to 1 vertical (2-1/2H:1V) without slope protection to limit erosion and surficial sloughing of the slope. Additional analyses may be required to assess the stability of slopes steeper than 2-1/2H:1V as the station design is finalized.

Excavation Slopes and Shoring

The slopes of temporary open cuts should be no steeper than 1-1/2H:1V. Open cuts should not be used below the water table because of the likelihood of soil sloughing into the excavation.

The temporary excavation support system, if needed, should be selected by the Contractor and designed by an experienced Professional Engineer registered in the Commonwealth of Massachusetts and retained by the Contractor. Where excavation sides can be sloped back, they should be performed in accordance with the Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

Protection of Existing Facilities

It is recommended that a geotechnical instrumentation and monitoring program be performed during construction of the project to evaluate impacts on adjacent structures. It is recommended that the program be developed to provide data for the following considerations:

- To monitor ground movements and vibration levels during construction.
- To provide early warning of potentially adverse trends by presenting sufficient data to determine the source of unanticipated ground movements, if present.
- If necessary, to plan remedial measures to limit damage to embankments and structures and to provide early warning when alternative means of protection are necessary.
- To document impacts of construction on adjacent facilities.
- To evaluate the performance and structural integrity of the constructed facilities.

We recommend the following instrumentation program to measure:

- Ground surface settlement and lateral movement adjacent to proposed construction.
- Horizontal and vertical movement of any excavation support system, and existing structures.
- Vibrations as a result of construction activities.

Vertical and horizontal survey points should be established on the adjacent structures. The monitoring points should be surveyed prior to the start of construction and monitored during construction to detect movement.

Vibration monitoring shall be conducted within 100 feet of existing structures during construction activities.

We recommend conducting a pre-construction survey of structures and utilities within 100 feet of the site to document existing conditions prior to construction. Documentation should include photographs, video, sketches, and/or written comments.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

CLOSING

This report and the recommendations contained herein have been prepared for the exclusive use of MBTA and VHB and their representatives for specific application to the design and construction of the proposed Taunton Station in Taunton, Massachusetts.

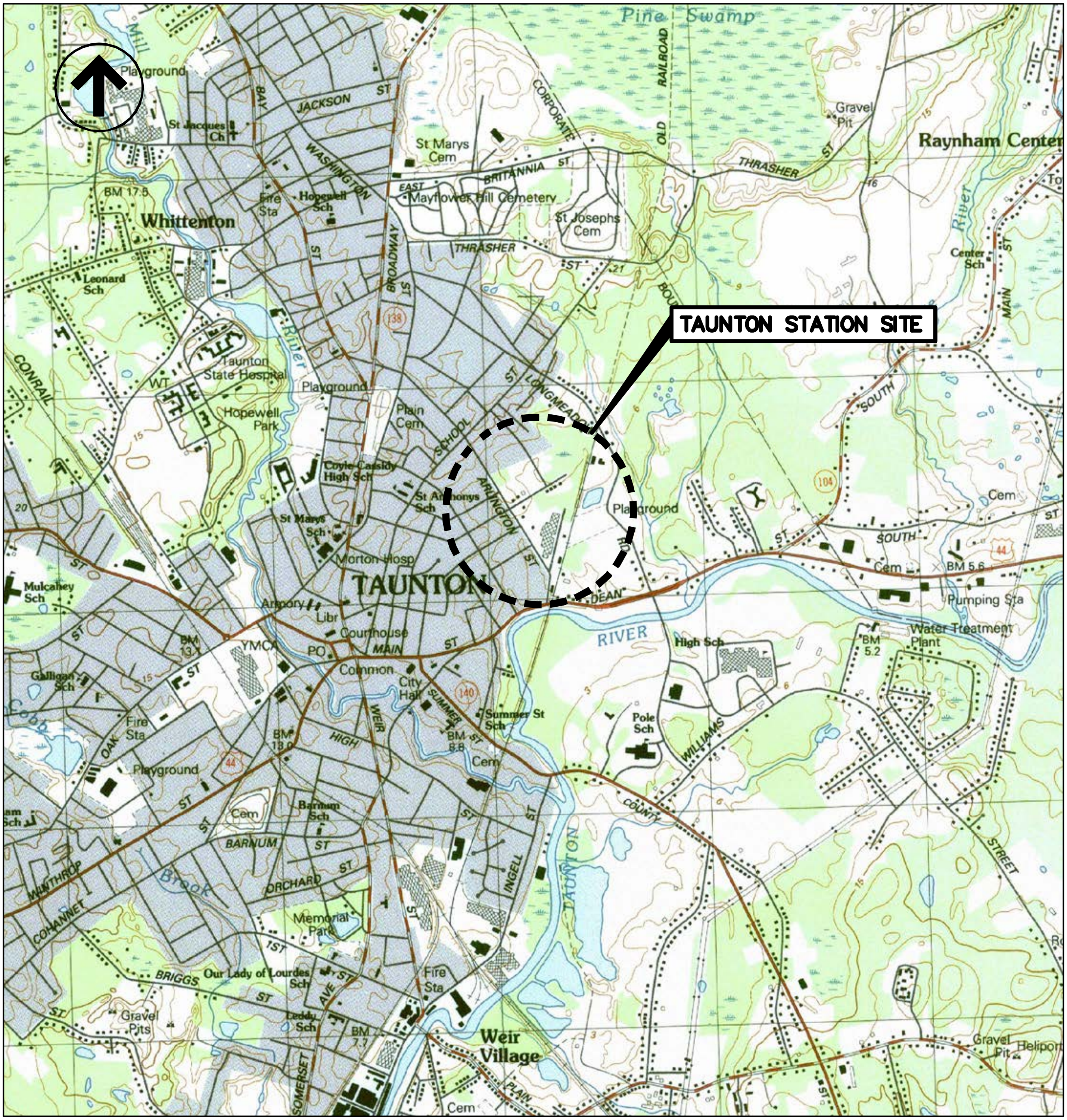
This report was prepared in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations then appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

ATTACHMENTS

FIGURE 1 – SITE LOCATION PLAN
FIGURE 2 – SUBSURFACE EXPLORATION PLAN
FIGURE 3 – SUBSURFACE SOIL PROFILES
APPENDIX A – EXPLORATION LOGS
APPENDIX B – LABORATORY DATA
APPENDIX C – GEOTECHNICAL CALCULATIONS

F:\Proj\013471\600 Discipline Files\610 Studies and Reports\2011 GIR\Taunton Station\Taunton Station.doc

FIGURES



TAUNTON STATION

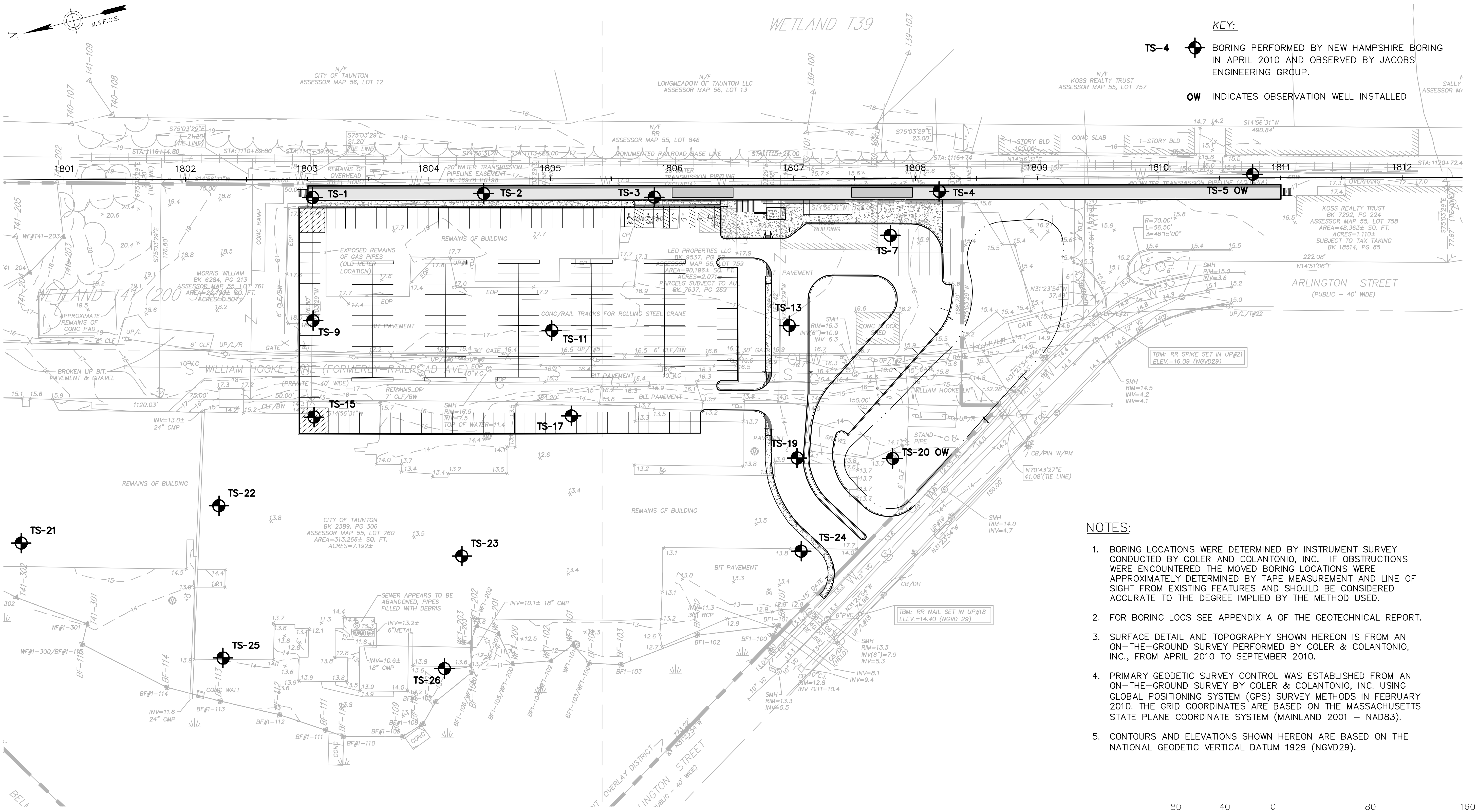
PROJECT LOCUS PLAN

NOT TO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

TAUNTON STATION
TAUNTON, MASSACHUSETTS
FIGURE 1



KEY:

TS-4 ⊕	BORING PERFORMED BY NEW HAMPSHIRE BORING IN APRIL 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
OW	INDICATES OBSERVATION WELL INSTALLED

NOTES:

1. BORING LOCATIONS WERE DETERMINED BY INSTRUMENT SURVEY CONDUCTED BY COLER AND COLANTONIO, INC. IF OBSTRUCTIONS WERE ENCOUNTERED THE MOVED BORING LOCATIONS WERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENT AND LINE OF SIGHT FROM EXISTING FEATURES AND SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.
2. FOR BORING LOGS SEE APPENDIX A OF THE GEOTECHNICAL REPORT.
3. SURFACE DETAIL AND TOPOGRAPHY SHOWN HEREON IS FROM AN ON-THE-GROUND SURVEY PERFORMED BY COLER & COLANTONIO, INC., FROM APRIL 2010 TO SEPTEMBER 2010.
4. PRIMARY GEODETIC SURVEY CONTROL WAS ESTABLISHED FROM AN ON-THE-GROUND SURVEY BY COLER & COLANTONIO, INC. USING GLOBAL POSITIONING SYSTEM (GPS) SURVEY METHODS IN FEBRUARY 2010. THE GRID COORDINATES ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (MAINLAND 2001 – NAD83).
5. CONTOURS AND ELEVATIONS SHOWN HEREON ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29).

80 40 0 80 160

SCALE: 1"=80'

TAUNTON STATION
BORING LOCATION PLAN
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_TauntonStation.dwg Feb 15, 2012

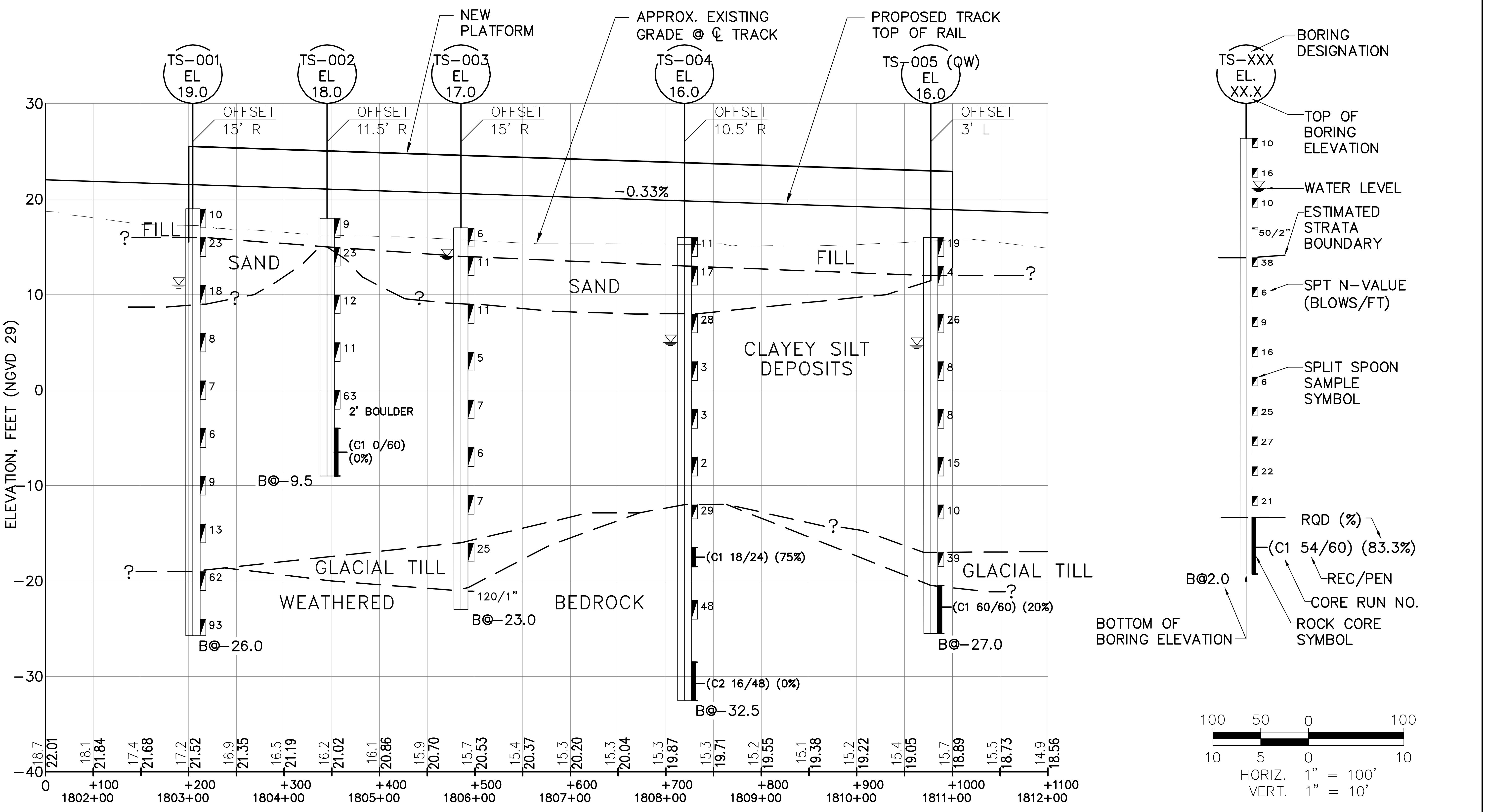
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

TAUNTON STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: FEBRUARY 2012

FIGURE NO: 2



MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS

343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

TAUNTON STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE PROFILE A-A

DATE: FEBRUARY 2012

FIGURE NO: 3

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Taunton-profile.dwg Feb 16, 2012

APPENDIX A: EXPLORATION LOGS

TS-001 TO TS-005
TS-007
TS-009
TS-011
TS-013
TS-015
TS-017
TS-019 TO TS-026

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 001
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION	19
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2791326
45	Terminated	4/19/2010	8	Upon Completion (Casing pulled)			E	770275
							DATE START	4/19/10
							DATE END	4/19/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		4 4 6 12	S1	0 - 2	15		WELL GRADED SAND (SW); fine to coarse sand, trace coarse gravel, some ash, black, dry, FILL.
						16.0	
5		2 10 13 15	S2	3 - 5	17		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, some non-plastic silt, gray, wet.
						13.0	
		6 8 10 4	S3	8 - 10	18		WELL GRADED SAND (SW); fine to coarse sand, orange/brown, wet, gray silt in tip of spoon.
10						9.5	
15		3 4 4 4	S4	13 - 15	24		SILT (ML); slightly plastic silt, little clay, gray, wet.
20		4 3 4 5	S5	18 - 20	20		SIMILAR TO S4.
25		2 3 3 2	S6	23 - 25	24		SILT (ML); slightly plastic silt, trace clay, dark gray, wet.
30		3 4 5 5	S7	28 - 30	20		SIMILAR TO S6.
35		7 7 6	S8	33 - 35	13		SIMILAR TO S6.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 001

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	TS - 001
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		9					
						-18.0	Hard drilling from 37 to 38 ft.
40		18 18 44 24	S9	38 - 40	5		WEATHERED ROCK; dary gray, some gray silt, wet.
45		23 48 45 100/3"	S10	43 - 45	6	-26.0	WEATHERED ROCK; dary gray, some coarse sand, little silt, wet.
							Bottom of Hole at 45'.
50							
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 001

LOG OF TEST BORING

JACOBS

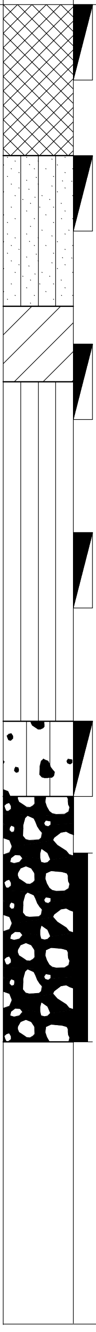
PROJECT	South Coast Rail	BORING NO.	TS - 002
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	T. Pentacost
				DRILL RIG	ATV D-50
				SPT HAMMER	140 lb Safety

ELEVATION	18
DATUM	NGVD 29
GRID COORD N	2791189
GRID COORD E	770243
DATE START	4/20/10
DATE END	4/20/10

METHOD OF DRILLING	
0	Wash Boring w/Casing
22.5	NX Rock Core
27.5	Terminated

GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		3 4 5 9	S1	0 - 2	11		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, little non-plastic silt, trace fine gravel, grayish brown, moist, FILL.
5		5 8 15 18	S2	4 - 6	16	14.0	SANDY SILT (ML); non-plastic silt, some fine sand, light brown, moist.
						10.0	
10		3 6 6 8	S3	9 - 11	12		(9 - 10') LEAN CLAY (CL); slightly plastic clay, little silt, stiff, light brown, moist.
						8.0	(10 - 11') LEAN CLAY (CL); slightly plastic clay, gray, wet.
15		4 5 6 5	S4	14 - 16	17		SILT (ML); slightly plastic silt, gray, wet, PP = 1.0 TSF.
20		40 31 32 58	S5	19 - 21	14	-1.0	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); mostly fine gravel up to 1", some fine to coarse sand, little silt, gray, wet, fractured rock in tip of spoon.
						-3.0	Boulder encountered at 21 ft, roller bit to 22.5 ft.
25			C1	22.5 - 27.5	0		NO RECOVERY; probable boulder, loss of drill water during last 1 ft of core.
						-9.5	Bottom of Hole at 27.5'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL BLOWS/FT	CONSISTENCY	NON-COHESIVE SOIL BLOWS/FT	DENSITY	RELATIVE PROPORTIONS OF SOIL COMPONENTS	
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 002

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail		BORING NO.	TS - 003
	LOCATION	Taunton, MA			
	OWNER	Mass.Bay Transportation Authority			
	JOB NUMBER	E2347101			SHEET 1 OF 2

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring			DRILLER	T. Pentacost	ELEVATION		17
METHOD OF DRILLING		GROUNDWATER READINGS				DRILL RIG	ATV D-50	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME		DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2791054
40	Terminated	4/20/2010		3	Upon Completion (Casing pulled)			COORD	E	770205
								DATE START		4/20/10
								DATE END		4/20/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 2 4 5	S1	0 - 2	11		WELL GRADED SAND (SW); fine to coarse sand, trace non-plastic silt, dark brown, moist, FILL.
5		7 5 6 7	S2	4 - 6	17	13.0	POORLY GRADED SAND (SP); mostly fine sand, gray, wet.
10		8 5 6 9	S3	9 - 11	18	8.0	LEAN CLAY (CL); moderately plastic clay, little silt, stiff, gray, wet, PP = 1.5 TSF.
15		3 2 3 4	S4	14 - 16	24		SIMILAR TO S3; medium stiff, PP = 1.25 TSF.
20		2 3 4 4	S5	19 - 21	24	-2.0	SILT (ML); slightly plastic silt, trace clay, medium stiff, gray, wet, PP = 1.0 TSF
25		2 3 3 4	S6	24 - 26	24		SIMILAR TO S5; PP = 0.5 TSF.
30		4 3 4 5	S7	29 - 31	24		SIMILAR TO S5; PP = 0.5 TSF.
35		6	S8	34 - 36	8	-17.0	SANDY SILT WITH GRAVEL (ML); slightly plastic silt, some fine to coarse sand,

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◪ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 003

LOG OF TEST BORING

JACOBS				
PROJECT	South Coast Rail	BORING NO.	TS - 003
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		8 17 12					little fine gravel, gray, wet, possible GLACIAL TILL.
		120/1"	S9	38 - 38.08	0	-21.0	NO RECOVERY; top of apparent bedrock at 38 ft, roller bit to 40 ft.
40						-23.0	Bottom of Hole at 40'.
45							
50							
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 003

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 004
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring	DRILLER	T. Pentacost	ELEVATION	16
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2790826
						GRID COORD E	770151
						DATE START	4/19/10
						DATE END	4/19/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
0	Wash Boring w/Casing	4/19/2010	11	Upon Completion (In Casing)
44.5	NX Rock Core			
48.5	Terminated			

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		7 6 5 5	S1	0 - 2	10		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, ash, black, dry, FILL.
5		4 8 9 13	S2	4 - 6	11	12.0	POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, some non-plastic silt, grayish-brown, wet.
10		12 17 11 12	S3	8 - 10	13	8.0	SILT (ML); slightly plastic silt, trace clay, grayish-brown, wet.
15		1 1 2 1	S4	13 - 15	15		SILT (ML); slightly plastic silt, trace clay, soft, gray, wet.
20		1 1 2 2	S5	18 - 20	21		SILT (ML); slightly plastic silt, trace clay, soft, dark gray, wet.
25		2 1 1 2	S6	23 - 25	14		SIMILAR TO S5; very soft.
30		4 15 14 100/0"	S7	28 - 29.5	10	-12.0	WEATHERED SHALE; some silt, dark gray, wet, possible bedrock, roller bit to 32.5 ft.
		RQD=75	C1	32.5 - 34.5	18		SHALE; joints spaced 5 - 13", slightly weathered, gray, broke through at 34.5 ft.
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 004

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	TS - 004
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	▤	16 20 28 100/5"	S8	38 - 40	14		WEATHERED SHALE; some silt, dark gray / black, possible weathered seam.
40	▤						
45	▤	RQD=0	C2	44.5 - 48.5	16		SHALE; dark gray.
						-32.5	
50							Bottom of Hole at 48.5'.
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ⊠ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 004

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 005 OW
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		16
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2790573
38	NX Rock Core	7/7/2010	22.5	Monitoring Well Reading			COORD	E	770100
43	Terminated	9/12/2011	11.3	Monitoring Well Reading			DATE START		4/22/10
							DATE END		4/22/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		9 13 6 5	S1	0.25 - 2.25	12	15.8	Top 3" Asphaltic Concrete. (.25 - 1') WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine gravel, brick fragments, moist, black, FILL. (1 - 2') POORLY GRADED SAND (SP); mostly fine sand, brown, moist, FILL.
		3 2 2 2	S2	3 - 5	9		(3 - 4') POORLY GRADED SAND (SP); mostly fine sand, brown, moist, FILL.
5						12.0	(4 - 5') SILT (ML); slightly plastic silt, dark brown, wet, moderate petroleum odor.
10		9 15 11 14	S3	8 - 10	16		(8 - 9') POORLY GRADED SAND (SP); mostly fine sand, gray, wet, moderate petroleum odor. (9 - 10') SILT (ML); slightly plastic silt, wet, grayish brown, moderate petroleum odor.
15		3 4 4 5	S4	13 - 15	20	3.0	SILT (ML); slightly plastic silt, trace clay, medium stiff, gray, wet, PP = 1.0 TSF.
20		3 4 4 6	S5	18 - 20	18		SIMILAR TO S4; PP = 0.75 TSF.
25		2 6 9 7	S6	23 - 25	16		SIMILAR TO S4; stiff.
30		4 5 5 6	S7	28 - 30	17		SIMILAR TO S4; stiff.
35		16 18 21	S8	33 - 35	8	-17.0	SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some slightly plastic silt, little fine to coarse gravel up to 1.5", gray, wet, GLACIAL TILL.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 005 OW

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 005 OW
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		17					
						-21.0	Top of apparent bedrock at ~37 ft.
40		RQD=20	C1	38 - 43	60		SILTSTONE; soft, joints spaced 0.5 - 6", joints angled at ~30 - 45 degrees from horizontal and generally parallel to folliation, thin bedding, slight weathering, gray.
						-27.0	Bottom of Hole at 43'.
45							
50							Notes: Observation well screened 33 - 43 ft. Contamination encountered between 3 and 10 ft. Petroleum-like odor, possible gasoline, sheen on drill water.
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 005 OW

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 007
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	16
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29

METHOD OF DRILLING		GROUNDWATER READINGS						
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2790874
15	Terminated	4/14/2010	3	Upon Completion (In Casing)			COORD E	770126
							DATE START	4/14/10
							DATE END	4/14/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		5 10 13 15	S1	0.33 - 2.33	12	15.7	Top 4" Asphaltic Concrete POORLY GRADED SAND (SP); mostly fine sand, trace fine gravel, brick fragments, black with light brown, FILL.
5		3 4 9 11	S2	3 - 5	16	13.0	SILT (ML); non-plastic silt, brown, moist.
10		3 5 5 5	S3	8 - 10	18	8.0	LEAN CLAY (CL); moderately plastic clay, little plastic silt, brownish gray, wet.
		6 7 4 4	S4	13 - 15	12		LEAN CLAY (CL); moderately plastic clay, little plastic silt, gray, wet.
15						1.0	Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 007

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 009	
LOCATION	Taunton, MA			
OWNER	Mass.Bay Transportation Authority			
JOB NUMBER	E2347101		SHEET 1 OF 1	

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	18
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft) / REMARKS	SPT HAMMER	140 lb Auto	GRID N	2791351
15	Terminated	4/14/2010	3 / Upon Completion (Casing pulled)			COORD E	770177
						DATE START	4/14/10
						DATE END	4/14/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	■ ▩	20 15 6 5	S1	0.16 - 2.16	18	17.8	Top 2" Asphaltic Concrete. SILTY SAND WITH GRAVEL (SM); mostly fine sand, some non-plastic silt, little fine gravel, black with gray, moist, FILL.
5	▨	6 1 4 4	S2	3 - 5	12	15.0 14.5	(3 - 3.5') ORGANIC SILT (OH); slightly plastic silt, slight organic odor, black, wet. (3.5 - 5') LEAN (CL); moderately plastic clay, little plastic silt, medium stiff, brownish gray, wet.
10	▨	6 7 8 8	S3	8 - 10	16		LEAN CLAY (CL); moderately plastic clay, little plastic silt, stiff, brownish gray, wet.
15	▨	6 6 7 7	S4	13 - 15	7	3.0	NO RECOVERY.
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	■ Rock Core (RC) and RQD (%) REC (%)	◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 009

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 011
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		SHEET 1 OF 1
JOB NUMBER	E2347101		

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight
				DRILL RIG	ATV CME - 550
				SPT HAMMER	140 lb Auto

ELEVATION			17
DATUM			NGVD 29
GRID	COORD	N	2791163
		E	770120
DATE START			4/14/10
DATE END			4/14/10

METHOD OF DRILLING

0	Wash Boring w/Casing
15	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH(ft)	REMARKS

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		8 11 12 8	S1	0.16 - 2.16	18	16.8	Top 2" Asphaltic Concrete. POORLY GRADED SAND WITH GRAVEL (SP); mostly fine sand, little fine gravel, dark brown, FILL.
		2 1 1 7	S2	3 - 5	18	14.0	ORGANIC SILT (ML); slightly plastic silt, slight organic odor, dark brown, moist.
5							
		6 6 6 3	S3	8 - 10	15		SIMILAR TO S2; wet, 1" lens of fine sand at bottom of spoon.
10						7.0	
		7 8 8 7	S4	13 - 15	18		SILT (ML); slightly plastic silt, dark gray, wet.
15						2.0	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 011

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	TS - 013
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	17
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2790973
						GRID COORD E	770075
						DATE START	4/14/10
						DATE END	4/14/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
0	Wash Boring w/Casing			
15	Terminated	4/14/2010	4	Upon Completion (Casing pulled)

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	10 12 7 5	S1	0.33 - 2.33	6	16.7	Top 4" Asphaltic Concrete. WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brick fragments, grayish brown, wet, FILL.
	5 5 10 9	S2	3 - 5	16	14.0	POORLY GRADED SAND (SP); mostly fine sand, grayish brown, wet.
5						
	5 6 3 5	S3	8 - 10	12	9.0 8.5	(8 - 8.5') SILTY SAND (SM); mostly fine sand, some slightly plastic silt, reddish brown, wet. (8.5 - 10') LEAN CLAY (CL); moderately plastic clay, little silt, gray, wet.
10						
	2 2 3 6	S4	13 - 15	18		LEAN CLAY (CL); moderately plastic clay, little silt, gray, wet.
15					2.0	
						Bottom of Hole at 15'.
20						
25						
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 013

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 015
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION	15
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID N	2791370
15	Terminated						COORD E	770100
							DATE START	4/14/10
							DATE END	4/14/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						14.7	Top 4" Concrete Slab.
		2 2 3 2	S1	0.33 - 2.33	18		SANDY SILT (ML); non-plastic silt, some fine sand, pieces of wood, dark brown, moist, FILL.
5		2 2 2 2	S2	3 - 5	12		WELL GRADED SAND (SW); fine to coarse sand, trace non-plastic silt, brown, brick fragments, wet, FILL.
						8.0	
10		2 3 3 2	S3	8 - 10	13		SANDY ORGANIC SOIL (OL); non-plastic silt, some fine to coarse sand, organic material, dark brown, wet.
						4.0	
15		2 3 3 2	S4	13 - 15	18		LEAN CLAY (CL); moderately plastic clay, some silt, gray, wet.
						0.0	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 015

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 017
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	P. Rosinha	ELEVATION	13
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2791165
15	Terminated	4/13/2010	0	Upon Completion (Casing pulled)			COORD E	770048
							DATE START	4/13/10
							DATE END	4/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						12.7	Top 4" Concrete Slab.
		▮ 29 9 4 4	S1	0.33 - 2.33	6		SILT (ML); non-plastic silt, gray, moist.
		▮ 6 13 11 7	S2	3 - 5	12		SILT (ML); non-plastic silt, trace fine sand, grayish brown, wet.
5							
						5.0	
		▮ 3 4 6 6	S3	8 - 10	15		LEAN CLAY (CL); moderately plastic clay, little silt, stiff, gray, wet.
10							
		▮ 3 5 4 6	S4	13 - 15	18		LEAN CLAY (CL); moderately plastic clay, little silt, stiff, gray, wet, PP = 0.75 TSF.
15						-2.0	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 017

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 019
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION	14
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID COORD N	2790994
15	Terminated						E	769968
							DATE START	4/13/10
							DATE END	4/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						13.8	Top 3" Asphaltic Concrete.
		5 13 20 5	S1	0.25 - 2.25	12		WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, dark brown, moist, FILL.
		6 10 10 11	S2	3 - 5	14	11.0	SANDY SILT (ML); non-plastic silt, some fine sand, grayish brown, wet, strong naphthalene-like odor.
5							
		3 3 3 5	S3	8 - 10	12	6.0	LEAN CLAY (CL); moderately plastic clay, little silt, medium stiff, gray, wet, slight naphthalene-like odor, PP = 0.5 TSF.
10							
		2 4 4 4	S4	13 - 15	20		LEAN CLAY (CL); moderately plastic clay, little silt, medium stiff, gray, wet, PP = 1.25 TSF.
15						-1.0	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 019

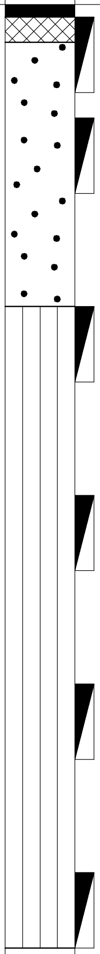
LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 020 OW
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	14
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS			
0	Wash Boring w/Casing				SPT HAMMER: 140 lb Safety	GRID COORD N	2790918
25	Terminated	7/7/2010	5.5	Monitoring Well Reading		GRID COORD E	769948
		9/12/2011	2	Monitoring Well Reading		DATE START	4/13/10
						DATE END	4/13/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 7 7 8	S1	0.33 - 2.33	12	13.7 13.0	Top 4" Asphaltic Concrete. (0 - 1') WELL GRADED SAND (SW); fine to coarse sand, trace fine gravel, brown, moist, FILL. (1 - 2') POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, gray, moist.
		6 8 9 10	S2	3 - 5	13		POORLY GRADED SAND (SP); mostly fine sand, gray, wet.
5							
		3 3 4 8	S3	8 - 10	16	6.0	SILT (ML); slightly plastic silt, trace clay, gray, wet.
10							
		4 4 6 3	S4	13 - 15	10		SIMILAR TO S3; stiff.
15							
		2 3 4 3	S5	18 - 20	6		SIMILAR TO S3; medium stiff.
20							
		2 3 5 5	S6	23 - 25	18		SIMILAR TO S3; medium stiff.
25						-11.0	
							Bottom of Hole at 25'. Notes: Observation well screened from 15 to 25 ft.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	█ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	☐ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	⊠ Bag Sample (B)

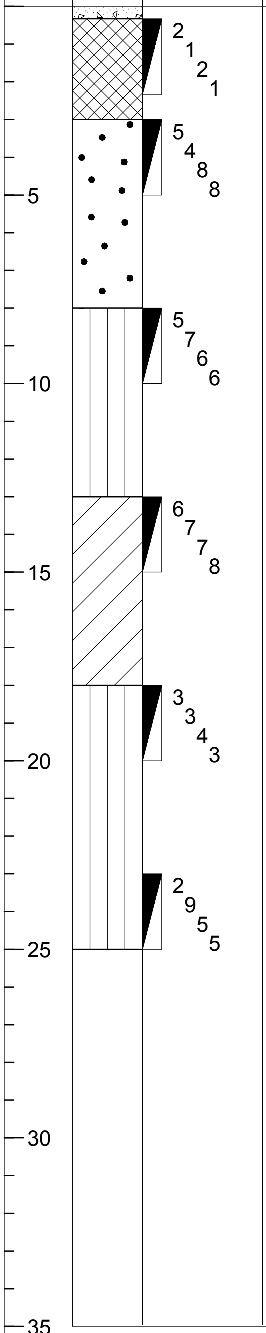
REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 020 OW

LOG OF TEST BORING

PROJECT	South Coast Rail			BORING NO.	TS - 021
LOCATION	Taunton, MA				
OWNER	Mass.Bay Transportation Authority				
JOB NUMBER	E2347101				SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		15
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID	N	2791629
25	Terminated	4/13/2010	3	Upon Completion (Casing pulled)			COORD	E	770060
							DATE START		4/13/10
							DATE END		4/13/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 1 2 1	S1	0.33 - 2.33	13	14.7	Top 4" Concrete Slab. SILTY SAND (SM); mostly fine sand, some non-plastic silt, brown, dry, FILL.
		5 4 8 8	S2	3 - 5	16	12.0	POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, grayish brown, wet.
		5 7 6 6	S3	8 - 10	24	7.0	SILT (ML); non-plastic silt, gray, wet.
		6 7 7 8	S4	13 - 15	18	2.0	LEAN CLAY (CL); moderately plastic clay, some silt, stiff, gray, wet.
		3 3 4 3	S5	18 - 20	24	-3.0	SILT (ML); slightly plastic silt, trace clay, gray, wet.
		2 9 5 5	S6	23 - 25	11		SIMILAR TO S5.
25						-10.0	Bottom of Hole at 25'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 021

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 022
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		SHEET 1 OF 1
	JOB NUMBER	E2347101		

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION	14
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID N	2791464
25	Terminated						COORD E	770049
							DATE START	4/13/10
							DATE END	4/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 39 32 43	S1	0 - 2	6		WELL GRADED SAND (SW); fine to coarse sand, trace silt, brick fragments, dark brown, moist, FILL.
5		13 16 14 14	S2	3 - 5	20	11.0	SILTY SAND (SM); mostly fine sand, some non-plastic silt, gray, wet.
10		3 5 5 7	S3	8 - 10	20	6.0	SILT (ML); slightly plastic silt, gray, wet, PP = 1.25 TSF.
15		2 2 3 3	S4	13 - 15	16	1.0	LEAN CLAY (CL); moderately plastic clay, some silt, medium stiff, gray, wet, PP = 1.0 TSF.
20		2 2 2 3	S5	18 - 20	22	-4.0	SILT (ML); slightly plastic silt, trace clay, gray, wet, PP = 0.75 TSF.
		1 2 2 2	S6	23 - 25	24		SIMILAR TO S5.
25 30 35						-11.0	Bottom of Hole at 25'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 022

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 023
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	13
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2791281
						E	769959
						DATE START	4/13/10
						DATE END	4/13/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
0	Wash Boring w/Casing	4/13/2010	1	Upon Completion (Casing pulled)
25	Terminated			

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Top 11" Concrete Slab.
		11 6 3 6	S1	1 - 3	6	12.0	WELL GRADED SAND (SW); fine to coarse sand, black, wet, FILL.
		18 10 12 11	S2	3 - 5	18		(3 - 4.5') POORLY GRADED SAND (SP); mostly fine sand, dark brown with lenses of black, wet, FILL.
5						8.5	(4.5 - 5') SILT (ML); non-plastic silt, trace fine sand, light brown, wet.
		3 2 3 5	S3	8 - 10	15	5.0	SILT (ML); slightly plastic silt, trace clay, gray, wet, PP = 1.25 TSF.
10							
		3 3 6 5	S4	13 - 15	13		SIMILAR TO S3; PP = 1.0 TSF.
15							
		2 5 8 7	S5	18 - 20	14		SIMILAR TO S3; PP = 1.25 TSF.
20							
		2 3 3 7	S6	23 - 25	16		SIMILAR TO S3; PP = 0.5 TSF.
25						-12.0	
							Bottom of Hole at 25'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 023

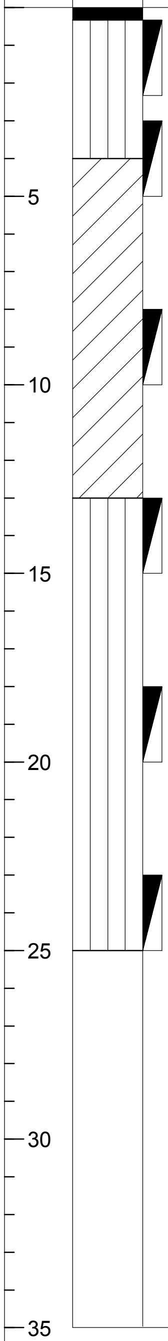
LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TS - 024
LOCATION	Taunton, MA		SHEET 1 OF 1
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	14
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2791010
						GRID COORD E	769893
						DATE START	4/13/10
						DATE END	4/13/10

METHOD OF DRILLING		GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS
0	Wash Boring w/Casing	4/13/2010	4	Upon Completion (Casing pulled)
25	Terminated			



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	3 2 4 4	S1	0.33 - 2.33	12	13.7	Top 4" Asphaltic Concrete. SILT (ML); slightly plastic silt, trace fine sand, dark brown, moist.
	4 16 24 13	S2	3 - 5	15	10.0	(3 - 4') SIMILAR TO S1. (4 - 5') LEAN CLAY (CL); moderately plastic clay, some silt, gray, wet.
	5 6 5 5	S3	8 - 10	18		LEAN CLAY (CL); moderately plastic clay, some silt, gray, wet, PP = 1.0 TSF.
	2 2 2 2	S4	13 - 15	24	1.0	SILT (ML); slightly plastic silt, trace clay, gray, wet, PP = 1.25 TSF.
	2 3 4 4	S5	18 - 20	19		SIMILAR TO S4; PP = 0.75 TSF.
	1 1 1 2	S6	23 - 25	24		SIMILAR TO S4; PP = 0.5 TSF.
					-11.0	Bottom of Hole at 25'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 024

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TS - 025
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		14
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV CME - 550	DATUM		NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Auto	GRID	N	2791492
25	Terminated	4/13/2010	2	Upon Completion (Casing pulled)			COORD	E	769927
							DATE START		4/13/10
							DATE END		4/13/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 3 3 3	S1	0.33 - 2.33	14	13.7	Top 4" Concrete Slab. SILT (ML); non-plastic silt, gray with dark brown, moist.
5		7 11 13 12	S2	3 - 5	20	11.0	SANDY SILT (ML); non-plastic silt, some fine sand, grayish brown, wet.
10		3 4 5 5	S3	8 - 10	24	6.0	SILT (ML); slightly plastic silt, trace clay, gray, wet.
15		2 3 3 4	S4	13 - 15	24		SIMILAR TO S3; PP = 1.0 TSF.
20		2 2 3 3	S5	18 - 20	24		SIMILAR TO S3; PP = 0.75 TSF.
		3 3 4 4	S6	23 - 25	18		SIMILAR TO S3; PP = 0.75 TSF.
25						-11.0	Bottom of Hole at 25'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 025

LOG OF TEST BORING

PROJECT	South Coast Rail			BORING NO.	TS - 026
LOCATION	Taunton, MA				
OWNER	Mass.Bay Transportation Authority				
JOB NUMBER	E2347101				SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	14
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER 140 lb Safety	GRID COORD N	2791318
25	Terminated	4/13/2010	2	Upon Completion (Casing pulled)		E	769873
						DATE START	4/13/10
						DATE END	4/13/10

DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
						Top 4" Concrete Slab, then ~8" base course.
	21 11 7 7	S1	1 - 3	5	13.0	SILTY SAND (SM); fine to medium sand, some non-plastic silt, gray, wet.
5	3 3 5 5	S2	3 - 5	8	11.0	LEAN CLAY (CL); plastic clay, some silt, gray, wet, PP = 1.25 TSF.
10	2 3 4 4	S3	8 - 10	22		SIMILAR TO S2; PP = 0.75 TSF.
					4.0	
15	3 4 3 4	S4	13 - 15	0		NO RECOVERY
20	3 3 3 4	S5	18 - 20	15		SILT (ML); slightly plastic silt, trace clay, gray, wet, PP = 0.75 TSF.
25	4 5 4 5	S6	23 - 25	14		SIMILAR TO S5.
					-11.0	Bottom of Hole at 25'.
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TS - 026

APPENDIX B: LABORATORY DATA

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.		
Project:	South Coast Rail		
Location:	MA	Project No:	GTX-9764
Boring ID: ---	Sample Type: ---	Tested By:	mmd
Sample ID:---	Test Date: 05/03/10	Checked By:	jdt
Depth : ---	Sample Id: ---		

Moisture Content of Soil - ASTM D 2216-05

Boring ID	Sample ID	Depth	Description	Moisture Content,%	
FTS-4	S-2	4-6 ft	Moist, black silt	42.4	
FTS-11	S-1	0-2 ft	Moist, yellowish brown sandy silt	24	
FTS-13	S-2	3-5 ft	Moist, yellowish brown silt	23.8	
TS-2	S-3	9-11 ft	Moist, gray clay	32	←
TS-2	S-4	14-16 ft	Wet, light gray silt	37	←
TS-3	S-3	9-11 ft	Moist, gray clay	37.7	←
TS-7	S-3	8-10 ft	Wet, yellowish brown clay	36.5	←
TS-7	S-4	13-15 ft	Moist, gray clay	32.8	←
TS-11	S-2	3-5 ft	Moist, black silt with organics	26.1	←
TS-20	S-3	8-10 ft	Wet, gray silt	41.4	←

Notes: Temperature of Drying : 110° Celsius

printed 5/3/2010 12:18:30 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	---	Sample Type:	---	Tested By:	mmd
Sample ID:	---	Test Date:	04/28/10	Checked By:	jdt
Depth :	---	Test Id:	178378		

Moisture, Ash, and Organic Matter - ASTM D 2974

Boring ID	Sample ID	Depth	Description	Moisture Content,%	Ash Content,%	Organic Matter,%
FTS-4	S-2	4-6 ft	Moist, black silt	42	95.3	4.7
TS-11	S-2	3-5 ft	Moist, black silt with organics	26	92.2	7.8

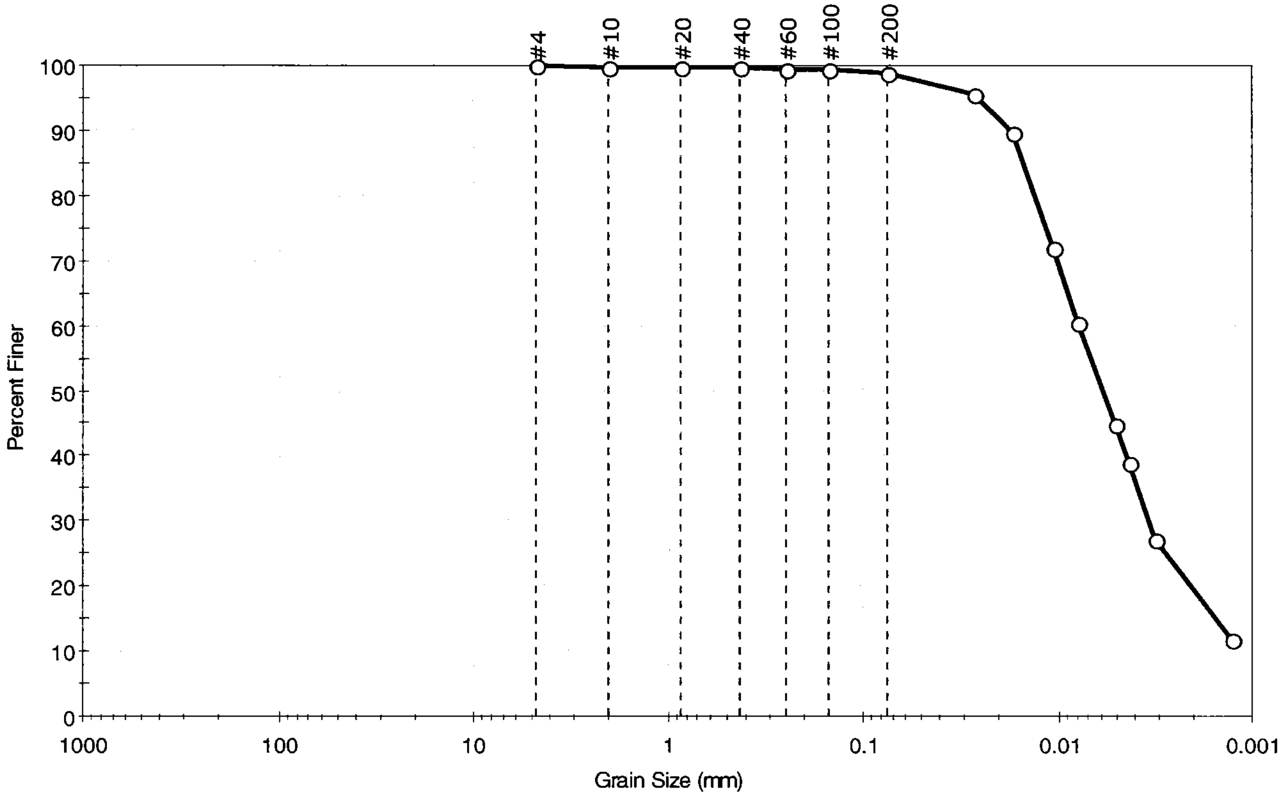
Notes: Moisture content determined by Method A and reported as a percentage of oven-dried mass;
dried to a constant mass at temperature of 110° C
Ash content and organic matter determined by Method C; dried to constant mass at temperature 440° C

printed 5/3/2010 12:15:37 PM

GeoTesting
express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: TS-2
Sample Type: jar
Tested By: jbr
Sample ID:S-4
Test Date: 04/28/10
Checked By: jdt
Depth : 14-16 ft
Test Id: 178363
Test Comment: ---
Sample Description: Wet, light gray silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	1.1	98.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	99		
#200	0.075	99		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0266	95		
---	0.0171	90		
---	0.0106	72		
---	0.0079	60		
---	0.0051	45		
---	0.0043	39		
---	0.0031	27		
---	0.0013	12		

Coefficients

D_{85} =0.0151 mm
D_{30} =0.0034 mm
D_{60} =0.0078 mm
D_{15} =0.0015 mm
D_{50} =0.0059 mm
D_{10} =0.0012 mm
C_u =N/A
C_c =N/A

Classification

ASTM silt (ML)

AASHTO Silty Soils (A-4 (3))

Sample/Test Description

Sand/Gravel Particle Shape : ---

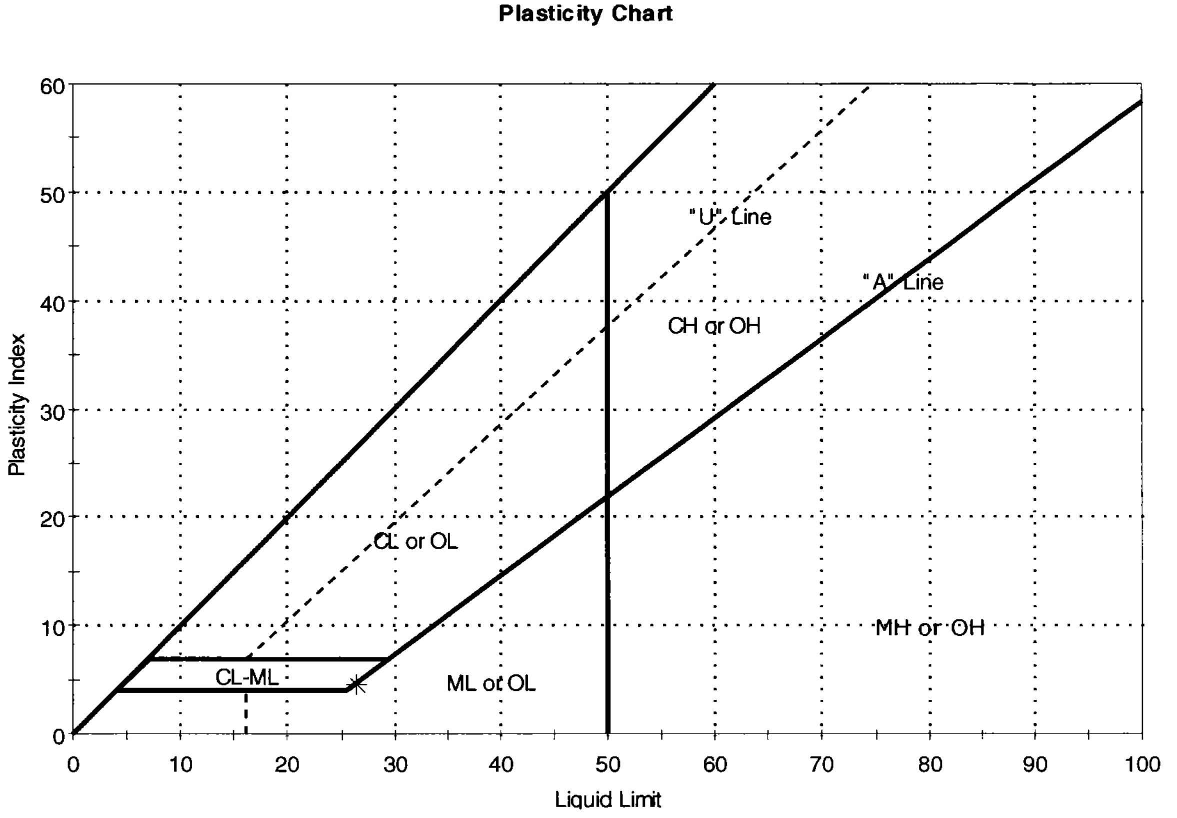
Sand/Gravel Hardness : ---

printed 5/3/2010 12:11:43 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	TS-2	Sample Type:	jar	Tested By:	cam
Sample ID:	S-4	Test Date:	04/29/10	Checked By:	jdt
Depth :	14-16 ft	Test Id:	178359		
Test Comment:	---				
Sample Description:	Wet, light gray silt				
Sample Comment:	---				

Atterberg Limits - ASTM D 4318-05



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
✳	S-4	TS-2	14-16 ft	37	26	22	4	4	silt (ML)

Sample Prepared using the WET method

0% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilentancy: SLOW

Toughness: LOW

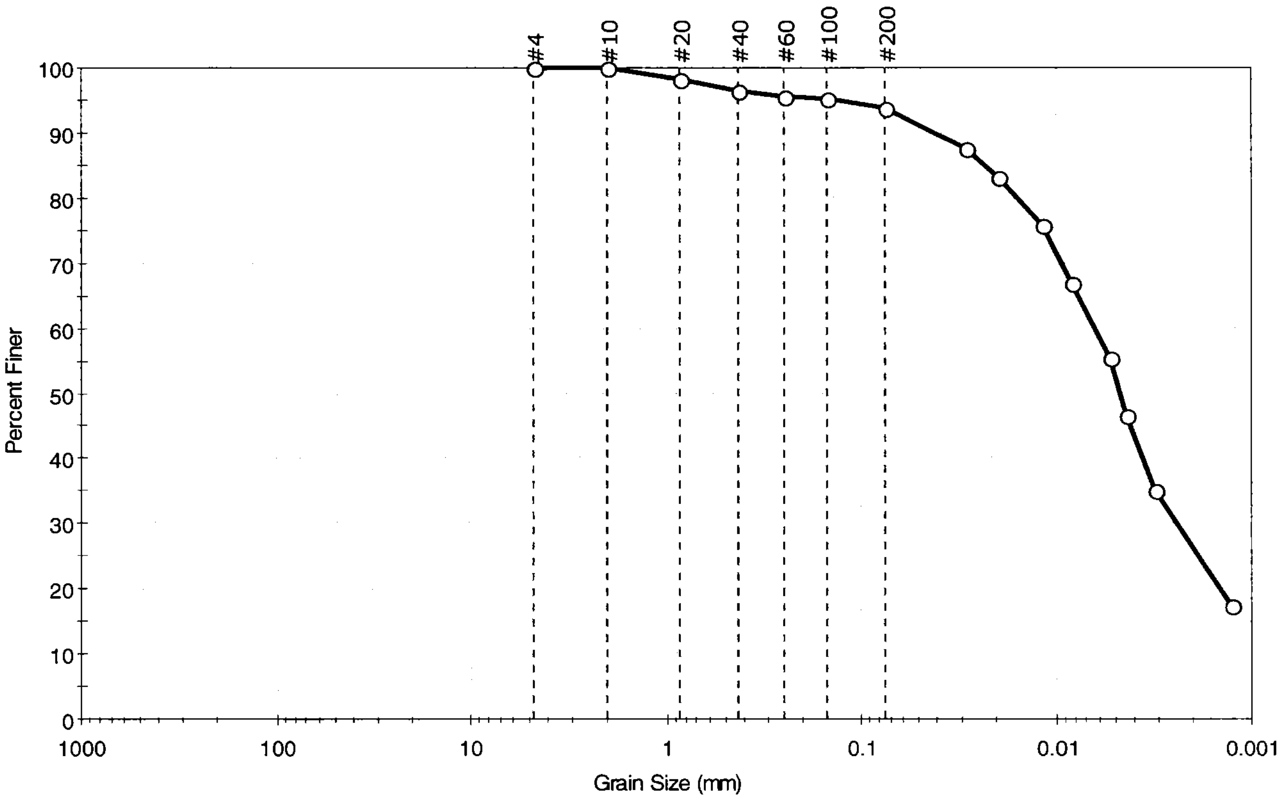
printed 5/3/2010 12:07:51 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	TS-7	Sample Type:	jar	Tested By:	jbr
Sample ID:	S-3	Test Date:	04/28/10	Checked By:	jdt
Depth :	8-10 ft	Test Id:	178364		

Test Comment: ---
Sample Description: Wet, yellowish brown clay
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	6.1	93.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	98		
#40	0.42	97		
#60	0.25	96		
#100	0.15	95		
#200	0.075	94		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0287	87		
---	0.0198	83		
---	0.0116	76		
---	0.0084	67		
---	0.0053	55		
---	0.0044	47		
---	0.0032	35		
---	0.0013	17		

Coefficients

D_{85} =0.0233 mm	D_{30} =0.0024 mm
D_{60} =0.0063 mm	D_{15} =N/A
D_{50} =0.0047 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

<u>ASTM</u> lean clay (CL)

<u>AASHTO</u> Clayey Soils (A-6 (11))

Sample/Test Description

Sand/Gravel Particle Shape : ---

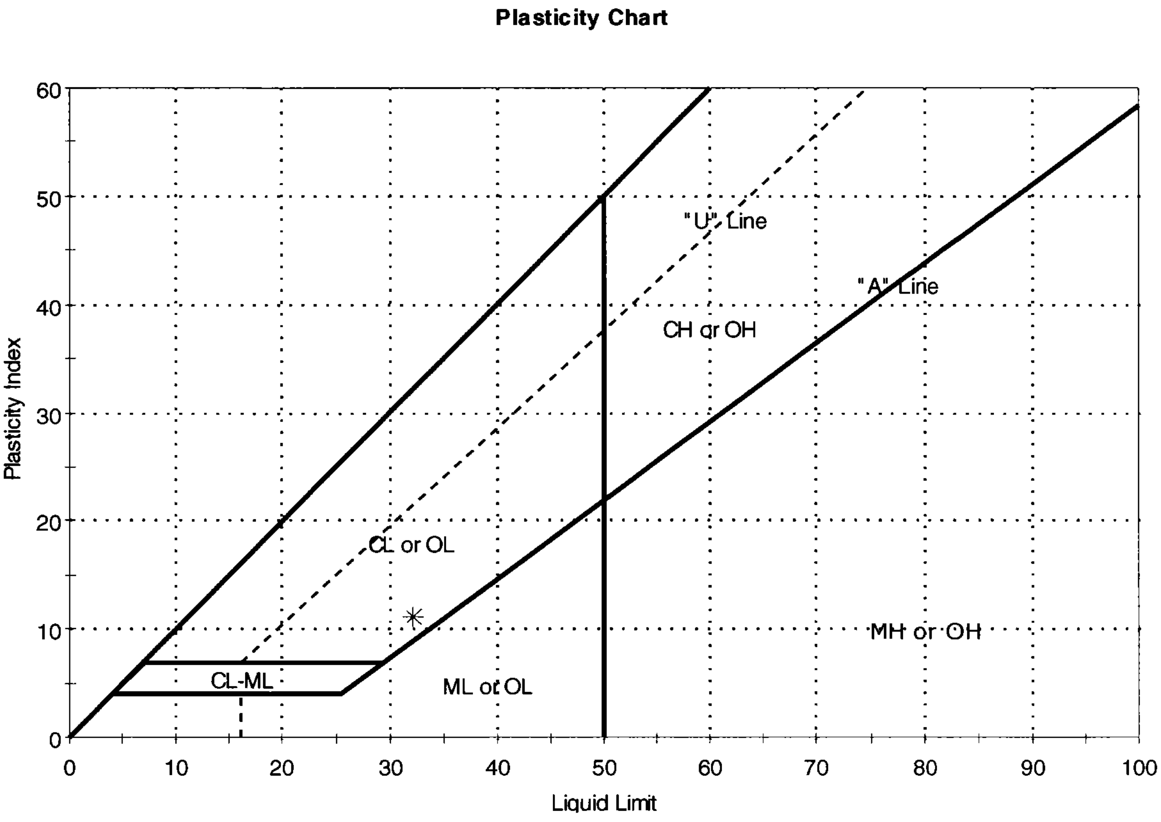
Sand/Gravel Hardness : ---

printed 5/3/2010 12:14:49 PM

Client:	Jacobs Civil, Inc.		
Project:	South Coast Rail		
Location:	MA	Project No:	GTX-9764
Boring ID: TS-7	Sample Type: jar	Tested By:	cam
Sample ID:S-3	Test Date: 04/29/10	Checked By:	jdt
Depth : 8-10 ft	Test Id: 178360		

Test Comment: ---
Sample Description: Wet, yellowish brown clay
Sample Comment: ---

Atterberg Limits - ASTM D 4318-05



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
✳	S-3	TS-7	8-10 ft	37	32	21	11	1	lean clay (CL)

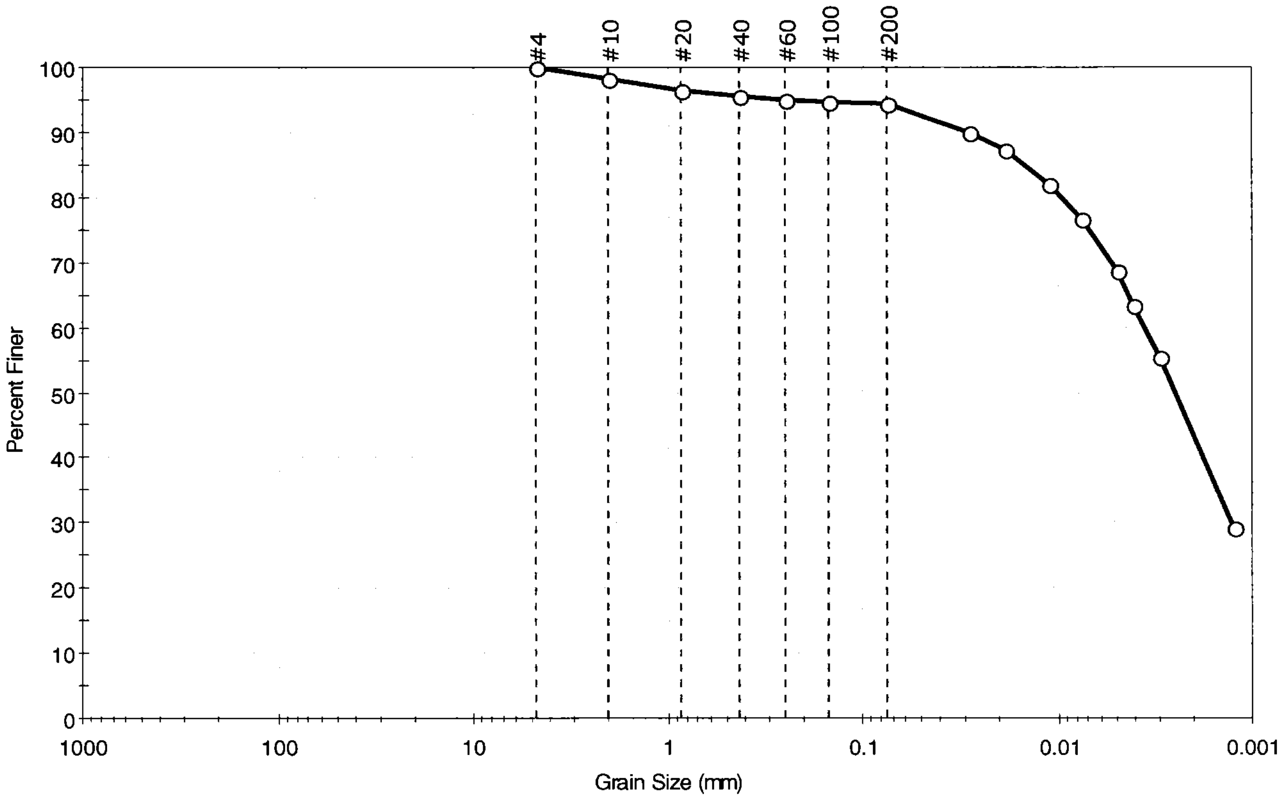
Sample Prepared using the WET method
3% Retained on #40 Sieve
Dry Strength: VERY HIGH
Dilentancy: SLOW
Toughness: LOW

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	TS-20	Sample Type:	jar	Tested By:	jbr
Sample ID:	S-3	Test Date:	04/28/10	Checked By:	jdt
Depth :	8-10 ft	Test Id:	178365		

Test Comment: ---
Sample Description: Wet, gray silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	5.6	94.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	98		
#20	0.85	96		
#40	0.42	95		
#60	0.25	95		
#100	0.15	95		
#200	0.075	94		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0291	90		
---	0.0187	87		
---	0.0112	82		
---	0.0075	77		
---	0.0049	69		
---	0.0041	63		
---	0.0030	56		
---	0.0012	29		

Coefficients

D_{85} =0.0150 mm
D_{30} =0.0013 mm
D_{60} =0.0036 mm
D_{15} =N/A
D_{50} =0.0025 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM silt (ML)

AASHTO Silty Soils (A-4 (8))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

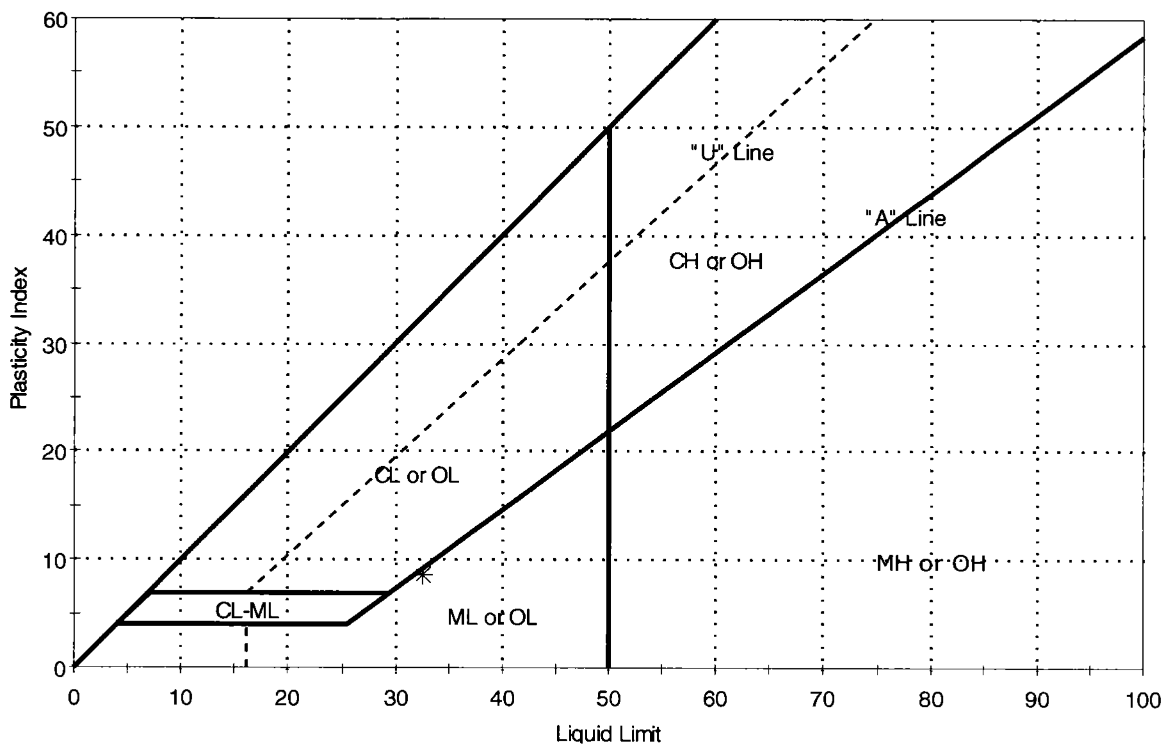
printed 5/3/2010 12:13:44 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: TS-20
Sample Type: jar
Tested By: cam
Sample ID:S-3
Test Date: 04/29/10
Checked By: jdt
Depth : 8-10 ft
Test Id: 178361
Test Comment: ---
Sample Description: Wet, gray silt
Sample Comment: ---

Atterberg Limits - ASTM D 4318-05

Plasticity Chart



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
✳	S-3	TS-20	8-10 ft	41	33	24	9	2	silt (ML)

Sample Prepared using the WET method

5% Retained on #40 Sieve

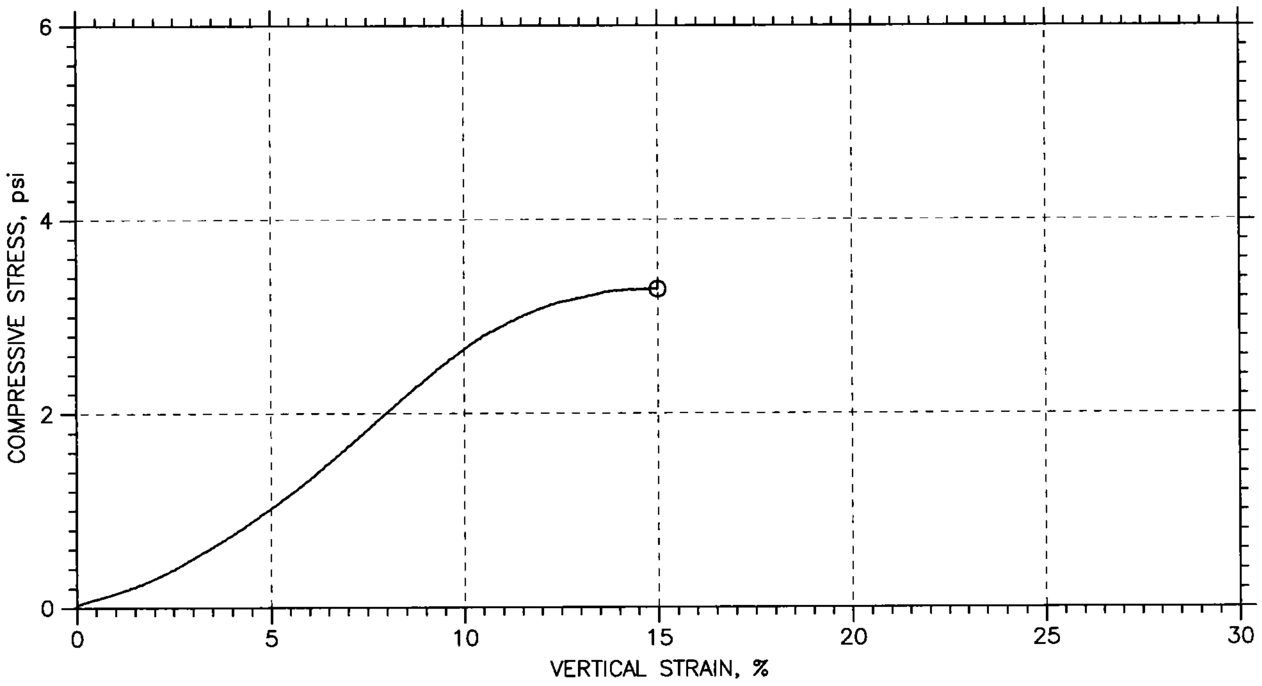
Dry Strength: VERY HIGH

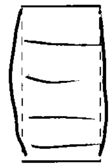
Dilentancy: SLOW

Toughness: LOW

printed 5/3/2010 12:08:11 PM

UNCONFINED COMPRESSION TEST REPORT - ASTM D 2166



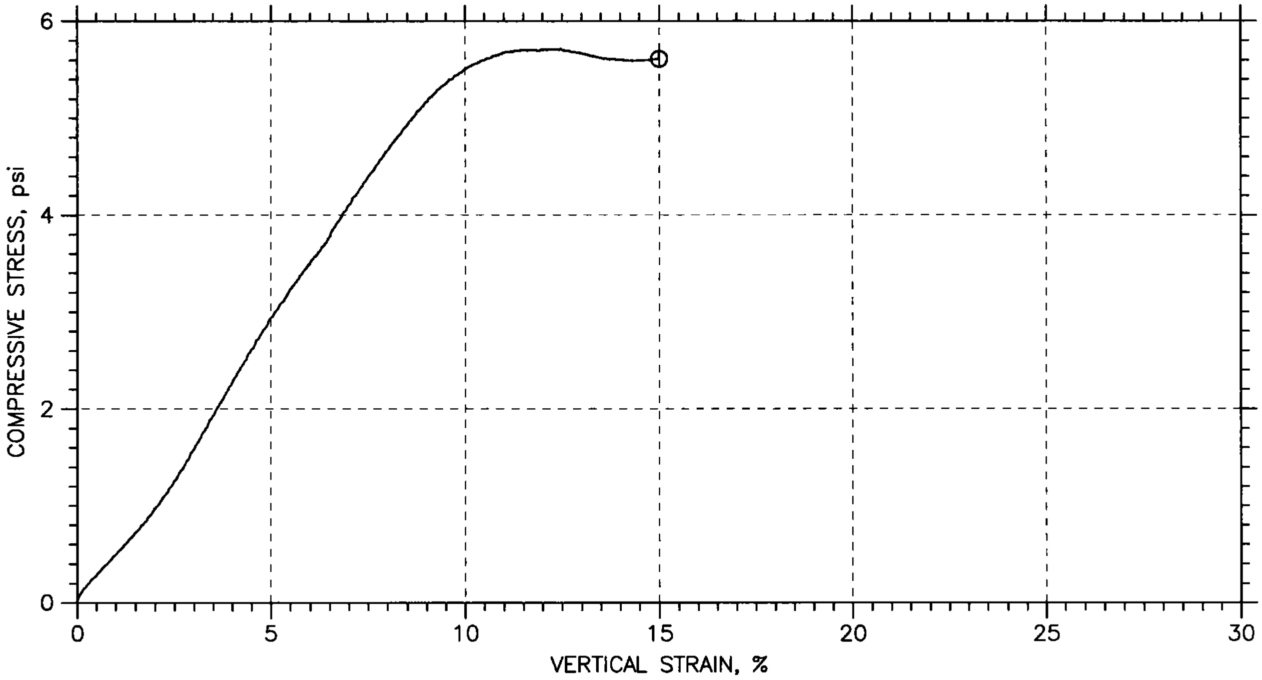
Symbol		⦶			
Test No.		UC-1			
Initial	Diameter, in	1.5			
	Height, in	3.1			
	Water Content, %	35.84			
	Dry Density, pcf	83.57			
	Saturation, %	95.16			
	Void Ratio	1.02			
Unconfined Compressive Strength, psi		3.285			
Undrained Shear Strength, psi		1.642			
Time to Failure, min		14.425			
Strain Rate, %/min		1			
Estimated Specific Gravity		2.70			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

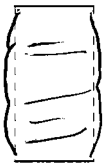
GeoTesting express
a subsidiary of Geocomp Corporation

Project: South Coast Rail
Location: MA
Project No.: GTX-9764
Boring No.: TS-3
Sample Type: tube
Description: Moist, gray clay
Remarks: System Q - Depth: 8-10 ft

Mon, 03-MAY-2010 13:24:05

UNCONFINED COMPRESSION TEST REPORT - ASTM D 2166



Symbol		⦶			
Test No.		UC-2			
Initial	Diameter, in	1.52			
	Height, in	3.29			
	Water Content, %	32.39			
	Dry Density, pcf	89.85			
	Saturation, %	99.83			
	Void Ratio	0.876			
Unconfined Compressive Strength, psi		5.716			
Undrained Shear Strength, psi		2.858			
Time to Failure, min		14.091			
Strain Rate, %/min		1			
Estimated Specific Gravity		2.70			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

GeoTesting
express
a subsidiary of Geocomp Corporation

Project: South Coast Rail
Location: MA
Project No.: GTX-9764
Boring No.: TS-24
Sample Type: tube
Description: Moist, gray clay
Remarks: System Q - Depth: 8-10 ft

Mon, 03-MAY-2010 14:23:57

APPENDIX C: GEOTECHNICAL CALCULATIONS

- Allowable Bearing Capacity and Estimated Settlement
- Seismic Site Class Evaluation

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

SHEET 1 OF 2
JOB MBTA South Coast Rail
SUBJECT Taunton Station
CALCULATED BY DH **DATE** 2/10/2012
CHECKED BY AH/PJM **DATE** 2/14/2012

PURPOSE: Evaluate bearing resistance for platform shallow foundations.

REFERENCE: AASHTO LRFD Bridge Design Specifications, 2010

ASSUMPTIONS:

- Platform footing is 7 ft wide by 10 ft long.
- Bearing surface is compacted Gravel Borrow overlying poorly graded sand (SP) or sandy silt (ML).
- Footing embedment is at least 4 feet below ground surface.
- Groundwater level is at 6 feet below surface.
- Footing eccentricity is assumed to be zero.
- Estimated soil properties (experience, geotech literature, Table 10.4.6.2.4-1):

	γ (pcf)	ϕ
Gravel Borrow:	125	34

BEARING CAPACITY FACTORS (Table 10.6.3.1.2a-1):

	ϕ	N_c	N_q	N_γ
Gravel Borrow:	34	42.2	29.4	41.1

CALCULATE EFFECTIVE FOOTING WIDTH (B'):

$e < B/4$ (Section 10.6.3.3)

where: B = footing width (ft) = 7
e = eccentricity (ft)

Assume no footing eccentricity, thus, e = 0

B' = B-2e 7

NOMINAL BEARING RESISTANCE (q_n):

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$ (Eqn. 10.6.3.1.2a-1)

where: c = cohesion = 0
γ = total unit weight 125
D_f = depth of footing (ft) = 4 Assumed
B' = effective width of footing (ft) = 7
L = length of footing (ft) = 10
B'/L = 0.70
D_f /B' = 0.57
C_{wq} $C_{w\gamma}$ = groundwater correction factors (using B')
C_{wq} = 1.0 (Table 10.6.3.1.2a-2)
$C_{w\gamma}$ = 0.6 (Table 10.6.3.1.2a-2)

N_{cm} N_{qm} $N_{\gamma m}$ = bearing capacity factors

$N_{qm} = N_q s_q d_q i_q$ (Eqn. 10.6.3.1.2a-3)

s_q = 1.47 (Table 10.6.3.1.2a-3)

d_q = 1.20 (Table 10.6.3.1.2a-4)

i_q = 1.0 (see AASHTO p. 10-62)

N_{qm} = 51.9

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

$s_\gamma =$ 0.72 (Table 10.6.3.1.2a-3)

$i_\gamma =$ 1 (see AASHTO p. 10-62)

$N_{\gamma m} =$ 29.6

$q_n =$ 33,737 psf

ALLOWABLE BEARING RESISTANCE (q_a):

$q_a = q_n/FOS$

where: FOS = factor of safety = 2.5 for granular soil

$q_a =$ 13,495 psf

use

q_a = 13.49 ksf strength limit value

Note: Based on the existence of underlying clay/silt soils, an allowable bearing capacity of 3 ksf is recommended.

Elastic Settlement Calculations:

$$S_e = \frac{\left(q_o\,(1-\nu^2)\sqrt{A'}\right)}{144E_s\beta_z}$$

eqn. 10.6.2.4.2-1

where: q_o = applied vert. stress (ksf)
v = Poisson's Ratio
E_s = Young's Modulus (ksi)
β_z = Shape/Rigidity Factor

v = Poisson's Ratio = 0.30 (Table C10.4.6.3-1)
E_s = Young's Modulus (ksi) = 6.00 (Table C10.4.6.3-1)
β_z = Shape/Rigidity Factor = 1.08 (Table 10.6.2.4.2-1)

where: B' = eff. width of footing (ft) = 7 (from bearing resistance calcs)
L = length of footing (ft): 10 (from bearing resistance calcs)
A' =(B'xL) = footing area (ft^2): 70 ft^2

Settlement (S_e) for a given q_o:

q_o = applied vertical stress (ksf) = 3.00 ksf (assumed)

Se (inches) = 0.29 inches

343 Congress Street
Boston, MA 02210
617/242-9222

JOB MBTA South Coast Rail
SUBJECT Taunton Station
CALCULATED BY DH **DATE** 2/10/2012
CHECKED BY AH/PJM **DATE** 2/14/2012

Taunton Station - Consolidation Settlement Calculation

Platform Boring	**TS-1**	**TS-2**	**TS-3**	**TS-4**	**TS-5**	
Existing Ground Elevation (ft)	19	18	17	16	16	
Assumed Groundwater Elevation (ft)	13	12	11	10	10	
Assumed New Fill Height (ft)	3.2	3.9	4.6	5	4.3	
Assumed Final Ground Elevation (ft)	22.2	21.9	21.6	21	20.3	
Assumed Bottom of Footing Elevation (ft)	18.2	17.9	17.6	17	16.3	
Fill Surcharge (ksf)	0.38	0.47	0.55	0.60	0.52	
Soft Layer Top Elevation(ft)	9.5	8	8	6	3	
Soft Layer Bottom Elevation(ft)	-18	-1	-17	-12	-17	
Soft Layer Midpoint Elevation(ft)	-4.25	3.5	-4.5	-3	-7	
Thickness of Soft Layer (ft)	27.5	9	25	18	20	
Enlarged B (ft)	29.45	21.40	29.10	27.00	30.30	
Enlarged L (ft)	32.45	24.40	32.10	30.00	33.30	
Enlarged Compression Area (ft^2)	955.65	522.16	934.11	810.00	1008.99	
Footing Surcharge at the midpoint of soft layer (ksf)	0.12	0.22	0.12	0.14	0.12	
Initial Vertical Stress at Midpoint (ksf)	1.71	1.21	1.61	1.47	1.70	
Final Vertical Stress at Midpoint (ksf)	2.22	1.90	2.29	2.21	2.33	< P_c Overconsolidated
RR	0.038	0.038	0.038	0.038	0.038	
Consolidation Settlement (inches)	**1.42**	**0.81**	**1.74**	**1.47**	**1.26**	

Assumptions:

1. Assume groundwater level is at 6 feet below existing ground surface.
2. Use 2:1 method to calculate the surcharge at the midpoint of the clay layer.
3. PI value from lab test data of TS-2, S4 was applied to all borings.
4. RR value based on lab test data of TS-2, S4 was applied to all borings.

Assumptions (Cont'd):

B' = effective width of footing =	7.00	ft	
L = length of footing =	10.00	ft	
P = vertical load at bottom of footing =	210.00	kips	
Weight of Excavated Soil =	6.72	kips	TS-1
Footing Surcharge at bottom of footing =	2.90	ksf	
c_{min} = minimum cohesion =	0.50	ksf	TS-3, S6
PI = plasticity index =	4		TS-2, S4
PL = plastic limit =	22	%	TS-2, S4
w = water content =	37	%	TS-2, S4
P_c = preconsolidation pressure =	4.31	ksf	
RR = recompression ratio =	0.038		

Equations used in the calculations:

$$\delta_c = \frac{C_c}{1+e_o} H \log\left(\frac{\sigma'_{vf}}{\sigma'_{vo}}\right)$$

$$P_c = \frac{c}{0.1+0.004PI}$$

$$C = \frac{1+e_o}{C_c}$$

$$RR = 0.001598 + 0.0007160w + 0.0004613PL$$

$$\delta_c = \frac{1}{C} H \log\left(\frac{\sigma'_{vf}}{\sigma'_{vo}}\right)$$

Taunton Station Seismic Site Class Evaluation

Based on the platform boring with the deepest soil overburden and lowest average blow counts (worst case)

Boring No.	Sample No.	N Value	Di	D_i/N_i	N_{bar}
TS-03	S-1	6	4	0.67	18
	S-2	11	5	0.45	
	S-3	11	5	0.45	
	S-4	5	5	1.00	
	S-5	7	5	0.71	
	S-6	6	5	0.83	
	S-7	7	5	0.71	
	S-8	25	4	0.16	
	Bedrock	100	62	0.62	
	Total Depth =	100			
	Depth to Bedrock =	38	Sum =	5.62	

Approx. Project Coordinates

Lat	41.905783
Long	-71.080822

Seismic Coefficients

S_S = 0.24 (Table 1604.10*)

S_1 = 0.062 (Table 1604.10*)

For Site Class D

F_A = 1.6 (See Table 9.4.1.2.4a*)

F_V = 2.4 (See Table 9.4.1.2.4b*)

Design Spectral Response Parameters

$S_{MS} = Ss \times F_A$ = 0.384

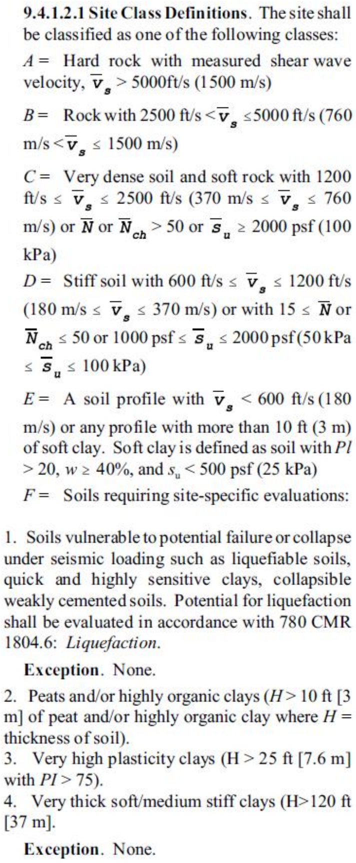
$S_{M1} = S_1 \times F_V$ = 0.149

$S_{DS} = 2/3 \times S_{MS}$ = 0.256

$S_{D1} = 2/3 \times S_{M1}$ = 0.099

Per 9.4.1.2.1, 15 < N_{bar} < 50, Site Class D

Notes: * The Massachusetts State Building Code, 8th Edition (2010)



9.4.1.2.1 Site Class Definitions. The site shall be classified as one of the following classes:

A = Hard rock with measured shear wave velocity, $\overline{v}_s$ > 5000ft/s (1500 m/s)

B = Rock with 2500 ft/s < $\overline{v}_s$ ≤ 5000 ft/s (760 m/s < $\overline{v}_s$ ≤ 1500 m/s)

C = Very dense soil and soft rock with 1200 ft/s ≤ $\overline{v}_s$ ≤ 2500 ft/s (370 m/s ≤ $\overline{v}_s$ ≤ 760 m/s) or $\overline{N}$ or $\overline{N}_{ch}$ > 50 or $\overline{s}_u$ ≥ 2000 psf (100 kPa)

D = Stiff soil with 600 ft/s ≤ $\overline{v}_s$ ≤ 1200 ft/s (180 m/s ≤ $\overline{v}_s$ ≤ 370 m/s) or with 15 ≤ $\overline{N}$ or $\overline{N}_{ch}$ ≤ 50 or 1000 psf ≤ $\overline{s}_u$ ≤ 2000 psf (50 kPa ≤ $\overline{s}_u$ ≤ 100 kPa)

E = A soil profile with $\overline{v}_s$ < 600 ft/s (180 m/s) or any profile with more than 10 ft (3 m) of soft clay. Soft clay is defined as soil with *PI* > 20, *w* ≥ 40%, and s_u < 500 psf (25 kPa)

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. Potential for liquefaction shall be evaluated in accordance with 780 CMR 1804.6: *Liquefaction*.

Exception. None.

2. Peats and/or highly organic clays (*H* > 10 ft [3 m] of peat and/or highly organic clay where *H* = thickness of soil).
3. Very high plasticity clays (H > 25 ft [7.6 m] with *PI* > 75).
4. Very thick soft/medium stiff clays (H>120 ft [37 m].

Exception. None.

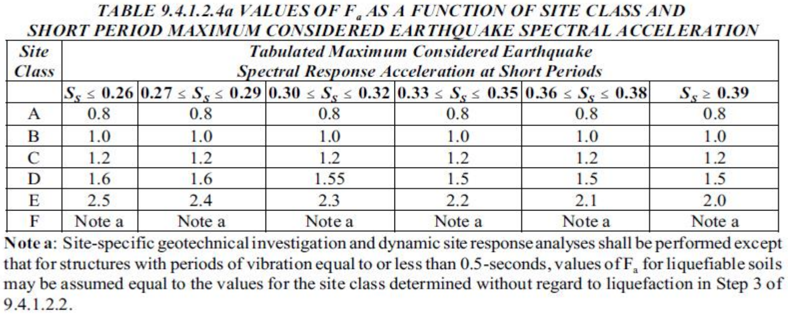


TABLE 9.4.1.2.4a VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods*					
	$S_S \le 0.26$	$0.27 \le S_S \le 0.29$	$0.30 \le S_S \le 0.32$	$0.33 \le S_S \le 0.35$	$0.36 \le S_S \le 0.38$	$S_S \ge 0.39$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5	1.5	1.5
E	2.5	2.4	2.3	2.2	2.1	2.0
F	Note a	Note a	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

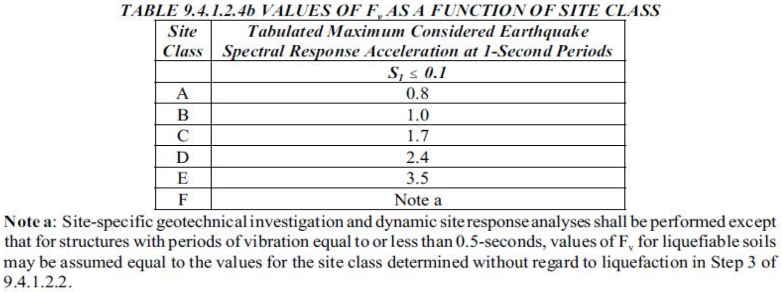


TABLE 9.4.1.2.4b VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods*
	$S_1 \le 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

TABLE 1604.10 GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

(For R-3 of three stories or less one- and two-family stand alone buildings, see 780 CMR 53.00 for snow and wind loads)

City/Town	Ground Snow Load p_g, psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Rochester	45	110	0.23	0.059
Rockland	45	110	0.26	0.064
Rockport	45	110	0.33	0.073
Rowe	65	100	0.22	0.069
Rowley	55	110	0.34	0.075
Royalston	65	100	0.25	0.070
Russell	65	100	0.23	0.066
Rutland	55	100	0.24	0.068
Salem	45	110	0.31	0.071
Salisbury	55	110	0.35	0.077
Sandisfield	65	90	0.23	0.066
Sandwich	35	120	0.22	0.058
Saugus	45	110	0.30	0.070
Savoy	65	90	0.22	0.068
Scituate	45	110	0.27	0.065
Seekonk	55	110	0.24	0.062
Sharon	55	100	0.25	0.065
Sheffield	65	90	0.23	0.066
Shelburne	65	100	0.23	0.068
Sherborn	55	100	0.26	0.066
Shirley	65	100	0.28	0.072
Shrewsbury	55	100	0.25	0.067
Shutesbury	65	100	0.23	0.068
Somerset	55	110	0.23	0.060
Somerville	45	105	0.28	0.069
South Hadley	55	100	0.23	0.066
Southampton	55	100	0.23	0.066
Southborough	55	100	0.26	0.067
Southbridge	55	100	0.23	0.064
Southwick	55	100	0.23	0.065
Spencer	55	100	0.23	0.066
Springfield	55	100	0.23	0.065
Sterling	55	100	0.26	0.069
Stockbridge	65	90	0.22	0.066
Stoneham	45	105	0.30	0.071
Stoughton	55	100	0.26	0.065
Stow	55	100	0.27	0.069
Sturbridge	55	100	0.23	0.065
Sudbury	55	100	0.27	0.069
Sunderland	65	100	0.23	0.068
Sutton	55	100	0.24	0.065
Swampscott	45	110	0.30	0.070
Swansea	55	110	0.24	0.061
Taunton	55	110	0.24	0.062
Templeton	65	100	0.25	0.070
Tewksbury	55	100	0.31	0.073
Tisbury	35	120	0.18	0.052
Tolland	65	100	0.23	0.066
Topsfield	45	110	0.33	0.074
Townsend	65	100	0.28	0.072
Truro	35	120	0.22	0.057

Stormwater Report

Taunton Depot Station

City of Taunton, Massachusetts

Prepared for

massDOT
Massachusetts Department of Transportation
10 Park Plaza
Boston, Massachusetts

Prepared by

VHB **/Vanasse Hangen Brustlin, Inc.**
Transportation, Land Development, Environmental Services
99 High Street
Boston, Massachusetts 02110
617 728 7777

June 2012

Table of Contents

List of Figures

List of Tables

Appendices

Checklist for Stormwater Report

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☒ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

  ☐ Credit 1

  ☐ Credit 2

  ☐ Credit 3

☒ Use of “country drainage” versus curb and gutter conveyance and pipe

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☐ Other (describe): ____________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

 ☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

---

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☒ The ½” or 1” Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

  ☐ Limited Project

  ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.

  ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area

  ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff

  ☐ Bike Path and/or Foot Path

  ☐ Redevelopment Project

  ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

  ☐ Name of the stormwater management system owners;

  ☐ Party responsible for operation and maintenance;

  ☐ Schedule for implementation of routine and non-routine maintenance tasks;

  ☐ Plan showing the location of all stormwater BMPs maintenance access areas;

  ☐ Description and delineation of public safety features;

  ☐ Estimated operation and maintenance budget; and

  ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

  ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;

  ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Water Quality Certification Regulations (314 CMR 9.00).

Project Description

The Applicant, MassDOT, is proposing to construct a commuter rail station (the Project) at Taunton Depot Shopping Mall, Taunton Depot Drive in Taunton, Massachusetts along the New Bedford Main Line. As proposed, the Project will require approximately 13 acres of land acquisition, of which approximately 6 acres will be developed for the new station, with the remaining land mostly vegetated wetlands. The Project will involve a center platform with canopy, ancillary landscape improvements, 398 parking spaces, a pick up/drop off area, bicycle parking facilities, and utility improvements to support this use. The Project will also construct a sidewalk that connects the station to the existing sidewalk on Taunton Depot Drive and to the Taunton Gardens apartment complex.

The site is not considered a Land Use with Higher Potential Pollutant Loads (LUHPPL) as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Site Description

The Project Site consists of approximately 6 acres of land (the Site) located at Taunton Depot Drive in Taunton, Massachusetts (see Figure 1 & 2). Vegetated wetlands surround the Site on south, west, and north sides with the New Bedford Main Line tracks to the west of the wetlands. The Site is west of the Taunton Depot Shopping Center and is bound by retail buildings to the east and vegetated area and wetlands to the north, west, and south. The New Bedford Main Line tracks are on an elevated berm to the west, just beyond the wetlands. There is an existing stormwater basin for the shopping center drainage system located to the immediate southeast of the Site. A paved driveway leads to a pump station in the northwest corner of the Site and there are many dirt paths throughout the Site. See Figure 1, Site Locus Map.

Wetland Resource Areas on the Site, shown in Figures 3 and 4, are described in Table 1. For additional information regarding the wetland resource areas present on the site see the Abbreviated Notice of Resource Area Delineation (ANRAD) prepared by VHB dated May 2011.

Table 1
Wetland Resource Areas

Name	Critical Area	Zone 1 or Zone A	ORW or SRW	Zone II or IWPA	Description
Wetland 1 (TCM-7 East)	No	No	No	No	PFO/PEM
Wetland 3	No	No	No	No	Deep Marsh

Notes: Wetland Classifications: PEM = Palustrine Emergent, PFO = Palustrine Forested

According to the National Resources Conservation Service (NRCS), surface soils on the Site include Deerfield loamy sand, Scarboro mucky loamy fine sand, Whitman fine sandy loam, and Hinckley sandy loam, and are classified as Hydrologic Soil Groups (HSG) B, D, D, and A, respectively. Based on the soil evaluation, the Site is not considered to be within an area of rapid infiltration (soils with a saturated hydraulic conductivity greater than 2.4 inches per hour). Most of the Site has A and B soils which, according to 1982 Rawls Rates, infiltration rates for the soils will be approximately 1.02 inches per hour.

The project is not located within the 100-year flood plain as shown on FEMA Floodway Map, City of Taunton, Massachusetts Bristol County, Community Panel number 25005C0164F dated July 7, 2009, included in Appendix B.

Existing Drainage Conditions

Under existing conditions, the Site consists of mostly cleared, undeveloped land, and is generally surrounded by vegetated wetlands. The Site is primarily dirt and gravel with some pockets of scrub shrubs and grass. There are dirt paths throughout the site and a paved driveway is in the northeast corner of the Site. Runoff sheet flows across the Site, resulting in considerable erosion and deposition into the wetlands. Groundwater is high throughout the Site, ranging from one to four feet below grade in the upland area. For the existing conditions hydrologic analysis, the site was divided into two drainage areas that contribute to two design points. The following is a summary of each drainage area.

Drainage Area 1 – This approximately 5.0-area comprises the majority of the Site and stretches from the northeast portion of the Site, across the northern and western parts, to the southwestern edge. The area consists of bare earth dirt and gravel with many pockets of sparse grass and a few clumps of saplings. Runoff from Drainage Area 1 flows in a westerly direction to Wetland 1 on the west side of the site.

Drainage Area 2 – This approximately 1.0-acre area in the southeast portion of the Site consists of bare earth dirt and gravel with many pockets of sparsely grassed landscape. Lightly wooded areas are minimally present as well. Runoff from Drainage Area 2 flows in a southerly direction to Wetland 2 on the south side of the site.

Figure 3 illustrates the existing drainage patterns on the Site. Table 2 below provides a summary of the existing conditions hydrologic data.

Table 2
Existing Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland 1	1	4.97	67	13.3
2	Wetland 3	2	0.99	63	9.1

Proposed Drainage Conditions

Figure 4 illustrates the proposed "post construction" drainage conditions for the project. As shown, the Site will be divided into five drainage areas that discharge treated stormwater to the two existing Design Points. The runoff from the paved areas is split between three drainage areas that flow to three lined bioretention basins, used to control peak rates and treat the stormwater. Existing drainage and grading patterns were maintained to the maximum extent possible. Drainage Areas 1, 2, and 4 flow to Design Point 1 and Drainage Areas 3 and 5 flow to Design Point 2. Low impact development stormwater management techniques have been incorporated into the design. These practices are focused on decentralizing stormwater management techniques into the design that will reduce peak runoff rates and treat for water quality. Water quality basins are dispersed around the perimeter of the development area. The following is a summary of each drainage area.

Drainage Area 1 – This 1.99-acre area in the northern portion of the site consists of a paved parking area for the station and Bioretention Basin 1 to the north of the parking. Runoff from Drainage Area 1 is directed through drainage grates in the sidewalk to Bioretention Basin 1, which discharges to Wetland 1.

Drainage Area 2 – This 1.35-acre area in the southern portion of the site consists of a paved parking area for the station and Bioretention Basin 2 to the south of the parking. Runoff from Drainage Area 2 is directed to Bioretention Basin 2, which discharges to Wetland 1.

Drainage Area 3 – This 1.35-acre area in the east portion of the site consists of the entrance drive, some of the paved parking for the station, grassed landscape area, and Bioretention Basin 3 to the south of the parking. Runoff from Drainage Area 3 is directed to a grassed swale that flows to Bioretention Basin 3, which discharges to Wetland 3.

Drainage Area 4 – This 1.00-acre area wraps around the perimeter of the site from the northeast corner, around the northwest portion of the Site, to the southwest corner. The area consists mostly of sloped grassed areas but also includes the new paved entranceway to the pump station. Runoff from the new pavement is captured by a grassed swale which flows to Wetland 1. Runoff from the rest of Drainage Arera 4 flows directly to Wetland 1.

Drainage Area 5 – This 0.29-acre area wraps around the southeastern perimeter of the site and consists of sloped grassed areas. Runoff flows directly to Wetland 3.

Table 3 below provides a summary of the proposed conditions hydrologic data.

Table 3
Proposed Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland 1	1	1.99	92	5.0
2	Wetland 1	1	1.35	97	5.0
3	Wetland 3	2	1.35	77	5.3
4	Wetland 1	1	1.00	66	5.0
5	Wetland 3	2	0.29	65	8.9

Integrated into the site design is a comprehensive stormwater management system that has been developed in accordance with the Massachusetts Stormwater Handbook. The proposed stormwater management system has been designed to treat the half inch Water Quality Volume.

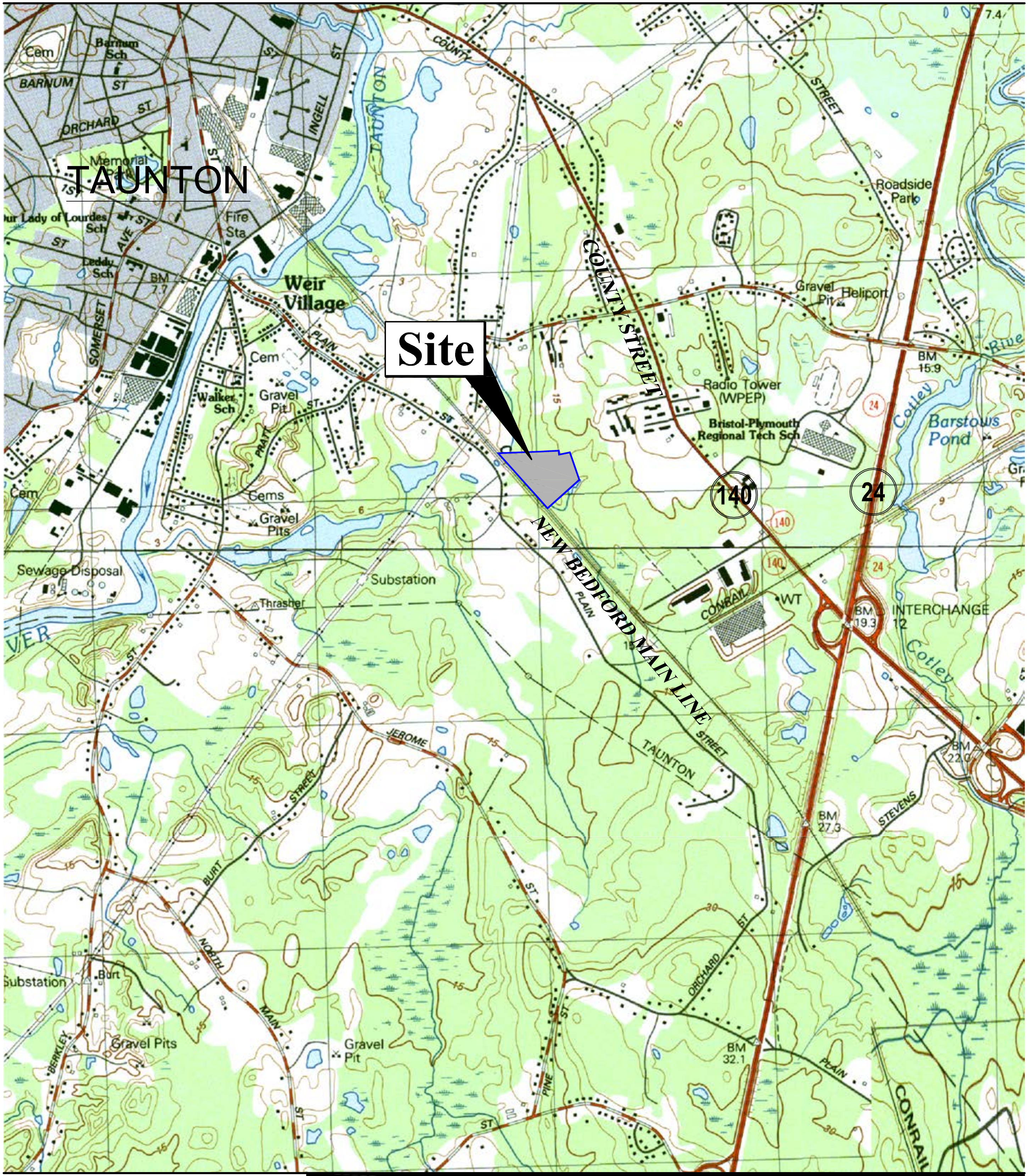
Environmentally Sensitive and Low Impact Development (LID) Techniques

Low Impact Development (LID) techniques and stormwater Best Management Practices (BMPs) implemented into the site design include:

- Bioretention basins
- Light colored pavement sidewalks
- Grassed swale

Most of the runoff from Drainage Area 3 will sheet flow to a grass swale before it is connected to bioretention Basin 3. The bioretention basins have been designed with soils to mimic the hydrology of the existing conditions in the upland areas

\\Vhb\proj\Boston\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Taunton Depot\Stormwater Figures\Figure 1\Figure 1-Site Locus.dwg



Vanasse Hangen Brustlin, Inc.

USGS Locus Map

Taunton Depot Station
South Coast Rail
Taunton, Massachusets

Figure 1
May 2012

0 1000 2000 Feet

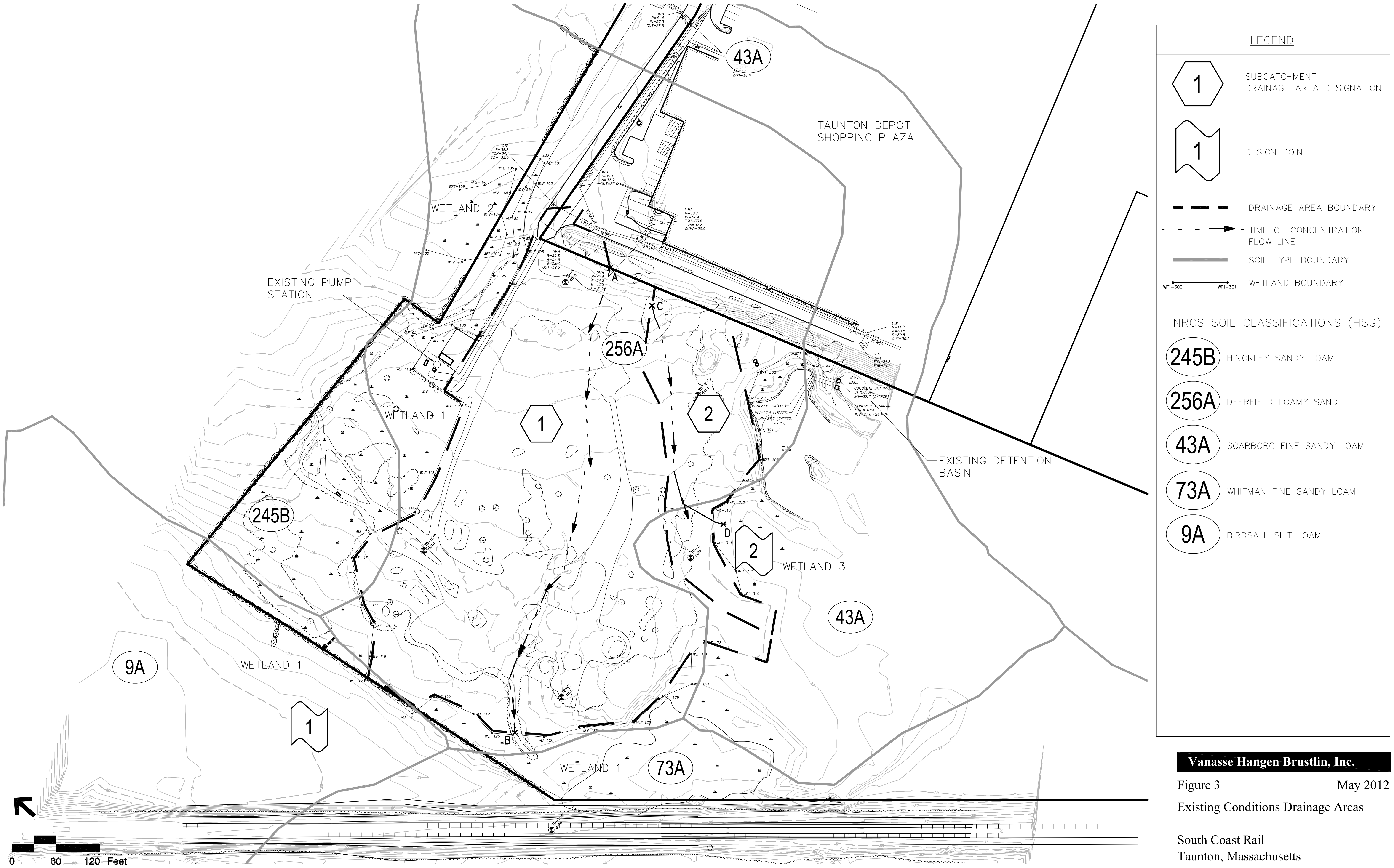
Vanasse Hangen Brustlin, Inc.

Site Aerial Map

Figure 2
May 2012

Taunton Depot Station
South Coast Rail
Taunton, Massachusets

\\Vhb\proj\Boston\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Taunton Depot\Stormwater Figures\Figure 3\Taunton Depot Existing Conditions.dwg

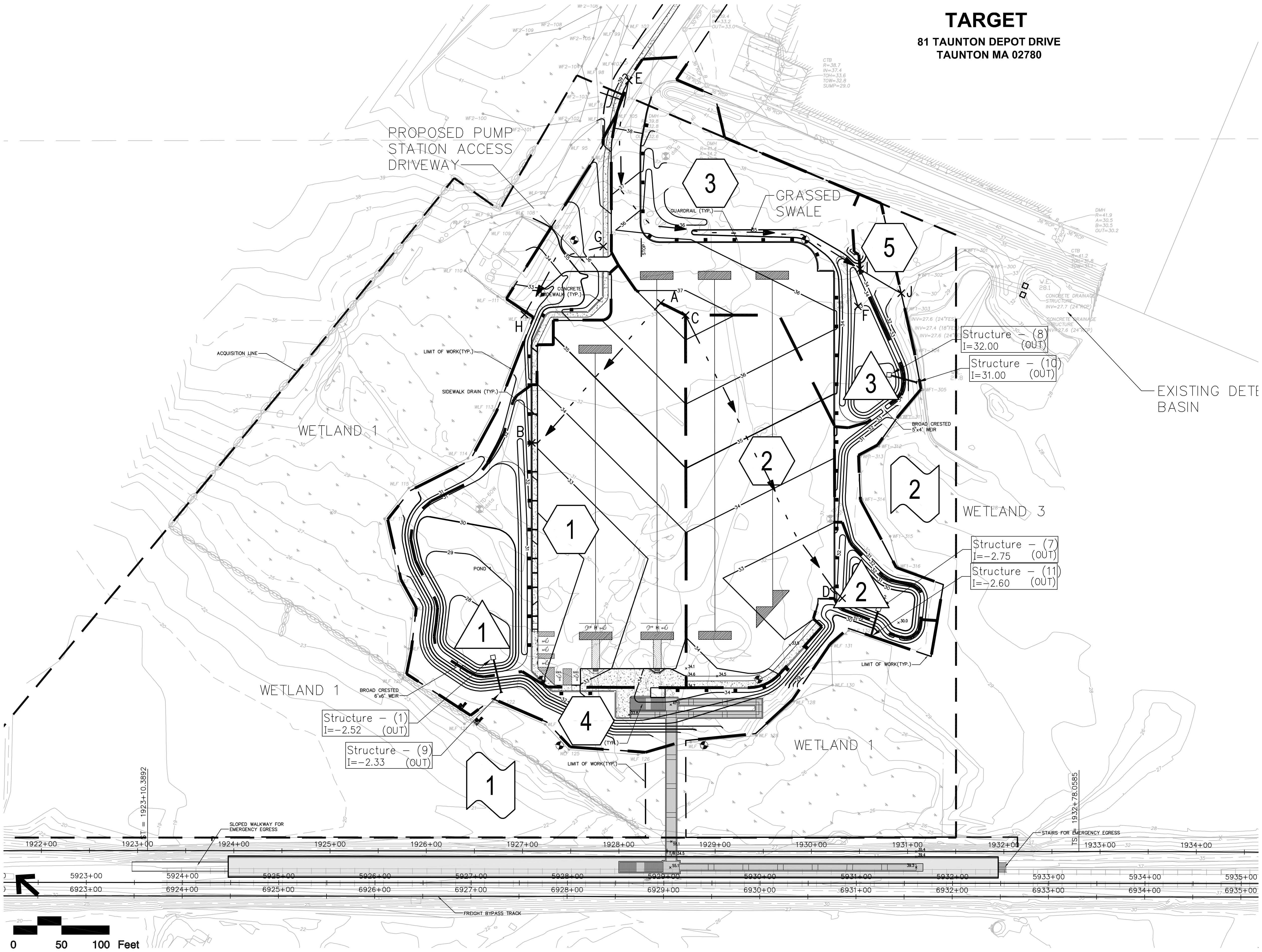


Vanasse Hangen Brustlin, Inc.

Figure 3 May 2012

Existing Conditions Drainage Areas

South Coast Rail
Taunton, Massachusetts



LEGEND

⬡ 1 SUBCATCHMENT DRAINAGE AREA DESIGNATION

△ 1 POND

1 DESIGN POINT

DRAINAGE AREA BOUNDARY

TIME OF CONCENTRATION FLOW LINE

SOIL TYPE BOUNDARY

WF1–300 WF1–301 WETLAND BOUNDARY

LIMIT OF ACQUISITION

LIMIT OF WORK

Vanasse Hangen Brustlin, Inc.

Figure 4 May 2012

Proposed Conditions Drainage Areas

South Coast Rail
Taunton, Massachusetts

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards at 310 CMR 10.05.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

All proposed Project stormwater outlets and conveyances have been designed to not cause erosion or scour to wetlands or receiving waters. Drainage basin outlets have been designed with flared end sections and stone protection to dissipate discharge velocities. Overflows from BMPs that impound stormwater have been designed with stone to protect downgradient areas from erosion.

Computations and supporting information for the sizing and selection of materials used to protect from scour and erosion are included in Appendix A.

Standard 2: Peak Rate Attenuation

The Project has been designed to fully comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, and 100-years. The results of the analysis, as summarized in Table 4 below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions.

Computations and supporting information regarding the hydrologic modeling are included in Appendix B.

Table 4
Peak Discharge Rates (cfs*)

Design Point	*2-year*	*10-year*	*100-year*
Design Point 1: Wetland 1			
Existing	3.1	7.2	15.2
Proposed	3.0	5.3	10.9
Design Point 2: Wetland 3			
Existing	0.5	1.3	3.0
Proposed	0.4	1.0	2.9

Standard 3: Stormwater Recharge

As described in the site description, the existing surface soils on the Site are comprised primarily of HSG B soils and provide an infiltration rate of approximately 1.02 inches per hour, according to 1982 Rawls Rates. In addition to the soil parameters, the Site has both a flat geography and a seasonal high groundwater table approximately one foot below existing grade that hinder the ability to provide the required two foot separation between the bottom of an infiltration structure and the seasonal high groundwater table. In existing conditions, however, infiltration on the site provides subsurface flow to wetland resource areas along the Site's border.

In an effort to mimic the Site's natural hydrology and meet the intent of the recharge requirements of Standard 3, the onsite bioretention basins have been oversized for treatment and exceed the Required Recharge Volume. The bioretention basins are required to be lined due to the elevation of the seasonal high groundwater table that does not allow for a separation of greater than two feet from the bottom of the bioretention basins. The soil within the bioretention basins however will be designed to approximate the infiltration rates of the existing soils (1.02 inches per hour) and provide two feet of depth in order to mimic the necessary separation from the seasonal high groundwater table and exceed that of existing conditions. After runoff is filtered through the two feet of biofiltration soil media, underdrains within the bioretention basins will slowly convey water to the wetland resource areas that surround the site, mimicking the base flows to the wetlands provided by the subsurface flows of the existing conditions.

A Geotechnical Report is included in Appendix E. The report indicates that the site has high groundwater so the basins will be lined.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum of 80% TSS removal for stormwater runoff from all proposed impervious surfaces.

Computations and supporting information are included in Appendix D.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a LUHPPL as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Standard 6: Critical Areas

The Project will not discharge stormwater near or to a critical area.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is not a redevelopment.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Controls

The Project would disturb approximately 6.0 acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) would be developed and a Notice of Intent for the CGP would be submitted by the contractor and owner at least 14 days before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls were discussed in the DEIR/S. Appropriate controls will be prepared and implemented by the contractor and MassDOT (MBTA) during construction in accordance with the final design and NPDES SWPPP.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan will be developed by the MBTA during final design for the Project.

Standard 10: Prohibition of Illicit Discharges

The site was previously undeveloped and no sanitary sewer or storm drainage infrastructure is known to exist on the site. The design plans submitted with this report have been designed in full compliance with current standards. The Long-Term Pollution Prevention Plan will include measures to prevent illicit discharges.

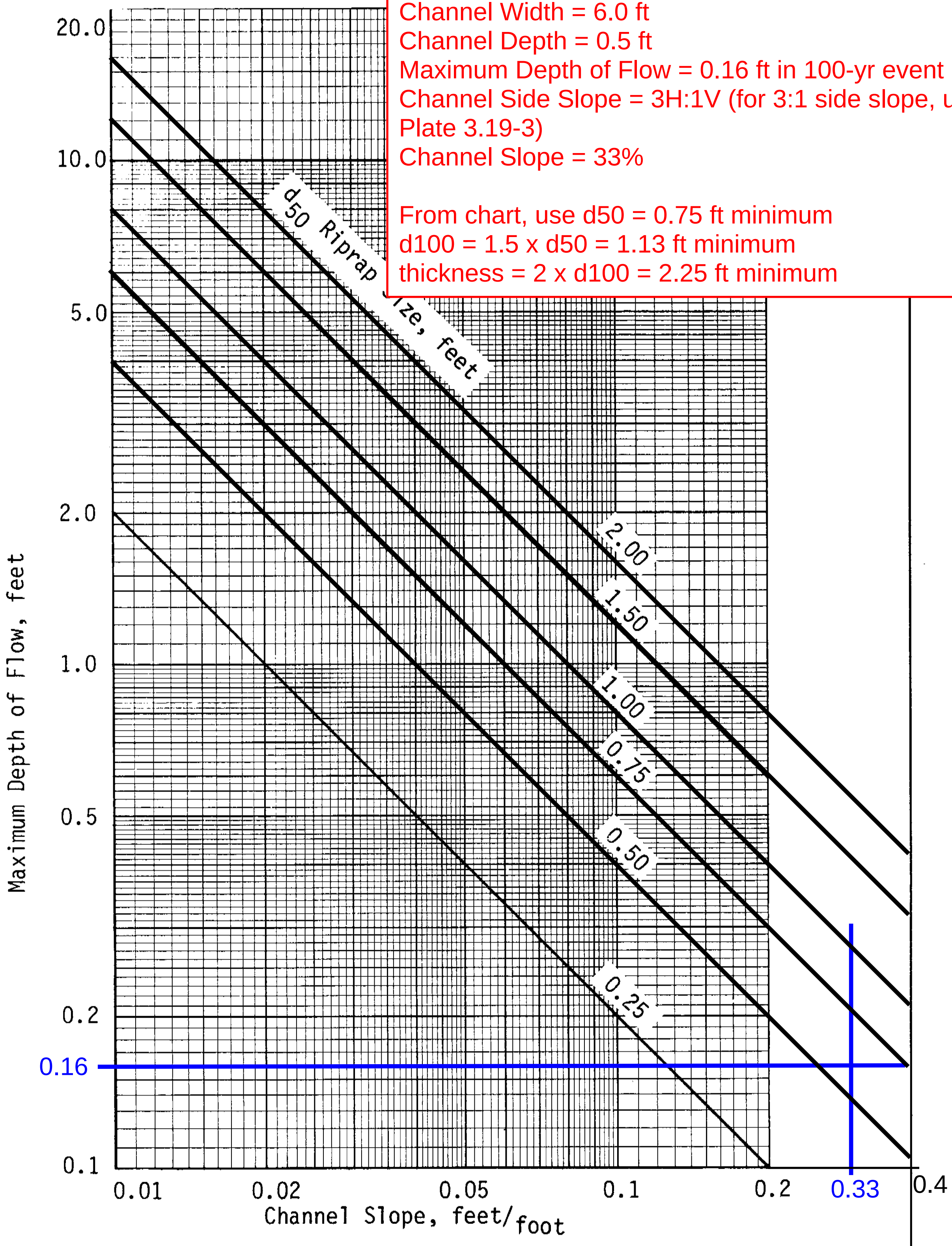
Appendix A
Standard 1 Computations and Supporting Information

Project No: 10111
Date: April 2012
Calculated By: EJM
Re: Bioretention Basin 1 Overflow Stone Sizing

Project Name: SCR
Location: Taunton, MA

Channel Width = 6.0 ft
Channel Depth = 0.5 ft
Maximum Depth of Flow = 0.16 ft in 100-yr event
Channel Side Slope = 3H:1V (for 3:1 side slope, use Plate 3.19-3)
Channel Slope = 33%

From chart, use d50 = 0.75 ft minimum
d100 = 1.5 x d50 = 1.13 ft minimum
thickness = 2 x d100 = 2.25 ft minimum



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

Source: VDOT Drainage Manual

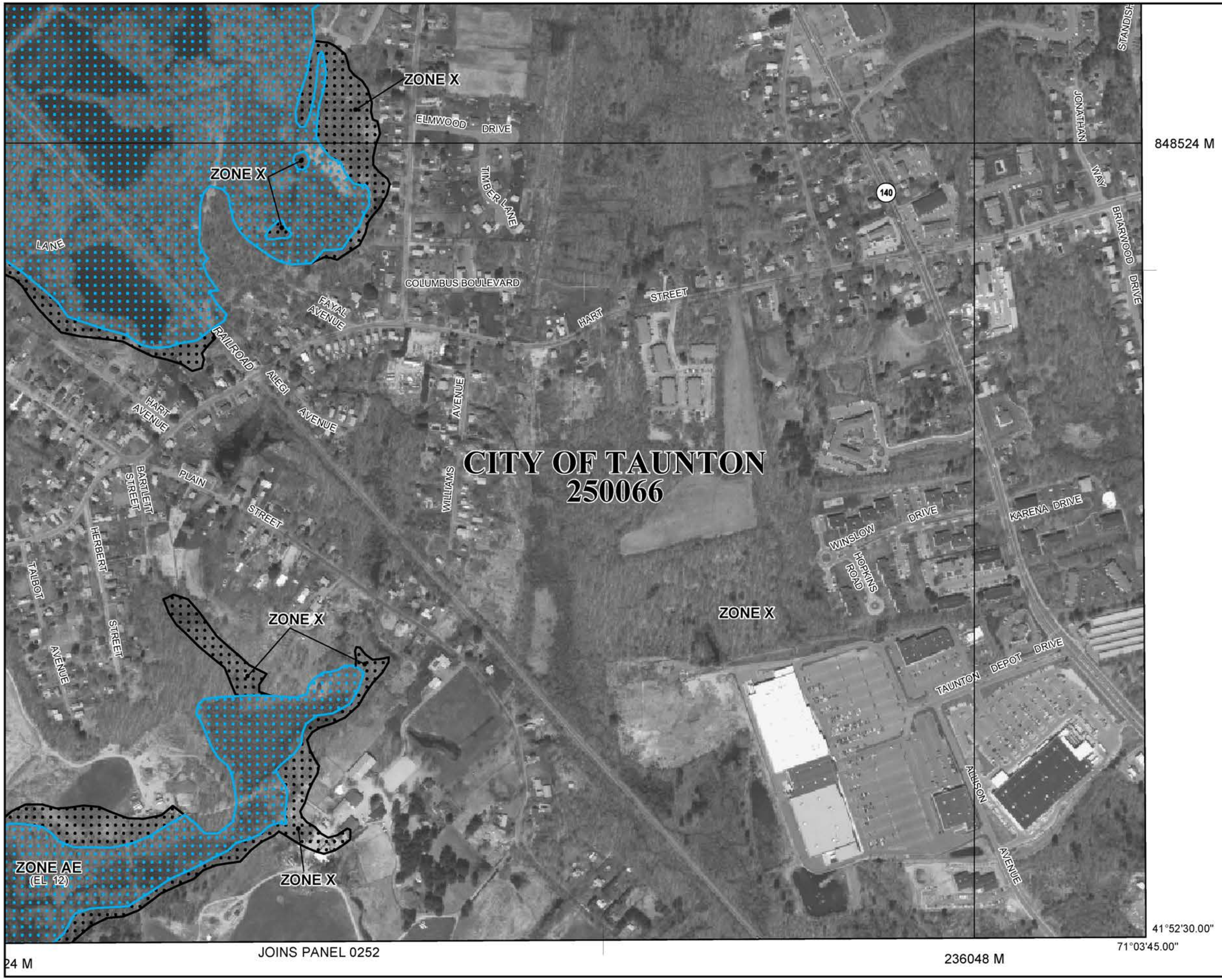
Plate 3.19-3

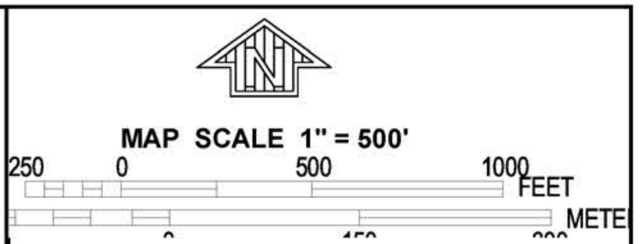
*Sizing calculations represent minimum stone size. Larger stone may be required per detail plans.

Appendix B
Standard 2 Computations and Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Bristol County. Runoff coefficients for the existing and proposed conditions, as previously shown in Tables 1 and 2 respectively, were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

FEMA Flood Map





NATIONAL FLOOD INSURANCE PROGRAM

NFIP

PANEL 0164F

FIRM
FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 164 OF 550
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
RAYNHAM, TOWN OF	250061	0164	F
TAUNTON, CITY OF	250066	0164	F

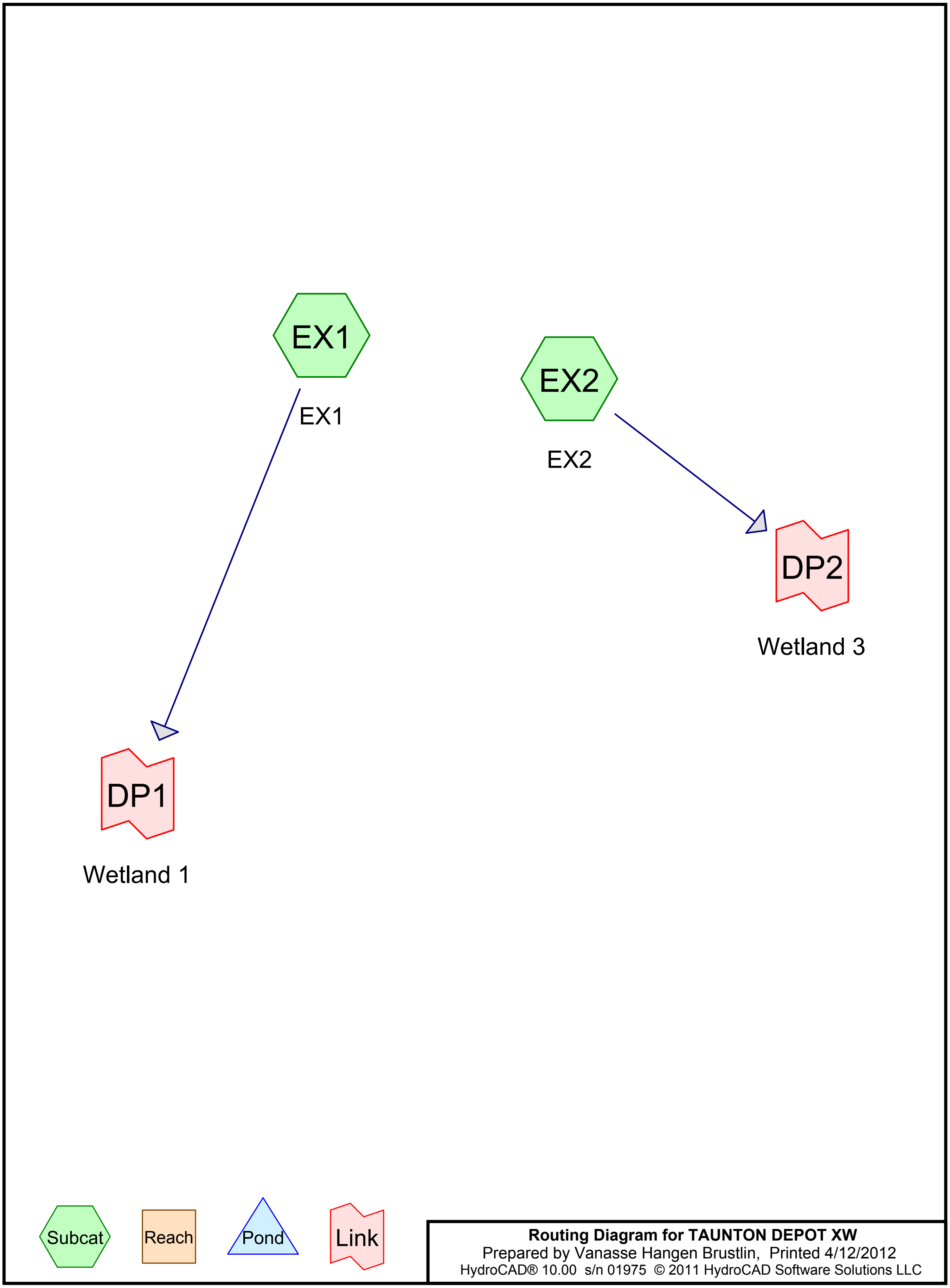
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25005C0164F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

HydroCAD Analysis: Existing Conditions



Routing Diagram for TAUNTON DEPOT XW
Prepared by Vanasse Hangen Brustlin, Printed 4/12/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.051	39	>75% Grass cover, Good, HSG A (EX1)
0.849	55	Woods, Good, HSG B (EX1, EX2)
3.261	61	>75% Grass cover, Good, HSG B (EX1, EX2)
0.010	72	Dirt roads, HSG A (EX1)
0.282	77	Woods, Good, HSG D (EX1, EX2)
0.151	80	>75% Grass cover, Good, HSG D (EX1, EX2)
1.243	82	Dirt roads, HSG B (EX1)
0.110	98	Paved parking, HSG B (EX1)
5.957	**66**	**TOTAL AREA**

2-Year Storm Event - Existing

```
                    Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
                           Runoff by SCS TR-20 method, UH=SCS
          Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentEX1: EX1                Runoff Area=4.967 ac   2.21% Impervious   Runoff Depth=0.79"
                                  Flow Length=699'   Tc=13.3 min   CN=67   Runoff=3.12 cfs  0.329 af

SubcatchmentEX2: EX2                Runoff Area=0.990 ac   0.00% Impervious   Runoff Depth=0.61"
                                   Flow Length=337'   Tc=9.1 min   CN=63   Runoff=0.48 cfs  0.050 af

Link DP1: Wetland 1                                                        Inflow=3.12 cfs  0.329 af
                                                                          Primary=3.12 cfs  0.329 af

Link DP2: Wetland 3                                                        Inflow=0.48 cfs  0.050 af
                                                                          Primary=0.48 cfs  0.050 af

          Total Runoff Area = 5.957 ac   Runoff Volume = 0.379 af   Average Runoff Depth = 0.76"
                                   98.15% Pervious = 5.847 ac     1.85% Impervious = 0.110 ac
```

Summary for Subcatchment EX1: EX1

Runoff = 3.12 cfs @ 12.21 hrs, Volume= 0.329 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.110	98	Paved parking, HSG B
0.051	39	>75% Grass cover, Good, HSG A
2.786	61	>75% Grass cover, Good, HSG B
0.085	80	>75% Grass cover, Good, HSG D
0.574	55	Woods, Good, HSG B
0.108	77	Woods, Good, HSG D
0.010	72	Dirt roads, HSG A
1.243	82	Dirt roads, HSG B
4.967	67	Weighted Average
4.857		97.79% Pervious Area
0.110		2.21% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	38	0.0790	0.25		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.2	12	0.0420	1.25		**Sheet Flow, Dirt B** Smooth surfaces n= 0.011 P2= 3.40"
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.5	44	0.0450	1.48		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.4	87	0.0230	1.06		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.6	75	0.0130	0.80		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
4.9	158	0.0060	0.54		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
1.1	136	0.0150	1.97		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.7	75	0.0130	1.84		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
13.3	699	Total			

Summary for Subcatchment EX2: EX2

Runoff = 0.48 cfs @ 12.16 hrs, Volume= 0.050 af, Depth= 0.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.275	55	Woods, Good, HSG B
0.174	77	Woods, Good, HSG D
0.475	61	>75% Grass cover, Good, HSG B
0.066	80	>75% Grass cover, Good, HSG D
0.990	63	Weighted Average
0.990		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	50	0.0600	0.24		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.1	75	0.0267	1.14		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.5	104	0.0096	0.69		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.2	54	0.0210	0.72		**Shallow Concentrated Flow, Woods D** Woodland Kv= 5.0 fps
0.2	14	0.0310	1.23		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.5	28	0.0196	0.98		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.1	12	0.0430	1.45		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
9.1	337	Total			

Summary for Link DP1: Wetland 1

Inflow Area = 4.967 ac, 2.21% Impervious, Inflow Depth = 0.79" for 2 yr storm event
Inflow = 3.12 cfs @ 12.21 hrs, Volume= 0.329 af
Primary = 3.12 cfs @ 12.21 hrs, Volume= 0.329 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Summary for Link DP2: Wetland 3

Inflow Area = 0.990 ac, 0.00% Impervious, Inflow Depth = 0.61" for 2 yr storm event
Inflow = 0.48 cfs @ 12.16 hrs, Volume= 0.050 af
Primary = 0.48 cfs @ 12.16 hrs, Volume= 0.050 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

10-Year Storm Event - Existing

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=4.967 ac 2.21% Impervious Runoff Depth=1.63"
Flow Length=699' Tc=13.3 min CN=67 Runoff=7.16 cfs 0.675 af

SubcatchmentEX2: EX2 Runoff Area=0.990 ac 0.00% Impervious Runoff Depth=1.35"
Flow Length=337' Tc=9.1 min CN=63 Runoff=1.29 cfs 0.112 af

Link DP1: Wetland 1 Inflow=7.16 cfs 0.675 af
Primary=7.16 cfs 0.675 af

Link DP2: Wetland 3 Inflow=1.29 cfs 0.112 af
Primary=1.29 cfs 0.112 af

Total Runoff Area = 5.957 ac Runoff Volume = 0.787 af Average Runoff Depth = 1.58"
98.15% Pervious = 5.847 ac 1.85% Impervious = 0.110 ac

Summary for Subcatchment EX1: EX1

Runoff = 7.16 cfs @ 12.19 hrs, Volume= 0.675 af, Depth= 1.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.110	98	Paved parking, HSG B
0.051	39	>75% Grass cover, Good, HSG A
2.786	61	>75% Grass cover, Good, HSG B
0.085	80	>75% Grass cover, Good, HSG D
0.574	55	Woods, Good, HSG B
0.108	77	Woods, Good, HSG D
0.010	72	Dirt roads, HSG A
1.243	82	Dirt roads, HSG B
4.967	67	Weighted Average
4.857		97.79% Pervious Area
0.110		2.21% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	38	0.0790	0.25		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.2	12	0.0420	1.25		**Sheet Flow, Dirt B** Smooth surfaces n= 0.011 P2= 3.40"
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.5	44	0.0450	1.48		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.4	87	0.0230	1.06		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.6	75	0.0130	0.80		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
4.9	158	0.0060	0.54		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
1.1	136	0.0150	1.97		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.7	75	0.0130	1.84		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
13.3	699	Total			

Summary for Subcatchment EX2: EX2

Runoff = 1.29 cfs @ 12.14 hrs, Volume= 0.112 af, Depth= 1.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.275	55	Woods, Good, HSG B
0.174	77	Woods, Good, HSG D
0.475	61	>75% Grass cover, Good, HSG B
0.066	80	>75% Grass cover, Good, HSG D
0.990	63	Weighted Average
0.990		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	50	0.0600	0.24		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.1	75	0.0267	1.14		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.5	104	0.0096	0.69		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.2	54	0.0210	0.72		**Shallow Concentrated Flow, Woods D** Woodland Kv= 5.0 fps
0.2	14	0.0310	1.23		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.5	28	0.0196	0.98		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.1	12	0.0430	1.45		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
9.1	337	Total			

Summary for Link DP1: Wetland 1

Inflow Area = 4.967 ac, 2.21% Impervious, Inflow Depth = 1.63" for 10 yr storm event
Inflow = 7.16 cfs @ 12.19 hrs, Volume= 0.675 af
Primary = 7.16 cfs @ 12.19 hrs, Volume= 0.675 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Summary for Link DP2: Wetland 3

Inflow Area = 0.990 ac, 0.00% Impervious, Inflow Depth = 1.35" for 10 yr storm event
Inflow = 1.29 cfs @ 12.14 hrs, Volume= 0.112 af
Primary = 1.29 cfs @ 12.14 hrs, Volume= 0.112 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

100-Year Storm Event - Existing

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEX1: EX1 Runoff Area=4.967 ac 2.21% Impervious Runoff Depth=3.31"
Flow Length=699' Tc=13.3 min CN=67 Runoff=15.15 cfs 1.369 af

SubcatchmentEX2: EX2 Runoff Area=0.990 ac 0.00% Impervious Runoff Depth=2.90"
Flow Length=337' Tc=9.1 min CN=63 Runoff=2.97 cfs 0.239 af

Link DP1: Wetland 1 Inflow=15.15 cfs 1.369 af
Primary=15.15 cfs 1.369 af

Link DP2: Wetland 3 Inflow=2.97 cfs 0.239 af
Primary=2.97 cfs 0.239 af

Total Runoff Area = 5.957 ac Runoff Volume = 1.608 af Average Runoff Depth = 3.24"
98.15% Pervious = 5.847 ac 1.85% Impervious = 0.110 ac

Summary for Subcatchment EX1: EX1

Runoff = 15.15 cfs @ 12.19 hrs, Volume= 1.369 af, Depth= 3.31"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.110	98	Paved parking, HSG B
0.051	39	>75% Grass cover, Good, HSG A
2.786	61	>75% Grass cover, Good, HSG B
0.085	80	>75% Grass cover, Good, HSG D
0.574	55	Woods, Good, HSG B
0.108	77	Woods, Good, HSG D
0.010	72	Dirt roads, HSG A
1.243	82	Dirt roads, HSG B
4.967	67	Weighted Average
4.857		97.79% Pervious Area
0.110		2.21% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	38	0.0790	0.25		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.2	12	0.0420	1.25		**Sheet Flow, Dirt B** Smooth surfaces n= 0.011 P2= 3.40"
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.5	44	0.0450	1.48		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.4	87	0.0230	1.06		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.6	75	0.0130	0.80		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
4.9	158	0.0060	0.54		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
0.2	37	0.0540	3.74		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
1.1	136	0.0150	1.97		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
0.7	75	0.0130	1.84		**Shallow Concentrated Flow, Dirt B** Unpaved Kv= 16.1 fps
13.3	699	Total			

Summary for Subcatchment EX2: EX2

Runoff = 2.97 cfs @ 12.13 hrs, Volume= 0.239 af, Depth= 2.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.275	55	Woods, Good, HSG B
0.174	77	Woods, Good, HSG D
0.475	61	>75% Grass cover, Good, HSG B
0.066	80	>75% Grass cover, Good, HSG D
0.990	63	Weighted Average
0.990		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	50	0.0600	0.24		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.1	75	0.0267	1.14		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.5	104	0.0096	0.69		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.2	54	0.0210	0.72		**Shallow Concentrated Flow, Woods D** Woodland Kv= 5.0 fps
0.2	14	0.0310	1.23		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.5	28	0.0196	0.98		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
0.1	12	0.0430	1.45		**Shallow Concentrated Flow, Landscape D** Short Grass Pasture Kv= 7.0 fps
9.1	337	Total			

Summary for Link DP1: Wetland 1

Inflow Area = 4.967 ac, 2.21% Impervious, Inflow Depth = 3.31" for 100 yr storm event
Inflow = 15.15 cfs @ 12.19 hrs, Volume= 1.369 af
Primary = 15.15 cfs @ 12.19 hrs, Volume= 1.369 af, Atten= 0%, Lag= 0.0 min

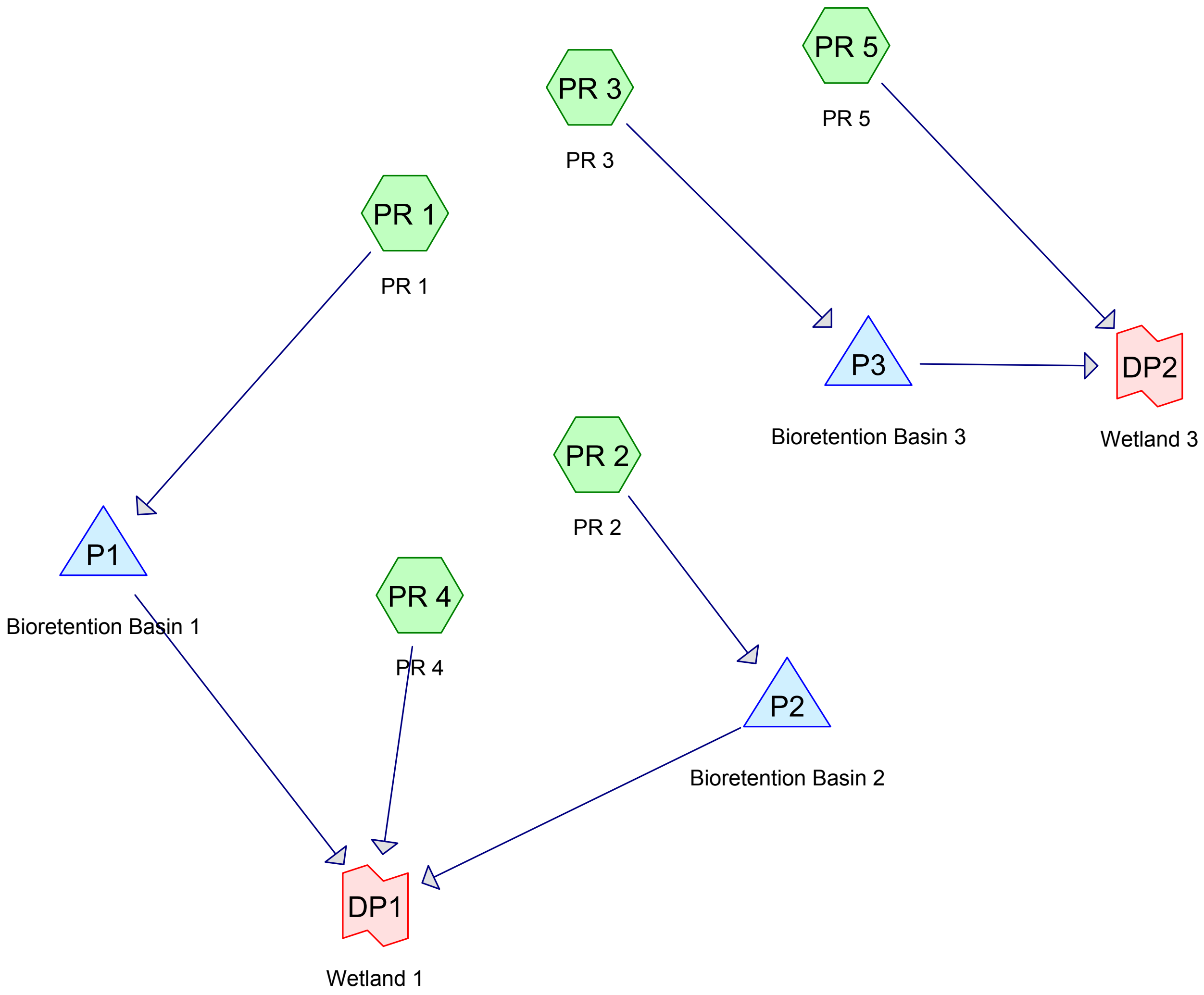
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

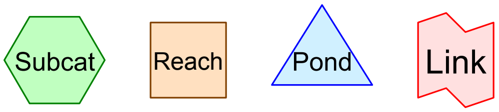
Summary for Link DP2: Wetland 3

Inflow Area = 0.990 ac, 0.00% Impervious, Inflow Depth = 2.90" for 100 yr storm event
Inflow = 2.97 cfs @ 12.13 hrs, Volume= 0.239 af
Primary = 2.97 cfs @ 12.13 hrs, Volume= 0.239 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

HydroCAD Analysis: Proposed Conditions





Routing Diagram for TAUNTON DEPOT PR
Prepared by Vanasse Hangen Brustlin, Printed 5/3/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.001	30	Woods, Good, HSG A (PR 4)
0.061	39	>75% Grass cover, Good, HSG A (PR 1, PR 4)
0.411	55	Woods, Good, HSG B (PR 4, PR 5)
1.554	61	>75% Grass cover, Good, HSG B (PR 1, PR 2, PR 3, PR 4, PR 5)
0.107	77	Woods, Good, HSG D (PR 4, PR 5)
0.082	80	>75% Grass cover, Good, HSG D (PR 2, PR 4, PR 5)
3.269	98	Paved parking, HSG B (PR 1, PR 2, PR 3, PR 4)
0.159	98	Paved parking, HSG D (PR 2)
0.242	98	Water Surface, 0% imp, HSG B (PR 1, PR 2)
0.077	98	Water Surface, 0% imp, HSG D (PR 2)
5.963	**84**	**TOTAL AREA**

2-Year Storm Event - Proposed

```
                      Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
                             Runoff by SCS TR-20 method, UH=SCS
             Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentPR 1: PR 1               Runoff Area=1.985 ac   72.34% Impervious   Runoff Depth=2.54"
                                    Flow Length=200'   Tc=5.0 min   CN=92   Runoff=5.96 cfs  0.420 af

SubcatchmentPR 2: PR 2               Runoff Area=1.348 ac   90.58% Impervious   Runoff Depth=3.06"
                                    Flow Length=337'   Tc=5.0 min   CN=97   Runoff=4.55 cfs  0.343 af

SubcatchmentPR 3: PR 3               Runoff Area=1.348 ac   42.80% Impervious   Runoff Depth=1.36"
                                    Flow Length=438'   Tc=5.3 min   CN=77   Runoff=2.16 cfs  0.152 af

SubcatchmentPR 4: PR 4               Runoff Area=0.996 ac   19.48% Impervious   Runoff Depth=0.75"
                                    Flow Length=117'   Tc=5.0 min   CN=66   Runoff=0.76 cfs  0.062 af

SubcatchmentPR 5: PR 5                Runoff Area=0.286 ac   0.00% Impervious   Runoff Depth=0.70"
                                     Flow Length=50'   Tc=8.9 min   CN=65   Runoff=0.17 cfs  0.017 af

Pond P1: BioretentionBasin 1          Peak Elev=30.07'  Storage=17,870 cf   Inflow=5.96 cfs  0.420 af
                                                                           Outflow=0.04 cfs  0.022 af

Pond P2: BioretentionBasin 2           Peak Elev=31.60'  Storage=5,671 cf   Inflow=4.55 cfs  0.343 af
                                                                           Outflow=2.48 cfs  0.288 af

Pond P3: BioretentionBasin 3           Peak Elev=32.87'  Storage=2,902 cf   Inflow=2.16 cfs  0.152 af
                                                                           Outflow=0.33 cfs  0.117 af

Link DP1: Wetland 1                                                         Inflow=3.03 cfs  0.372 af
                                                                           Primary=3.03 cfs  0.372 af

Link DP2: Wetland 3                                                         Inflow=0.39 cfs  0.134 af
                                                                           Primary=0.39 cfs  0.134 af

          Total Runoff Area = 5.963 ac   Runoff Volume = 0.995 af   Average Runoff Depth = 2.00"
                                   42.51% Pervious = 2.535 ac     57.49% Impervious = 3.428 ac
```

Summary for Subcatchment PR 1: PR 1

Runoff = 5.96 cfs @ 12.07 hrs, Volume= 0.420 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
1.436	98	Paved parking, HSG B
0.014	39	>75% Grass cover, Good, HSG A
0.300	61	>75% Grass cover, Good, HSG B
0.235	98	Water Surface, 0% imp, HSG B
1.985	92	Weighted Average
0.549		27.66% Pervious Area
1.436		72.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0180	1.18		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	150	0.0270	3.34		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
3.6					**Direct Entry, <5 min Tc Adjustment**
5.0	200	Total			

Summary for Subcatchment PR 2: PR 2

Runoff = 4.55 cfs @ 12.07 hrs, Volume= 0.343 af, Depth= 3.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
1.062	98	Paved parking, HSG B
0.159	98	Paved parking, HSG D
0.008	61	>75% Grass cover, Good, HSG B
0.035	80	>75% Grass cover, Good, HSG D
0.007	98	Water Surface, 0% imp, HSG B
0.077	98	Water Surface, 0% imp, HSG D
1.348	97	Weighted Average
0.127		9.42% Pervious Area
1.221		90.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	50	0.0120	1.01		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
1.7	287	0.0200	2.87		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
2.5					**Direct Entry, <5 min Tc Adjustment**
5.0	337	Total			

Summary for Subcatchment PR 3: PR 3

Runoff = 2.16 cfs @ 12.08 hrs, Volume= 0.152 af, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.577	98	Paved parking, HSG B
0.771	61	>75% Grass cover, Good, HSG B
1.348	77	Weighted Average
0.771		57.20% Pervious Area
0.577		42.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.23		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	114	0.0180	2.72		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
1.1	59	0.0170	0.91		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.3	159	0.0060	1.16		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
0.5	56	0.0180	2.01		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
5.3	438	Total			

Summary for Subcatchment PR 4: PR 4

Runoff = 0.76 cfs @ 12.09 hrs, Volume= 0.062 af, Depth= 0.75"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.194	98	Paved parking, HSG B
0.001	30	Woods, Good, HSG A
0.293	55	Woods, Good, HSG B
0.005	77	Woods, Good, HSG D
0.047	39	>75% Grass cover, Good, HSG A
0.420	61	>75% Grass cover, Good, HSG B
0.036	80	>75% Grass cover, Good, HSG D
0.996	66	Weighted Average
0.802		80.52% Pervious Area
0.194		19.48% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	38	0.0530	0.21		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.1	12	0.0540	1.38		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.3	47	0.0210	2.94		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
0.3	20	0.0250	1.11		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.3					**Direct Entry, <5 min Tc Adjustment**
5.0	117	Total			

Summary for Subcatchment PR 5: PR 5

Runoff = 0.17 cfs @ 12.15 hrs, Volume= 0.017 af, Depth= 0.70"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.055	61	>75% Grass cover, Good, HSG B
0.011	80	>75% Grass cover, Good, HSG D
0.118	55	Woods, Good, HSG B
0.102	77	Woods, Good, HSG D
0.286	65	Weighted Average
0.286		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	3	0.3300	0.27		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.4	11	0.0310	0.13		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
5.0	21	0.0310	0.07		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
2.3	15	0.1100	0.11		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
8.9	50	Total			

Summary for Pond P1: Bioretention Basin 1

Inflow Area = 1.985 ac, 72.34% Impervious, Inflow Depth = 2.54" for 2 yr storm event
Inflow = 5.96 cfs @ 12.07 hrs, Volume= 0.420 af
Outflow = 0.04 cfs @ 24.05 hrs, Volume= 0.022 af, Atten= 99%, Lag= 718.9 min
Primary = 0.04 cfs @ 24.05 hrs, Volume= 0.022 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 30.07' @ 24.05 hrs Surf.Area= 14,070 sf Storage= 17,870 cf

Plug-Flow detention time= 969.4 min calculated for 0.022 af (5% of inflow)
Center-of-Mass det. time= 679.5 min (1,474.2 - 794.7)

Volume	Invert	Avail.Storage	Storage Description
#1	28.00'	33,480 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
28.00	3,790	237.0	0	0	3,790
29.00	8,407	366.0	5,947	5,947	9,987
30.00	13,678	468.0	10,936	16,883	16,770
31.00	19,697	573.0	16,596	33,480	25,484

Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**12.0" Round RCP_Round 12"** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 28.00' / 27.00' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	30.00'	**8.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600
#3	Primary	30.50'	**6.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

```
Primary OutFlow Max=0.04 cfs @ 24.05 hrs  HW=30.07'   (Free Discharge)
├─1=RCP_Round  12" (Passes 0.04 cfs of 4.74 cfs potential flow)
│  └─2=Orifice/Grate  (Orifice Controls 0.04 cfs @ 0.86 fps)
└─3=Broad-Crested Rectangular Weir( Controls 0.00 cfs)
```

Summary for Pond P2: Bioretention Basin 2

```
Inflow Area =         1.348 ac,  90.58% Impervious,  Inflow Depth =   3.06"    for  2 yr storm event
Inflow      =        4.55 cfs @   12.07 hrs,  Volume=          0.343 af
Outflow     =        2.48 cfs @   12.18 hrs,  Volume=          0.288 af,  Atten= 45%,  Lag= 6.6 min
Primary     =        2.48 cfs @   12.18 hrs,  Volume=          0.288 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 31.60' @ 12.18 hrs   Surf.Area= 4,268 sf   Storage= 5,671 cf

Plug-Flow detention time= 156.5 min calculated for 0.288 af (84% of inflow)
Center-of-Mass det. time= 89.9 min ( 853.5 - 763.6 )

Volume       Invert     Avail.Storage   Storage Description
   #1        30.00'          7,449 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation        Surf.Area     Perim.         Inc.Store        Cum.Store          Wet.Area
    (feet)           (sq-ft)     (feet)      (cubic-feet)     (cubic-feet)            (sq-ft)
     30.00            2,881      246.0                 0                0              2,881
     31.00            3,690      371.0             3,277            3,277              9,026
     32.00            4,673      320.0             4,172            7,449             11,852

Device   Routing            Invert   Outlet Devices
   #1    Primary            30.00'   12.0"  Round RCP_Round  12"
                                     L= 65.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                     Inlet / Outlet Invert= 30.00' / 29.25'   S= 0.0115 '/'   Cc= 0.900
                                     n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
   #2    Device 1           30.75'   10.0" W x 9.0" H Vert. Orifice/Grate  C= 0.600
   #3    Primary            31.50'   6.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                     Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                     2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                     Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                                     2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32

Primary OutFlow Max=2.48 cfs @ 12.18 hrs  HW=31.60'   (Free Discharge)
├─1=RCP_Round  12" (Passes 2.02 cfs of 3.89 cfs potential flow)
│  └─2=Orifice/Grate  (Orifice Controls 2.02 cfs @ 3.23 fps)
└─3=Broad-Crested Rectangular Weir(Weir Controls 0.47 cfs @ 0.76 fps)
```

Summary for Pond P3: Bioretention Basin 3

```
Inflow Area =       1.348 ac,  42.80% Impervious,  Inflow Depth =   1.36"    for  2 yr storm event
Inflow      =       2.16 cfs @   12.08 hrs,  Volume=          0.152 af
Outflow     =       0.33 cfs @   12.64 hrs,  Volume=          0.117 af,  Atten= 85%,  Lag= 33.5 min
Primary     =       0.33 cfs @   12.64 hrs,  Volume=          0.117 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 32.87' @ 12.64 hrs   Surf.Area= 4,579 sf   Storage= 2,902 cf

Plug-Flow detention time= 218.8 min calculated for 0.117 af (77% of inflow)
Center-of-Mass det. time= 131.5 min ( 979.8 - 848.3 )

Volume       Invert    Avail.Storage   Storage Description
   #1        32.00'        9,440 cf    Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation       Surf.Area     Perim.        Inc.Store        Cum.Store          Wet.Area
    (feet)          (sq-ft)     (feet)     (cubic-feet)     (cubic-feet)            (sq-ft)
     32.00            2,207      177.0                0                0              2,207
     33.00            4,993      291.0            3,507            3,507              6,459
     34.00            6,927      401.0            5,934            9,440             12,526

Device   Routing           Invert   Outlet Devices
   #1    Primary           32.00'   12.0"  Round RCP_Round  12"
                                    L= 35.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                    Inlet / Outlet Invert= 32.00' / 31.00'   S= 0.0286 '/'   Cc= 0.900
                                    n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
   #2    Device 1          32.50'   6.0" Vert. Orifice/Grate   C= 0.600
   #3    Primary           33.60'   5.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                    Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                    2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                    Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                                    2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32

Primary OutFlow  Max=0.33 cfs @ 12.64 hrs  HW=32.87'   (Free Discharge)
├─1=RCP_Round  12" (Passes 0.33 cfs of 2.32 cfs potential flow)
│  └─2=Orifice/Grate  (Orifice Controls 0.33 cfs @ 2.08 fps)
└─3=Broad-Crested Rectangular Weir( Controls 0.00 cfs)
```

Summary for Link DP1: Wetland 1

```
Inflow Area =       4.329 ac,  65.86% Impervious,  Inflow Depth >   1.03"    for  2 yr storm event
Inflow      =       3.03 cfs @   12.16 hrs,  Volume=          0.372 af
Primary     =       3.03 cfs @   12.16 hrs,  Volume=          0.372 af,  Atten= 0%,  Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
```

Summary for Link DP2: Wetland 3

Inflow Area = 1.634 ac, 35.31% Impervious, Inflow Depth > 0.98" for 2 yr storm event
Inflow = 0.39 cfs @ 12.49 hrs, Volume= 0.134 af
Primary = 0.39 cfs @ 12.49 hrs, Volume= 0.134 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

10-Year Storm Event- Proposed

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentPR 1: PR 1 Runoff Area=1.985 ac 72.34% Impervious Runoff Depth=3.85"
Flow Length=200' Tc=5.0 min CN=92 Runoff=8.83 cfs 0.636 af

SubcatchmentPR 2: PR 2 Runoff Area=1.348 ac 90.58% Impervious Runoff Depth=4.40"
Flow Length=337' Tc=5.0 min CN=97 Runoff=6.44 cfs 0.494 af

SubcatchmentPR 3: PR 3 Runoff Area=1.348 ac 42.80% Impervious Runoff Depth=2.42"
Flow Length=438' Tc=5.3 min CN=77 Runoff=3.91 cfs 0.271 af

SubcatchmentPR 4: PR 4 Runoff Area=0.996 ac 19.48% Impervious Runoff Depth=1.56"
Flow Length=117' Tc=5.0 min CN=66 Runoff=1.79 cfs 0.129 af

SubcatchmentPR 5: PR 5 Runoff Area=0.286 ac 0.00% Impervious Runoff Depth=1.49"
Flow Length=50' Tc=8.9 min CN=65 Runoff=0.42 cfs 0.035 af

Pond P1: Bioretention Basin 1 Peak Elev=30.28' Storage=20,873 cf Inflow=8.83 cfs 0.636 af
Outflow=0.31 cfs 0.231 af

Pond P2: Bioretention Basin 2 Peak Elev=31.78' Storage=6,433 cf Inflow=6.44 cfs 0.494 af
Outflow=4.53 cfs 0.439 af

Pond P3: Bioretention Basin 3 Peak Elev=33.31' Storage=5,146 cf Inflow=3.91 cfs 0.271 af
Outflow=0.71 cfs 0.236 af

Link DP1: Wetland 1 Inflow=6.03 cfs 0.799 af
Primary=6.03 cfs 0.799 af

Link DP2: Wetland 3 Inflow=0.97 cfs 0.271 af
Primary=0.97 cfs 0.271 af

Total Runoff Area = 5.963 ac Runoff Volume = 1.566 af Average Runoff Depth = 3.15"
42.51% Pervious = 2.535 ac 57.49% Impervious = 3.428 ac

Summary for Subcatchment PR 1: PR 1

Runoff = 8.83 cfs @ 12.07 hrs, Volume= 0.636 af, Depth= 3.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
1.436	98	Paved parking, HSG B
0.014	39	>75% Grass cover, Good, HSG A
0.300	61	>75% Grass cover, Good, HSG B
0.235	98	Water Surface, 0% imp, HSG B
1.985	92	Weighted Average
0.549		27.66% Pervious Area
1.436		72.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0180	1.18		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	150	0.0270	3.34		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
3.6					**Direct Entry, <5 min Tc Adjustment**
5.0	200	Total			

Summary for Subcatchment PR 2: PR 2

Runoff = 6.44 cfs @ 12.07 hrs, Volume= 0.494 af, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
1.062	98	Paved parking, HSG B
0.159	98	Paved parking, HSG D
0.008	61	>75% Grass cover, Good, HSG B
0.035	80	>75% Grass cover, Good, HSG D
0.007	98	Water Surface, 0% imp, HSG B
0.077	98	Water Surface, 0% imp, HSG D
1.348	97	Weighted Average
0.127		9.42% Pervious Area
1.221		90.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	50	0.0120	1.01		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
1.7	287	0.0200	2.87		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
2.5					**Direct Entry, <5 min Tc Adjustment**
5.0	337	Total			

Summary for Subcatchment PR 3: PR 3

Runoff = 3.91 cfs @ 12.08 hrs, Volume= 0.271 af, Depth= 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.577	98	Paved parking, HSG B
0.771	61	>75% Grass cover, Good, HSG B
1.348	77	Weighted Average
0.771		57.20% Pervious Area
0.577		42.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.23		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	114	0.0180	2.72		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
1.1	59	0.0170	0.91		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.3	159	0.0060	1.16		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
0.5	56	0.0180	2.01		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
5.3	438	Total			

Summary for Subcatchment PR 4: PR 4

Runoff = 1.79 cfs @ 12.08 hrs, Volume= 0.129 af, Depth= 1.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.194	98	Paved parking, HSG B
0.001	30	Woods, Good, HSG A
0.293	55	Woods, Good, HSG B
0.005	77	Woods, Good, HSG D
0.047	39	>75% Grass cover, Good, HSG A
0.420	61	>75% Grass cover, Good, HSG B
0.036	80	>75% Grass cover, Good, HSG D
0.996	66	Weighted Average
0.802		80.52% Pervious Area
0.194		19.48% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	38	0.0530	0.21		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.1	12	0.0540	1.38		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.3	47	0.0210	2.94		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
0.3	20	0.0250	1.11		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.3					**Direct Entry, <5 min Tc Adjustment**
5.0	117	Total			

Summary for Subcatchment PR 5: PR 5

Runoff = 0.42 cfs @ 12.13 hrs, Volume= 0.035 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.055	61	>75% Grass cover, Good, HSG B
0.011	80	>75% Grass cover, Good, HSG D
0.118	55	Woods, Good, HSG B
0.102	77	Woods, Good, HSG D
0.286	65	Weighted Average
0.286		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	3	0.3300	0.27		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.4	11	0.0310	0.13		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
5.0	21	0.0310	0.07		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
2.3	15	0.1100	0.11		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
8.9	50	Total			

Summary for Pond P1: Bioretention Basin 1

Inflow Area = 1.985 ac, 72.34% Impervious, Inflow Depth = 3.85" for 10 yr storm event
Inflow = 8.83 cfs @ 12.07 hrs, Volume= 0.636 af
Outflow = 0.31 cfs @ 15.40 hrs, Volume= 0.231 af, Atten= 96%, Lag= 199.7 min
Primary = 0.31 cfs @ 15.40 hrs, Volume= 0.231 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 30.28' @ 15.40 hrs Surf.Area= 15,231 sf Storage= 20,873 cf

Plug-Flow detention time= 481.9 min calculated for 0.231 af (36% of inflow)
Center-of-Mass det. time= 346.2 min (1,129.6 - 783.4)

Volume	Invert	Avail.Storage	Storage Description
#1	28.00'	33,480 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
28.00	3,790	237.0	0	0	3,790
29.00	8,407	366.0	5,947	5,947	9,987
30.00	13,678	468.0	10,936	16,883	16,770
31.00	19,697	573.0	16,596	33,480	25,484

Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**12.0" Round RCP_Round 12"** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 28.00' / 27.00' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	30.00'	**8.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600
#3	Primary	30.50'	**6.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

```
Primary OutFlow Max=0.31 cfs @ 15.40 hrs  HW=30.28'   (Free Discharge)
 ├─1=RCP_Round  12" (Passes 0.31 cfs of 5.04 cfs potential flow)
 │  └─2=Orifice/Grate (Orifice Controls 0.31 cfs @ 1.69 fps)
 └─3=Broad-Crested Rectangular Weir( Controls 0.00 cfs)
```

Summary for Pond P2: Bioretention Basin 2

```
Inflow Area =        1.348 ac,  90.58% Impervious,  Inflow Depth =  4.40"   for  10 yr storm event
Inflow      =        6.44 cfs @   12.07 hrs,  Volume=          0.494 af
Outflow     =        4.53 cfs @   12.14 hrs,  Volume=          0.439 af,  Atten= 30%,  Lag= 4.4 min
Primary     =        4.53 cfs @   12.14 hrs,  Volume=          0.439 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 31.78' @ 12.14 hrs   Surf.Area= 4,444 sf   Storage= 6,433 cf

Plug-Flow detention time= 130.4 min calculated for 0.439 af (89% of inflow)
Center-of-Mass det. time= 77.2 min ( 833.1 - 755.9 )

Volume     Invert    Avail.Storage   Storage Description
   #1      30.00'         7,449 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation      Surf.Area    Perim.       Inc.Store       Cum.Store        Wet.Area
    (feet)        (sq-ft)    (feet)    (cubic-feet)    (cubic-feet)          (sq-ft)
     30.00          2,881     246.0               0               0            2,881
     31.00          3,690     371.0           3,277           3,277            9,026
     32.00          4,673     320.0           4,172           7,449           11,852

Device   Routing          Invert   Outlet Devices
   #1    Primary          30.00'   12.0"  Round RCP_Round  12"
                                   L= 65.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                   Inlet / Outlet Invert= 30.00' / 29.25'   S= 0.0115 '/'   Cc= 0.900
                                   n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
   #2    Device 1         30.75'   10.0" W x 9.0" H Vert. Orifice/Grate  C= 0.600
   #3    Primary          31.50'   6.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                   2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                   Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                                   2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32

Primary OutFlow Max=4.53 cfs @ 12.14 hrs  HW=31.78'   (Free Discharge)
 ├─1=RCP_Round  12" (Passes 2.39 cfs of 4.14 cfs potential flow)
 │  └─2=Orifice/Grate (Orifice Controls 2.39 cfs @ 3.83 fps)
 └─3=Broad-Crested Rectangular Weir(Weir Controls 2.13 cfs @ 1.28 fps)
```

Summary for Pond P3: Bioretention Basin 3

Inflow Area = 1.348 ac, 42.80% Impervious, Inflow Depth = 2.42" for 10 yr storm event
Inflow = 3.91 cfs @ 12.08 hrs, Volume= 0.271 af
Outflow = 0.71 cfs @ 12.55 hrs, Volume= 0.236 af, Atten= 82%, Lag= 28.0 min
Primary = 0.71 cfs @ 12.55 hrs, Volume= 0.236 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 33.31' @ 12.55 hrs Surf.Area= 5,560 sf Storage= 5,146 cf

Plug-Flow detention time= 164.7 min calculated for 0.236 af (87% of inflow)
Center-of-Mass det. time= 105.4 min (936.8 - 831.5)

Volume	Invert	Avail.Storage	Storage Description
#1	32.00'	9,440 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
32.00	2,207	177.0	0	0	2,207
33.00	4,993	291.0	3,507	3,507	6,459
34.00	6,927	401.0	5,934	9,440	12,526

Device	Routing	Invert	Outlet Devices
#1	Primary	32.00'	**12.0" Round RCP_Round 12"** L= 35.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 32.00' / 31.00' S= 0.0286 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	32.50'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	33.60'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.71 cfs @ 12.55 hrs HW=33.31' (Free Discharge)
└─**1=RCP_Round 12"** (Passes 0.71 cfs of 3.41 cfs potential flow)
  └─**2=Orifice/Grate** (Orifice Controls 0.71 cfs @ 3.61 fps)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link DP1: Wetland 1

Inflow Area = 4.329 ac, 65.86% Impervious, Inflow Depth > 2.22" for 10 yr storm event
Inflow = 6.03 cfs @ 12.12 hrs, Volume= 0.799 af
Primary = 6.03 cfs @ 12.12 hrs, Volume= 0.799 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Summary for Link DP2: Wetland 3

```
Inflow Area =       1.634 ac,  35.31% Impervious,  Inflow Depth >   1.99"    for  10 yr storm event
Inflow      =      0.97 cfs @   12.17 hrs,  Volume=          0.271 af
Primary     =      0.97 cfs @   12.17 hrs,  Volume=          0.271 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

100-Year Storm Event – Proposed

```
                   Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
                        Runoff by SCS TR-20 method, UH=SCS
           Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

SubcatchmentPR 1: PR 1              Runoff Area=1.985 ac  72.34% Impervious   Runoff Depth=6.05"
                               Flow Length=200'   Tc=5.0 min   CN=92   Runoff=13.55 cfs  1.002 af

SubcatchmentPR 2: PR 2              Runoff Area=1.348 ac  90.58% Impervious   Runoff Depth=6.64"
                                Flow Length=337'   Tc=5.0 min   CN=97   Runoff=9.55 cfs  0.746 af

SubcatchmentPR 3: PR 3              Runoff Area=1.348 ac  42.80% Impervious   Runoff Depth=4.37"
                                Flow Length=438'   Tc=5.3 min   CN=77   Runoff=7.05 cfs  0.490 af

SubcatchmentPR 4: PR 4              Runoff Area=0.996 ac  19.48% Impervious   Runoff Depth=3.20"
                                Flow Length=117'   Tc=5.0 min   CN=66   Runoff=3.85 cfs  0.266 af

SubcatchmentPR 5: PR 5               Runoff Area=0.286 ac   0.00% Impervious   Runoff Depth=3.10"
                                 Flow Length=50'   Tc=8.9 min   CN=65   Runoff=0.93 cfs  0.074 af

Pond P1: Bioretention Basin 1       Peak Elev=30.66'  Storage=27,117 cf   Inflow=13.55 cfs  1.002 af
                                                                       Outflow=1.64 cfs  0.593 af

Pond P2: Bioretention Basin 2         Peak Elev=31.97'  Storage=7,299 cf   Inflow=9.55 cfs  0.746 af
                                                                       Outflow=7.71 cfs  0.691 af

Pond P3: Bioretention Basin 3         Peak Elev=33.84'  Storage=8,389 cf   Inflow=7.05 cfs  0.490 af
                                                                       Outflow=2.45 cfs  0.455 af

Link DP1: Wetland 1                                                     Inflow=11.45 cfs  1.550 af
                                                                       Primary=11.45 cfs  1.550 af

Link DP2: Wetland 3                                                      Inflow=2.94 cfs  0.529 af
                                                                        Primary=2.94 cfs  0.529 af

          Total Runoff Area = 5.963 ac   Runoff Volume = 2.578 af   Average Runoff Depth = 5.19"
                                      42.51% Pervious = 2.535 ac     57.49% Impervious = 3.428 ac
```

Summary for Subcatchment PR 1: PR 1

Runoff = 13.55 cfs @ 12.07 hrs, Volume= 1.002 af, Depth= 6.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
1.436	98	Paved parking, HSG B
0.014	39	>75% Grass cover, Good, HSG A
0.300	61	>75% Grass cover, Good, HSG B
0.235	98	Water Surface, 0% imp, HSG B
1.985	92	Weighted Average
0.549		27.66% Pervious Area
1.436		72.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0180	1.18		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	150	0.0270	3.34		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
3.6					**Direct Entry, <5 min Tc Adjustment**
5.0	200	Total			

Summary for Subcatchment PR 2: PR 2

Runoff = 9.55 cfs @ 12.07 hrs, Volume= 0.746 af, Depth= 6.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
1.062	98	Paved parking, HSG B
0.159	98	Paved parking, HSG D
0.008	61	>75% Grass cover, Good, HSG B
0.035	80	>75% Grass cover, Good, HSG D
0.007	98	Water Surface, 0% imp, HSG B
0.077	98	Water Surface, 0% imp, HSG D
1.348	97	Weighted Average
0.127		9.42% Pervious Area
1.221		90.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.8	50	0.0120	1.01		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
1.7	287	0.0200	2.87		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
2.5					**Direct Entry, <5 min Tc Adjustment**
5.0	337	Total			

Summary for Subcatchment PR 3: PR 3

Runoff = 7.05 cfs @ 12.08 hrs, Volume= 0.490 af, Depth= 4.37"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.577	98	Paved parking, HSG B
0.771	61	>75% Grass cover, Good, HSG B
1.348	77	Weighted Average
0.771		57.20% Pervious Area
0.577		42.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.23		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.7	114	0.0180	2.72		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
1.1	59	0.0170	0.91		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
2.3	159	0.0060	1.16		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
0.5	56	0.0180	2.01		**Shallow Concentrated Flow, Landscape B** Grassed Waterway Kv= 15.0 fps
5.3	438	Total			

Summary for Subcatchment PR 4: PR 4

Runoff = 3.85 cfs @ 12.08 hrs, Volume= 0.266 af, Depth= 3.20"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.194	98	Paved parking, HSG B
0.001	30	Woods, Good, HSG A
0.293	55	Woods, Good, HSG B
0.005	77	Woods, Good, HSG D
0.047	39	>75% Grass cover, Good, HSG A
0.420	61	>75% Grass cover, Good, HSG B
0.036	80	>75% Grass cover, Good, HSG D
0.996	66	Weighted Average
0.802		80.52% Pervious Area
0.194		19.48% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	38	0.0530	0.21		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
0.1	12	0.0540	1.38		**Sheet Flow, Impervious B** Smooth surfaces n= 0.011 P2= 3.40"
0.3	47	0.0210	2.94		**Shallow Concentrated Flow, Impervious B** Paved Kv= 20.3 fps
0.3	20	0.0250	1.11		**Shallow Concentrated Flow, Landscape B** Short Grass Pasture Kv= 7.0 fps
1.3					**Direct Entry, <5 min Tc Adjustment**
5.0	117	Total			

Summary for Subcatchment PR 5: PR 5

Runoff = 0.93 cfs @ 12.13 hrs, Volume= 0.074 af, Depth= 3.10"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.055	61	>75% Grass cover, Good, HSG B
0.011	80	>75% Grass cover, Good, HSG D
0.118	55	Woods, Good, HSG B
0.102	77	Woods, Good, HSG D
0.286	65	Weighted Average
0.286		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	3	0.3300	0.27		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
1.4	11	0.0310	0.13		**Sheet Flow, Landscape B** Grass: Short n= 0.150 P2= 3.40"
5.0	21	0.0310	0.07		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
2.3	15	0.1100	0.11		**Sheet Flow, Woods D** Woods: Light underbrush n= 0.400 P2= 3.40"
8.9	50	Total			

Summary for Pond P1: Bioretention Basin 1

Inflow Area = 1.985 ac, 72.34% Impervious, Inflow Depth = 6.05" for 100 yr storm event
Inflow = 13.55 cfs @ 12.07 hrs, Volume= 1.002 af
Outflow = 1.64 cfs @ 12.61 hrs, Volume= 0.593 af, Atten= 88%, Lag= 32.4 min
Primary = 1.64 cfs @ 12.61 hrs, Volume= 0.593 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 30.66' @ 12.61 hrs Surf.Area= 17,514 sf Storage= 27,117 cf

Plug-Flow detention time= 343.4 min calculated for 0.593 af (59% of inflow)
Center-of-Mass det. time= 238.0 min (1,009.8 - 771.8)

Volume	Invert	Avail.Storage	Storage Description
#1	28.00'	33,480 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
28.00	3,790	237.0	0	0	3,790
29.00	8,407	366.0	5,947	5,947	9,987
30.00	13,678	468.0	10,936	16,883	16,770
31.00	19,697	573.0	16,596	33,480	25,484

Device	Routing	Invert	Outlet Devices
#1	Primary	28.00'	**12.0" Round RCP_Round 12"** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 28.00' / 27.00' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	30.00'	**8.0" W x 4.0" H Vert. Orifice/Grate** C= 0.600
#3	Primary	30.50'	**6.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

```
Primary OutFlow Max=1.64 cfs @ 12.61 hrs  HW=30.66'   (Free Discharge)
├─1=RCP_Round 12" (Passes 0.75 cfs of 5.56 cfs potential flow)
│  └─2=Orifice/Grate (Orifice Controls 0.75 cfs @ 3.36 fps)
└─3=Broad-Crested Rectangular Weir (Weir Controls 0.89 cfs @ 0.94 fps)
```

Summary for Pond P2: Bioretention Basin 2

```
Inflow Area =      1.348 ac,  90.58% Impervious,  Inflow Depth =   6.64"    for  100 yr storm event
Inflow      =      9.55 cfs @   12.07 hrs,  Volume=           0.746 af
Outflow     =      7.71 cfs @   12.12 hrs,  Volume=           0.691 af,  Atten= 19%,  Lag= 3.3 min
Primary     =      7.71 cfs @   12.12 hrs,  Volume=           0.691 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 31.97' @ 12.12 hrs   Surf.Area= 4,640 sf   Storage= 7,299 cf

Plug-Flow detention time= 104.2 min calculated for 0.691 af (93% of inflow)
Center-of-Mass det. time= 64.4 min ( 812.8 - 748.4 )

Volume      Invert    Avail.Storage  Storage Description
   #1       30.00'         7,449 cf  Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation       Surf.Area    Perim.       Inc.Store       Cum.Store        Wet.Area
    (feet)         (sq-ft)    (feet)    (cubic-feet)    (cubic-feet)          (sq-ft)
     30.00           2,881     246.0               0               0            2,881
     31.00           3,690     371.0           3,277           3,277            9,026
     32.00           4,673     320.0           4,172           7,449           11,852

Device  Routing         Invert   Outlet Devices
  #1    Primary         30.00'   12.0"  Round RCP_Round  12"
                                 L= 65.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                 Inlet / Outlet Invert= 30.00' / 29.25'   S= 0.0115 '/'   Cc= 0.900
                                 n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
  #2    Device 1        30.75'   10.0" W x 9.0" H Vert. Orifice/Grate  C= 0.600
  #3    Primary         31.50'   6.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                 Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                 2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                 Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                                 2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32

Primary OutFlow Max=7.70 cfs @ 12.12 hrs  HW=31.97'   (Free Discharge)
├─1=RCP_Round 12" (Passes 2.74 cfs of 4.39 cfs potential flow)
│  └─2=Orifice/Grate (Orifice Controls 2.74 cfs @ 4.38 fps)
└─3=Broad-Crested Rectangular Weir (Weir Controls 4.96 cfs @ 1.77 fps)
```

Summary for Pond P3: Bioretention Basin 3

Inflow Area = 1.348 ac, 42.80% Impervious, Inflow Depth = 4.37" for 100 yr storm event
Inflow = 7.05 cfs @ 12.08 hrs, Volume= 0.490 af
Outflow = 2.45 cfs @ 12.36 hrs, Volume= 0.455 af, Atten= 65%, Lag= 16.8 min
Primary = 2.45 cfs @ 12.36 hrs, Volume= 0.455 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 33.84' @ 12.36 hrs Surf.Area= 6,606 sf Storage= 8,389 cf

Plug-Flow detention time= 132.1 min calculated for 0.455 af (93% of inflow)
Center-of-Mass det. time= 94.3 min (908.7 - 814.5)

Volume	Invert	Avail.Storage	Storage Description
#1	32.00'	9,440 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
32.00	2,207	177.0	0	0	2,207
33.00	4,993	291.0	3,507	3,507	6,459
34.00	6,927	401.0	5,934	9,440	12,526

Device	Routing	Invert	Outlet Devices
#1	Primary	32.00'	**12.0" Round RCP_Round 12"** L= 35.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 32.00' / 31.00' S= 0.0286 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	32.50'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	33.60'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=2.45 cfs @ 12.36 hrs HW=33.84' (Free Discharge)
↑—**1=RCP_Round 12"** (Passes 0.99 cfs of 4.39 cfs potential flow)
  ↑—**2=Orifice/Grate** (Orifice Controls 0.99 cfs @ 5.04 fps)
└—**3=Broad-Crested Rectangular Weir** (Weir Controls 1.46 cfs @ 1.19 fps)

Summary for Link DP1: Wetland 1

Inflow Area = 4.329 ac, 65.86% Impervious, Inflow Depth > 4.30" for 100 yr storm event
Inflow = 11.45 cfs @ 12.11 hrs, Volume= 1.550 af
Primary = 11.45 cfs @ 12.11 hrs, Volume= 1.550 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Summary for Link DP2: Wetland 3

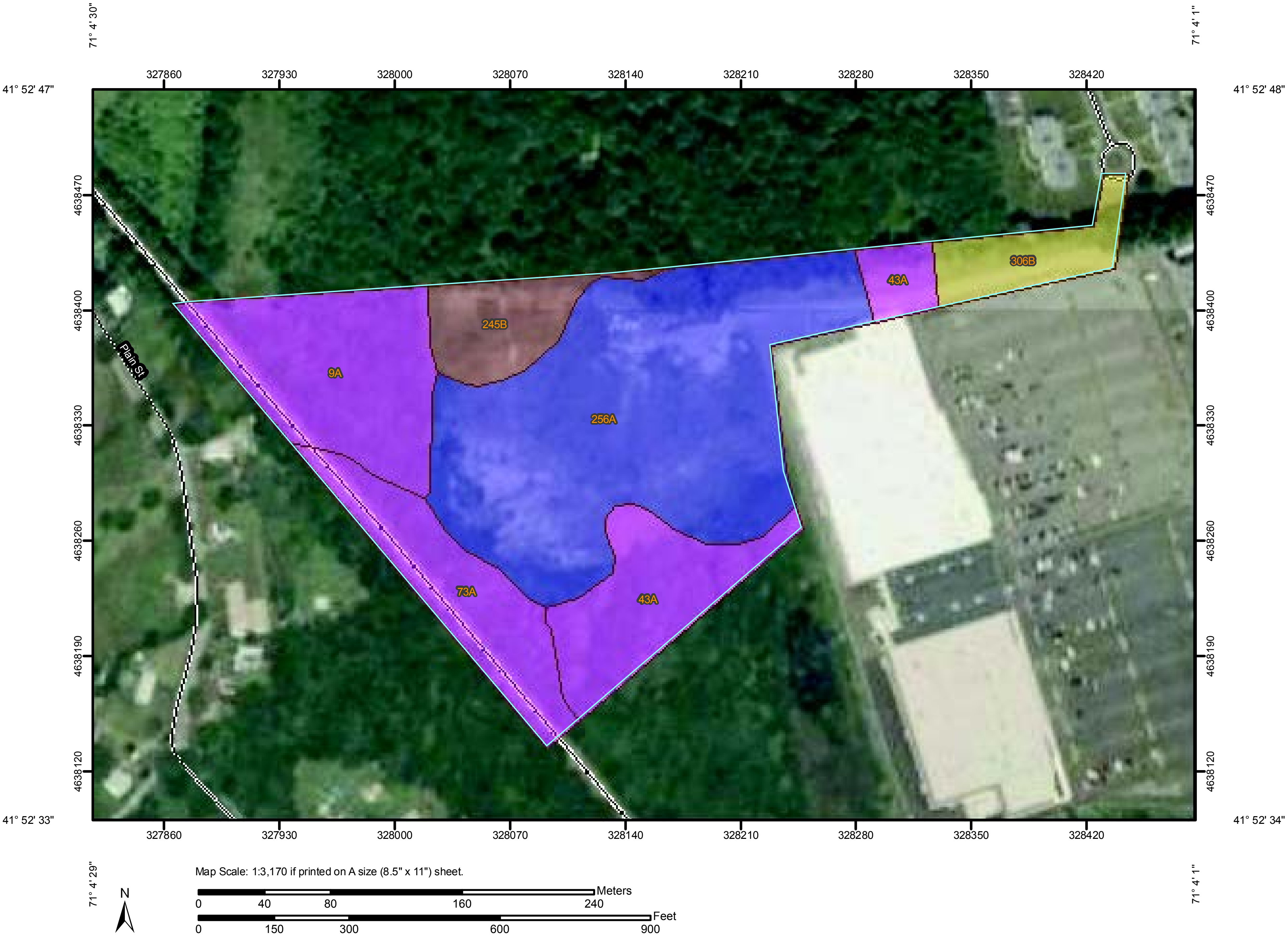
```
Inflow Area =         1.634 ac,  35.31% Impervious,  Inflow Depth >   3.88"    for  100 yr storm event
Inflow      =         2.94 cfs @   12.33 hrs,  Volume=           0.529 af
Primary     =         2.94 cfs @   12.33 hrs,  Volume=           0.529 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Appendix C
Standard 3 Computations and Supporting Information

Soil Evaluation and Analysis

Hydrologic Soil Group—Bristol County, Massachusetts, Northern Part
(Taunton Depot Soil Properties)



Map Scale: 1:3,170 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

☐ Area of Interest (AOI)

Soils

☐ Soil Map Units

Soil Ratings

🟪 A
🟩 A/D
🟦 B
☐ B/D
🟨 C
🟦 C/D
🟪 D
⬜ Not rated or not available

Political Features

● Cities

Water Features

~ Streams and Canals

Transportation

┼ Rails
~ Interstate Highways
~ US Routes
~ Major Roads
~ Local Roads

MAP INFORMATION

Map Scale: 1:3,170 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bristol County, Massachusetts, Northern Part
Survey Area Data: Version 5, Jul 27, 2010

Date(s) aerial images were photographed: 8/14/2003; 7/10/2003; 8/15/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Northern Part (MA602)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
9A	Birdsall silt loam, 0 to 3 percent slopes	D	3.1	16.8%
43A	Scarboro mucky loamy fine sand, 0 to 3 percent slopes	D	2.5	13.9%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	2.1	11.4%
245B	Hinckley sandy loam, 3 to 8 percent slopes	A	1.2	6.6%
256A	Deerfield loamy sand, 0 to 3 percent slopes	B	8.3	45.7%
306B	Paxton fine sandy loam, 0 to 8 percent slopes, very stony	C	1.0	5.7%
Totals for Area of Interest			**18.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Required and Provided Recharge Volumes

Recharge Calculations

Project Name: **Taunton Depot Station** **Proj. No.:** 10111.00
Project Location: **Taunton, MA** **Date:** 12-Apr-12
Calculated by: PAC
Checked by:

Proposed Impervious Surface Summary

Net Proposed Impervious Areas by Hydrologic Soil Group (HSG) in acres

Subcatchment	HSG A	HSG B	HSG C	HSG D	Total Area
1	0.0	1.4	0.0	0.0	1.4
2	0.0	1.1	0.0	0.2	1.2
3	0.0	0.6	0.0	0.0	0.6
4	0.0	0.1	0.0	0.0	0.1
5	0.0	0.0	0.0	0.0	0.0
TOTAL	**0.0**	**3.2**	**0.0**	**0.2**	**3.3**

Required Recharge Volume (Cubic Feet)

HSG	Area (acres)	Recharge Depth * (in.)	Volume (c.f.)
A	0.0	0.60	0
B	3.2	0.35	4,014
C	0.0	0.25	0
D	0.2	0.10	58
TOTAL			**4,071**

* Per 2008 Massachusetts DEP Recharge Requirement

Provided Recharge Volume (Cubic Feet)

Infiltration Volumes Provided in Infiltration Basins (below lowest overflow outlet)

Basin P1	17,141	
Basin P2	2,388	
Basin P3	1,452	
Total	**20,981**	c.f.

72-hour Drawdown Analysis

Drawdown Calculations

Project Name:	Taunton Depot Station	**Proj. No.:**	10111.00
		Date:	5/18/2012
Project Location:	Taunton, MA	**Calculated by:**	PAC

Bioretention Basin - 1

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
28.00	3,790	0
29.00	8,407	6,099
30.00	13,678	17,141
TOTAL		**17,141**

Assumptions:

Recharge Rate: 1.00 in/hr

Drawdown Time: 54.3 hours

Bioretention Basin - 2

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
30.00	2,881	0
30.75	3,488	2,388
TOTAL		**2,388**

Assumptions:

Recharge Rate: 1.00 in/hr

Drawdown Time: 9.9 hours

Bioretention Basin - 3

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
32.00	2,207	0
32.50	3,600	1,452
TOTAL		**1,452**

Assumptions:

Recharge Rate: 1.00 in/hr

Drawdown Time: 7.9 hours

Appendix D
Standard 4 Computations and Supporting Information

Water Quality Volume Calculations

Water Quality Volume Calculations

Project Name: **Taunton Depot Station** **Proj. No.:** 10111.00
Project Location: **Taunton, MA** **Date:** 4/13/2012
Calculated by: PAC

Bioretention Basin P1
(runoff from Area PR1)

Total Impervious Area = 1.44 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	521
Water Quality Volume	0.5	2,606

Provided:

Bioretention Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	28.0	3,790	0
	29.0	8,407	6,099
	30.0	13,678	17,141

Bioretention Basin P2
(runoff from Area PR2)

Total Impervious Area = 1.22 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	443
Water Quality Volume	0.5	2,216

Provided:

Bioretention Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	30.0	2,881	0
	30.75	3,488	2,388

Bioretention Basin P3
(runoff from Area PR3)

Total Impervious Area = 0.58 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	209
Water Quality Volume	0.5	1,047

Provided:

Bioretention Basin	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	32.0	2,207	0
	32.5	3,600	1,452

TSS Removal Worksheets

TSS Removal Calculation Worksheet

VHB

***Vanasse Hangen Brustlin, Inc*.**
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Taunton Depot Station**
Project Number: **10111.00**
Location: **Taunton, MA**
Discharge Point: **DP1**
Drainage Area(s): **PR 1, PR 2**

Sheet: **1 of 3**
Date: **12-Apr-2012**
Computed by: **PAC**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Taunton Depot Station**
Project Number: **10111.00**
Location: **Taunton, MA**
Discharge Point: **DP1**
Drainage Area(s): **PR 4 (Pump Station Access)**

Sheet: **2 of 3**
Date: **2-May-2012**
Computed by: **PAC**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Grass Channel	**50%**	**1.00**	**0.50**	**0.50**
	0%	**0.50**	**0.00**	**0.50**
	0%	**0.50**	**0.00**	**0.50**
	0%	**0.50**	**0.00**	**0.50**
	0%	**0.50**	**0.00**	**0.50**

Treatment Train TSS Removal = **50%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

TSS Removal Calculation Worksheet

VHB

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Taunton Depot Station**
Project Number: **10111.00**
Location: **Taunton, MA**
Discharge Point: **DP2**
Drainage Area(s): **PR 3**

Sheet: **3 of 3**
Date: **12-Apr-2012**
Computed by: **PAC**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Bioretention Area	**90%**	**1.00**	**0.90**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

Appendix E
Geotechnical Report

JACOBS
343 Congress Street
Boston, MA 02210

Design Memorandum

Date	March 29, 2012
To	Rick Carey, Natasha Velickovic - VHB
From	Paul Murphy, Da Ha, Peter Chou - Jacobs
Subject	MBTA South Coast Rail (New Bedford/Fall River Commuter Rail Extension) Taunton Depot Station Geotechnical Design Memorandum Taunton, MA
Project No.	E2347101

INTRODUCTION

The South Coast Rail project will restore passenger rail transportation from South Station in Boston to the cities of Fall River and New Bedford along an existing rail freight corridor running south from Taunton to Fall River and New Bedford. The project will include the construction of several existing and new passenger stations and two terminal layover facilities. This geotechnical design memorandum presents the foundation design considerations for the new station platform at the proposed Taunton Depot Station in Taunton, Massachusetts. The design recommendations presented in this report are based on the results of subsurface investigation performed by Jacobs in 2002 and 2010.

Existing Conditions

The proposed Taunton Depot Station site is behind the Target Plaza off of Route 140 in Taunton (Figure 1). Except for the two railroad tracks along the west side of the site, the site is currently undeveloped, with half the site cleared and half the site with forests and wetlands. Six large floor-plan retail buildings on the adjacent shopping plaza contain numerous retail establishments. Existing grades at the platform location range from elevations 38.6 to 32.9 feet (NGVD29 Datum), generally sloping downward from south to north.

Proposed Construction

Current station plans are to construct an 800 foot long, 12 foot wide high level center platform adjacent to the existing tracks with some track relocation required, as well as the addition of a third track, a new parking area (with access roads) and a new drop-off area. The tracks and the platform will be constructed on an embankment supported by 3 to 14 feet high retaining walls on both the west and east sides of the tracks.

Access to the platform will be from a new ramp/stair structure along the east side of the tracks with a pedestrian bridge over the wetland and northbound tracks to the platform. Approximately 320 feet of the platform will be under a new station canopy. The details of new track layout (including grading), associated sidewalks and ramps of the proposed station are still under development at the time of this report preparation. However, we anticipate that about 3-8 feet of fill will be placed at the site to raise the grade at the track level and platform area. This report focuses on the foundations for the platform, the ramp/stair structure and the pedestrian bridge.

SCOPE OF WORK

This memorandum was prepared by Jacobs in accordance with the scope of work under the contract between Jacobs and VHB for work on the New Bedford/Fall River Commuter Rail Line Extension Project for Massachusetts Bay Transportation Authority (MBTA). The geotechnical work included the following tasks:

- Perform a geotechnical exploration and laboratory testing program;
- Report and interpret the results of the exploration and laboratory testing program; and
- Provide geotechnical recommendations for design and construction of the platform foundations.

The Jacobs scope of work did not include environmental analyses to assess the potential presence of any hazardous materials at the project site or potential impacts to adjacent structures during construction.

LOCAL GEOLOGY

The site is located in the Narragansett Basin of southeastern Massachusetts. The rocks in the Narragansett Basin consist mostly of lightly metamorphosed shale and sandstone of Pennsylvanian and Permian age. The Taunton Depot site is located in the area of the Rhode Island Formation. The rocks encountered in the borings included coarse grained, weathered sandstone and dark gray siltstone. The upper few feet of the rock has been weathered to soil and was sampled by Standard Penetration Tests in some borings. The less-weathered rock was cored with RQD values ranging from 18 to 50. The cored rock was partially weathered and had both high-angle and bedding-plane joints, which had a dip of about 10 to 20 degrees.

GEOTECHNICAL INVESTIGATION

Jacobs planned the subsurface exploration program and retained the drilling contractors to perform the explorations. The results of the explorations were presented in geotechnical data reports entitled “New Bedford Line – South of Weir Junction Geotechnical Data Report” and “South Coast Rail, Jacobs Geotechnical Data Report” submitted in 2002 and 2010, respectively. Six borings (TD-1 and NBA-12 to NBA-16) were conducted along the proposed station platform and fifteen borings (TD-2 to TD-6, NBS-1 to NBS-5 and NBS-8 to NBS-12) were drilled in the general vicinity of the proposed parking lot and access roads. Boring locations are shown on the Subsurface Exploration Plan (Figures 2 and 3).

The 2010 borings were drilled by New Hampshire Boring using either a D-50 ATV mounted drill or a CME-75 truck mounted drill rig. The borings were advanced through the soil by wash boring methods using a 4-inch casing and roller bit with water. Standard penetration tests (SPT), consisting of 140-pound hammer dropping 30 inches on a standard 2-inch-diameter (OD) split-spoon sampler, were performed with a safety hammer to establish the consistency of the subsurface soils. The SPT's were typically performed at five foot intervals of depth. The obtained samples were sealed in glass jars to retain their natural moisture. Bedrock was encountered and cored in some of the borings during exploration.

The borings were observed and logged by a representative from Jacobs. The soil samples were classified in the field in accordance with ASTM D-2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) by Jacobs’ representative, and appropriate stratum breaks were interpolated from drilling and sampling observations. The boring logs were prepared by Jacobs based on the field classifications and laboratory testing, and are presented in Appendix A.

Note the vertical control datum of the 2002 borings was also the National Geodetic Vertical Datum (NGVD) of 1929, which is generally referred to as U.S. Coast Guard mean sea level.

LABORATORY TESTING

The results of the laboratory testing were previously submitted to VHB in reports entitled “South Coast Rail, Jacobs Geotechnical Data Report”, dated November 2010, and “New Bedford Line – South of Weir Junction Geotechnical Data Report”, dated October 2002.

Grain size distribution analyses were performed to evaluate the gradation of the fill material and natural granular soils for potential reuse as backfill, if needed, and to confirm sample classifications. The graduation analyses are summarized in Table 1 below and are presented in Appendix B.

Table 1: Laboratory Soil Classification Summary

BORING NO.	SAMPLE NO.	ELEVATION (FEET)	USCS SOIL CLASSIFICATION	W (%)	GRAVEL (%)	SAND (%)	FINES (%)
TD-05	S2	33.9	Silty Sand (SM)	NT	3.1	64.7	32.2
NBA-12	SS-2 *	28.8	Silty sand (SM)	NT	0	58	42
	SS-4	18.8	Silt with sand (ML)	NT	0	25	75
	SS-5	13.8	Sandy silt (ML)	NT	0	43	57
NBA-13 MW	SS-2 *	29.9	Silty sand (SM)	NT	1	58	41
	SS-3 *	24.9	Sandy silt (ML)	NT	1	34	65
	SS-5	14.9	Sandy silt (ML)	NT	1	28	71
NBA-15	SS-2 *	32.1	Silty sand with gravel (SM)	NT	29	56	15
	SS-4	22.1	Silty sand with gravel (SM)	NT	23	43	34
NBS-03	SS-1	31.6	Silty sand with gravel (SM)	NT	39	42	19
	SS-3	21.6	Poorly graded sand with gravel (SP)	NT	19	77	4
	SS-4	16.6	Sandy silt (ML)	NT	13	34	53
NBS-05 MW	SS-1	38.0	Silty sand (SM)	NT	4	62	34
	SS-2	33.0	Silty sand with gravel (SM)	NT	15	58	27
	SS-3	28.0	Silty sand (SM)	NT	13	41	46
NBS-12	SS-1	31.9	Silt with sand (ML)	NT	0	18	82
	SS-2	27.9	Silt (ML)	NT	0	7	93
	SS-3	22.9	Silty gravel with sand (GM)	NT	42	36	22

Where: w = natural moisture content, NT = Not Tested. * = Fill

SUBSURFACE CONDITIONS

The subsurface conditions at the site were inferred from the boring data collected for the Taunton Depot Station project, with some interpretations. The subsurface conditions encountered at the station platform area generally consist of a layer of granular fill with thickness of about 3 to 14 feet, underlain by a granular soil layer with thickness ranging from 4 to 14 feet overlying bedrock. Bedrock was encountered at a depth of about 14.5 to 22 feet in the platform area, corresponding to approximately elevations 20.1 to 11.0 feet.

In the vicinity of the proposed parking lot and access road areas, fill materials with thicknesses ranging from approximately 0 to 3 feet were encountered. Bedrock was encountered at a depth about 12.0 to 12.5 feet (corresponding to elevations 17.9 to 15.1 feet).

Subsurface soil conditions are summarized in Table 2 and discussed below.

Table 2: Summary of Subsurface Conditions at Borings

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Platform Borings							
TD-1 OW	33.0	3.0	30.0	6.0	1.0	27.8	Well screened from 22 to 32 ft.
NBA-12	32.8	12	20.8	NE	7.3	23.3	Organic silty sand encountered from 12.0 to 15.5 ft.
NBA-13 MW	33.9	14	19.9	NE	8.4	20.5	Well screened from 12.8 to 22.8 ft.
NBA-14	34.6	11	23.6	20.1	5.6	23.9	Large boulders. Argillite rock may be bedrock or boulder.
NBA-15	36.1	12	24.1	10.6	10.6	27.1	Possible top of weathered rock at Elev. 13.1'.
NBA-16	38.6	11	27.6	NE	23.1	35.6	
Site Borings							
TD-2	30.6	3.0	27.6	NE	6.6	28.6	
TD-3	30.7	3.0	27.7	NE	17.4	28.2	
TD-4	32.8	3.0	29.8	NE	17.8	30.8	
TD-5	36.9	0	36.9	NE	21.9	32.9	
TD-6 OW	29.9	3.0	26.9	16.9	16.9	28.9	Well screened from 8 to 13 ft.
NBS-1	27.6	0	27.6	12.1	12.1	27.1	
NBS-2	38.0	0	38.0	NE	22.5	36.3	
NBS-3	31.6	0	31.6	NE	15.1	28.6	Auger Boring.
NBS-4	30.0	0	30.0	NE	5.0	29.5	
NBS-5 MW	38.0	0	38.0	NE	21.5	32.5	Auger Boring.
NBS-8, 8A	28.8	0	28.8	NE	12.3	23.8	Refusal @ 11'. Offset. Auger Boring.
NBS-9	36.7	0	36.7	NE	20.2	32.7	Auger Boring.
NBS-10,A,B,C	32.2	0	32.2	17.5	17.5	29.2	Many drilling refusals. Boulders. Refusal @ BOB. Auger Boring.
NBS-11	34.9	0	34.9	18.7	18.7	Dry	Boulders. Refusal@ BOB. Auger Boring.
NBS-12, 12A	31.9	0	31.9	7.9	7.9	27.9	Boulders. Refusal @ 16'. Offset. Refusal @ BOB.
NE: Not encountered at the boring during drilling. Dry: Dry borehole observed							

Soil conditions in the platform area generally consisted of the following:

Fill: The fill layer typically consists of mostly granular, loose to dense sand and gravel with trace silt. Top 2 feet of fill may contain slag. The fill layer is generally about 3 to 14 feet in the platform area, and 3 feet or less at all other areas.

Organic Silt: A 3.5 foot thick layer of organic silt was encountered from approximately elevation 12.0 to 15.5 feet at boring NBA-12 at the north side of the platform. Note boring NBA-12 is located adjacent to a wetland area. Organic soils may also exist near other wetland areas at the site.

Natural Granular Deposits: In the platform area, the natural soil deposits below the fill generally consist of predominantly sandy silt and silty sand with up to 25% gravel. These deposits are loose to very dense with Standard Penetration Test (SPT) N-values ranging between 5 and 98 blows per foot (bpf).

Glacial Till: Dense glacial till was encountered at boring TD-1 at elevations ranging from 25.0 to 16.0 feet, and consisted of lean clay with up to 20% sand and gravel. Numerous boulders were encountered in the glacial till.

Bedrock: Bedrock was encountered in the platform area at a depth of about 14.5 to 22 feet below existing ground surface, corresponding to approximately elevations 20.1 to 11.0 feet. The bedrock was soft, jointed, slightly weathered SILTSTONE (TD-1) or moderately hard, very slightly weathered ARGILLITE (NBA-14). Bedrock RQD values at the platform range from 50% to 95%.

Hard, moderately weathered, moderately to highly fractured SANDSTONE (TD-2) was also encountered at elevation 22.6 feet in the pedestrian ramp area. Bedrock RQD values range from 18% to 27%.

Groundwater: Groundwater levels were measured in the observation wells and in test borings using a weighted tape during and at completion of drilling. The data indicated the groundwater level ranged from approximate elevations 35.6 to 23.3 feet along the platform alignment, and from elevations 36.3 to 23.8 feet in the general area of the proposed parking lot. The use of wash boring techniques for some of the soil borings may have artificially increased the water level readings due to the addition of water to the borings. Trapped/perched water is also commonly seen at a higher elevation within existing fill and silty materials. The longer term water level readings taken at Boring TD–1 OW on July 7, 2010 and September 12, 2011 indicated the water at a depth of about 8 feet (Elevation 25.0 feet) and 5.2 feet (Elevation 27.8 feet), respectively. The longer term water level readings taken at Boring TD–6 OW on July 7, 2010 and September 12, 2011 indicated the water at a depth of about 3.5 feet (Elevation 26.4 feet) and 1.0 feet (Elevation 28.9 feet), respectively. Based upon these short-term observations and readings from the observation wells, it is anticipated that the groundwater could be within 3 to 5 feet below existing grade at the platform area and within 1 to 3 feet below existing grade in the parking lot area.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. Local and periodic variations of ground water elevations may also be influenced by local subsurface drainage, leaking water or sewer pipes, and precipitation.

GEOTECHNICAL RECOMMENDATIONS

Due to variable thickness and consistency of the fill materials within the platform area, it is recommended to use ground improvement techniques to minimize differential settlement and to improve bearing capacity of the foundation soils. The ground should be improved with aggregate stone columns or rammed aggregate piers (RAPs). Stone columns and RAPs create stiff reinforcing elements in the foundation soil mass, thereby improving the soil bearing capacity.

As an alternative, the proposed station platforms can be supported on drilled micropiles extending through unsuitable soils (i.e., existing deep uncontrolled fills and organic soil layers) and bearing into competent natural soils. The use of deep foundations can also minimize the construction impacts on the existing track considering the existing track is active. The same type of foundation should be used for the pedestrian bridge to minimize any differential settlement. Due to the relatively shallow depth to dense to very dense natural soils in the ramp/stair structure area, it may be possible to use shallow spread footings to support this structure.

Platform and canopy design loads were not available at the time of this report preparation. However, it is anticipated that the station platform will be lightly (axially) loaded with limited horizontal forces from wind and seismic loads.

The following paragraphs provide project specific geotechnical recommendations for foundation soil preparation, structural fill/backfill placement, and design and construction of spread footings.

Ground Improvement

The stone column technique, also known as vibro-replacement or vibro-displacement, is a ground improvement process where vertical columns of compacted aggregate are formed through the soils to be improved. These columns result in considerable vertical load carrying capacity and improved shear resistance in the soil mass. The strength parameters of the stone columns-soil composite system can be estimated based on the reference FHWA/RD-83/026 and Priebe (1995). The rammed aggregate pier support elements are generally constructed by drilling a 18- to 36-inch diameter hole, removing or displacing the volume of soil, and then building a bottom bulb of clean, open-graded stone. The rammed aggregate pier is built on top of the bottom bulb, using well-graded highway base course stone placed in thin lifts (12-inches compacted thickness). The result of construction is a reinforced zone of soils directly beneath the foundations. Where subsurface conditions are such that an open hole is difficult to be maintained, the displacement rammed aggregate support elements (Impact System) can be used. In this method, the displacement rammed aggregate piers are installed by driving a variable-diameter mandrel into the soil, thereby displacing the soil laterally to form a cavity, and then filling the ensuing cavity by ramming thin lifts of open-graded aggregate within the cavity as the mandrel is retrieved from the hole.

Drilled Micropiles

Micropiles mainly rely on the grout/ground skin friction (bond) to transfer loads to the ground, since the pile displacement required to mobilize the frictional resistance is significantly less than that to mobilize end bearing. Micropiles should be designed to resist axial, lateral and eccentric loading conditions.

Based on our review of geological conditions and the split-spoon soil samples, it is our opinion that the skin friction within the existing fill and organic soils should be neglected. Type B pressure grouting or Types C and D post-grouting procedures should be required for micropile installation at this station for micropiles installed in soils. For micropiles installed in bedrock, Type A gravity grouting is acceptable. Side friction in soil should be neglected for micropiles bearing in rock. The allowable grout-to-ground bond strengths recommended for the materials encountered for this station are listed in Table 3 below.

Table 3: Summary of Micropile Design Parameters

SOIL/ROCK TYPE	BUOYANT UNIT WEIGHT (PCF)	ALLOWABLE SKIN ^{2} FRICTION (BOND STRENGTH) TYPE A (PSI)	ALLOWABLE SKIN ^{2} FRICTION (BOND STRENGTH) TYPES B AND C (PSI)	ALLOWABLE SKIN ^{2} FRICTION (BOND STRENGTH) TYPE D (PSI)
Fill and Organic Soils	57.5	--	--	--
Medium Dense to Very Dense Granular Soils	62.5	--	6	10
Competent Bedrock	82.5	35	--	--

Notes: 1. Fill/organic thickness ranges from 8 to 20 feet, top of bearing soils shall be top of natural granular soils.
2. Type A gravity grouting procedure is not recommended for micropiles in soil.

For corrosion protection, permanent casing should be installed to a depth of at least 5 feet below the bottom of the encountered fill and organic soils. The permanent casing design should include a 1/8-inch corrosion allowance.

In general, we recommend that the micropiles not be spaced within a distance less than 3 times the drilled holes/grout diameters. This spacing is to eliminate group effect for axially loaded piles bearing within soils.

Spread Footings

Spread footings are recommended for the ramp and stair structure foundations. The footings should be placed on compacted structural fill or on dense natural granular soils. The existing fill appears to have been placed without control and must be removed within the zone of influence of the footing down to natural soils. The zone of influence is defined by a line extending one foot from the bottom edge of the footing and continuing at a 1H:1V slope down to the natural soils.

The recommended allowable design bearing capacity for spread footings bearing on at least medium dense structural fill is 5 ksf, provided that subgrades are prepared as described herein. This provides an adequate factor of safety against bearing failure and limits the total estimated settlement to less than one inch and the differential settlement to less than ½ inch. All footings should be at least 4 feet wide. The bottom of footing elevation should be at least 4 feet below final grades for frost protection.

The structural fill material should be free from organics and other deleterious substances and should conform to the requirements listed in the MBTA Standard Specification Section 02200 - Earthwork for Type B Gravel Borrow. The exposed remaining fill and the structural fill should be compacted to 95% of the maximum dry density as determined by the Modified Proctor compaction test (ASTM D1557) and as described in the following sections.

All temporary open cuts required for footing construction should be in accordance with the related OSHA regulations and should have side slopes of no steeper than 1.5H:1V.

Seismic Consideration

The seismic design should comply with the requirements of the most current Massachusetts State Building Code 780 CMR and other relevant project design codes such as AREMA and AASHTO. Modification of the peak acceleration by the soils overlying bedrock depends upon the type of soil at the site. For the subsurface conditions encountered, the station site is classified as Seismic Site Class D soil profile in accordance with 780 CMR Chapter 1614.0 Section 9.4 Site Ground Motion. The structure could be designed for the total lateral seismic force using the equations specified in the code, or by the response spectrum method using the design spectra presented in the code. The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods (Ss) and at 1-sec (S_1) obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4.

For Site Class D Soils at the location of this station:

$S_{MS} = 0.384$ and $S_{M1} = 0.149$

$S_{DS} = 0.256$ and $S_{D1} = 0.099$

where:

- S_{MS} is the maximum consider earthquake spectral response acceleration for short periods adjusted for site class
- S_{M1} is the maximum consider earthquake spectral response acceleration at 1-sec adjusted for site class
- S_{DS} is the design earthquake spectral response acceleration for short periods adjusted for site class
- S_{D1} is the design earthquake spectral response acceleration at 1-sec adjusted for site class

The building code also requires that the soil be evaluated for the following potential hazards: slope instability, soil liquefaction, or surface rupture due to faulting or lateral spreading. The proposed grading is relatively flat and we are not aware of any pre-existing slope instability in this area. The existing overburden soils do not appear to be subject to surface rupture due to faulting or lateral spreading.

Liquefaction

Based on the observed subsurface conditions, recorded water levels, percentage of fine contents and the recorded SPT N-values, the soil layers underlying the site are judged to be not susceptible to liquefaction.

Retaining Walls

The track embankment retaining walls can be a cantilevered sheet pile wall. Steel anchor bars could also be used to connect the top portion of the two sheet pile walls on the east and west sides if analyses indicate bracing is needed. If anchor bars under the tracks are not acceptable to the MBTA, another option for the retaining walls is a soldier pile wall with precast concrete panels. Alternatively, if construction of the walls can be sequenced to limit excavation impacts on the existing tracks, use of Mechanically Stabilized Earth (MSE) walls may be possible.

CONSTRUCTION CONSIDERATIONS

Ground Improvement – Rammed Aggregate Piers/ Stone Columns

If a spread footing foundation option is desired by the designer but mass foundation over-excavation is not cost-effective or feasible, then ground improvement measures (such as rammed aggregate piers or stone columns) below foundation areas can be considered as a foundation alternative. The rammed aggregate piers/stone columns can improve soil bearing capacity characteristics of the existing fill, transfer (portions of) axial loads, and reduce potential foundation settlement. Rammed aggregate pier design and construction is typically provided by a specialty contractor based on a performance criteria, but should be reviewed by the Geotechnical Engineer.

Stone columns and rammed aggregate piers are constructed by excavating a hole (typically 18 to 36 inches in diameter) to the specified design depth (typically to competent soils) by augering or using a mandrel. The soil at the bottom of the hole is then densified with a high impact densification system having a rated energy of 250,000 ft.-lbs. to 1,200,000 ft.-lbs. Thin lifts (6- to 12-inches thick) of dense-grade aggregate or crushed stone are then compacted in the cavity. The proposed platform can then be supported on shallow foundation bearing on soils improved with rammed aggregate piers or stone columns. The footings can be designed based on a higher “composite” soil bearing capacity.

Stone columns and rammed aggregate pier elements are typically installed at about 6 to 8 feet center to center spacing. The length and spacing of the elements will depend on the foundation loads and settlement tolerance.

Drilled Micropiles

The drill rig should have adequate torque and downward pressure to facilitate drilling or coring through any obstruction and drilling into bedrock. A temporary or permanent casing is typically required to provide full length side support within soil embedment especially when drilling through sandy granular soils. The steel casing can provide high shear and bending capacity to resist lateral loads.

Water or polymer drilling mud (for flushing the hole during drilling) can also be used in addition to the casing to provide temporary side support during pile installation. Bentonite slurry may impair grout/ground bond capacity and therefore, it is not recommended.

Grouting under pressure should be performed through a tremie pipe from the bottom to the top of the casing in full until fresh grout tops out. No significant loss of grout from the pile should be observed. Re-grouting (post-grouting) after set of the initial grout may be necessary to improve the grout and ground bond strength within soil embedment. Suitable centralizers should be firmly fixed to maintain the specified grout cover. We recommend that the drilling, installation of the reinforcement, and grouting of a particular pile be completed in a short and continuous processes.

Field load testing including both performance and proof testing should be performed for production micropiles. The pile load test program and proof tests during installation should be conducted as described in the project specifications. Testing procedures and results should be observed and reviewed by the Geotechnical Engineer, and are subject to MBTA approval. In general, the compression load test should be performed in accordance with ASTM D1143 and tension load test in accordance with ASTM D3689.

Spread Footings

The existing fill should be stripped off and removed from within the zone of influence of the walkway area footings using a smooth edge excavation bucket. Following excavation, the exposed surface should be proof compacted with at least 10 passes of a large vibratory drum roller (minimum 10,000 pound static weight). All excavated areas should be backfilled with gravel borrow and compacted to 95% of the maximum dry density (ASTM D1557). Footing inspections should include hand auger probes by the geotechnical personnel to check for soft/weak zones. The need for undercutting and backfilling with structural fill should be closely evaluated in the field based on encountered conditions.

In areas where seepage is encountered within footing excavations, the need for placing a 3” thick lean concrete mud mat or a layer of ¾-inch crushed stone to protect the bearing surface should be evaluated in the field. Crushed stone thicker than 4 inches shall be wrapped by non-woven filter fabric.

Following observation of the bearing soils by geotechnical personnel, reinforcing steel and concrete can be placed in the excavation. It is recommended that footing reinforcing steel and concrete be placed the same day as the footing excavation is made, where possible, to avoid significant moisture content changes in the bearing soils. No water should be allowed to pond within excavations and drainage should be maintained away from foundations both during and after construction. The footing excavation should be free of loose debris at the time of footing concrete placement.

MSE Wall Construction

Wall Subgrade Preparation

Remove existing soil from the area to be occupied by the MSE wall structure, including facing and reinforcing strips, to the required grade, and extending at least 5 feet beyond the edge of structures on all sides. Where practical, final excavation should be undertaken using a smooth edged bucket to limit disturbance of the subgrade.

The exposed subgrade soils should be proof-compacted with a minimum of 10 passes of a minimum 10,000-lb (static weight) heavy vibratory roller. Loose or soft zones observed during proof-compaction should be over-excavated to firm and stable ground and replaced with compacted Gravel Borrow. Where exposed soil subgrades are at or near the groundwater level, static proof-compaction methods may be recommended in lieu of vibratory methods by the geotechnical engineer. Exposed subgrade soils should be protected from disturbance.

Existing fill may remain in place below the undercut zone of the MSE wall; however, if organic soils or soft or disturbed soils are observed, they should be completely removed from within the bearing influence zone of the retaining wall and reinforced soil mass. The bearing influence zone is defined by a one horizontal to one vertical (1H:1V) line sloping down and out from one foot outside the bottom exterior edge of the footing/reinforced soil zone to the exposed subgrade.

Once proof-compaction is complete, a layer of non-woven heavy duty geotextile, in accordance with MassDOT M9.50.0, Type I Separation, or Type II Stabilization geotextile fabric, should be placed at the bottom of excavation. The geotextile should have an Equivalent Opening Size (EOS) suitable to act as a filter to prevent loss of material from the new structural fill (Gravel Borrow) into the underlying existing fill materials (overlap roll ends and sides a minimum of 12 inches).

We recommend that a qualified geotechnical engineer evaluate the bearing subgrade and observe fill placement.

Leveling Pad

We recommend that a minimum 12 inch wide, 6 inch thick leveling pad consisting of reinforced concrete be provided as a leveling pad below the facing panels.

Backfill Material

MSE walls require placement of well-graded, granular soil (i.e. Gravel Borrow, MassDOT M1.03.0, Type a) in order to allow for drainage and to provide resistance to pullout of the reinforcing strips. Fill should be placed in loose lifts no greater than 8 inches thick and compacted to 95% of maximum density as determined by ASTM D1557 up to each layer of reinforcement. The reinforcing strips can be connected to the facing prior to placing subsequent lifts of backfill and reinforcing, or the strips can be wrapped around the subsequent lift, allowing the facing to be installed upon completion of backfilling. The method of construction should be provided by the MSE wall specialty designer and reviewed by the engineer.

Subgrade Preparation

Prior to performing any required grading operations and excavations in the proposed structure footprints, walkway and paved areas, these areas should be stripped of topsoil, vegetation, loose fill, and existing pavement, if present. The topsoil should be placed in a designated area for reuse during final grading. Following site clearing and stripping, the foundation areas should be prepared as discussed above. The exposed soil subgrade should be proof rolled with at least 10 passes of a minimum 10,000-lb (static weight) heavy vibratory roller. Any pockets of excessively soft, wet or disturbed soil or unsuitable soils should be removed and replaced with properly compacted fill materials. Where subgrade soils are close to the existing groundwater level or where silty subgrade soils are encountered, proof-compaction using non-vibratory methods may be considered by the geotechnical engineer.

If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches but not exceeding eighteen inches, aerated, re-compacted, and retested to provide uniform compaction. Following satisfactory compaction of the subgrade, controlled compacted fill material should be placed to bring the site to the required grade.

Fill should not be placed over frozen soil. Soil subgrades should be protected against frost both during and after construction.

Proper drainage of construction areas should be provided to protect the subgrades from the detrimental effects of weather conditions. Excavations should be made with as few passes of the backhoe bucket as possible to reduce disturbance of the subgrade. A backhoe bucket fitted with a smooth blade should be used during the final subgrade preparation, where necessary. The exposed base should be kept free of standing water at all times. The site should be graded to carry any surface runoff away from the work areas. Construction traffic should be controlled to prevent excessive stresses and disturbance to the subgrade.

If pavements are not constructed immediately after grading, the subgrade should be shaped so as to prevent ponding. If there is a substantial lapse in time between grading and paving, or if the subgrade is disturbed, it should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during proof-rolling or initial construction should be removed and replaced with compacted granular fill.

Within the proposed paved areas, and extending a distance of five feet beyond the edge on all sides, excavate existing granular fill soils to a depth of two feet below existing site grades. It may be possible to reuse the existing granular fill, depending on the suitability of the material, as described herein.

Fill Placement and Compaction

Fill materials most likely will be obtained by importing granular fill materials from off-site borrow sources. However, it may be possible to reuse existing site granular fill material provided that it can be properly placed and compacted. The gradation shall be in accordance with MBTA Standard Specification Section 02200-Earthwork for Type B Gravel Borrow.

All structural fill should be free of organics, demolition debris or other deleterious substances. The fill material should have a plasticity index (PI) less than 4 and a liquid limit (LL) less than 10, and contain fragments less than 4 inches in maximum dimension. Each lift should be compacted to the specified density prior to placing any subsequent lift. All materials to be used as structural fill should be tested in the laboratory to determine their project suitability and compaction characteristics.

The fill should be systematically compacted to the following percentages of the maximum dry density:

Table 3: Fill Compaction Requirements

DESCRIPTION	MINIMUM PERCENT COMPACTION (ASTM D-1557)
General Site Fills, Structural Fill (Below Footings and Slabs)	95
Behind Retaining Walls	92
Landscape Area	90

Soils which exhibit a well-defined moisture content–dry density relationship should be compacted to within plus or minus two percentage points of the optimum moisture content as determined by the Modified Proctor test (ASTM D-1557).

Where fill materials are placed against an existing embankment slope, the slope should be benched as the fill is brought up in layers. Benching should be of a sufficient width to permit placing and compaction of fill material upon the existing embankment materials. Typically, benches are between four to eight feet wide. Each bench cut should begin at the intersection of the existing embankment and the vertical side of the previous bench. Trench backfills over pipelines or utility structures should be performed so as not to adversely impact the underlying utilities. In fill areas, the backfill material, compaction method, and degree of compaction requirements should be similar to that for the fill adjacent to the trench.

Construction Dewatering

All excavations should be performed in the dry condition. Discharge of pumped water should be performed in accordance with all federal, state and/or local regulations which may require a discharge permit and possible filtration and chemical testing of the water prior to discharge.

Permanent Slopes

Permanent slopes with loamed and seeded surfaces should not be steeper than 2-1/2 horizontal to 1 vertical (2-1/2H:1V) without slope protection to limit erosion and surficial sloughing of the slope. Additional analyses may be required to assess the stability of slopes steeper than 2-1/2H:1V as the station design is finalized.

Excavation Slopes and Shoring

The slopes of open cuts should be no steeper than 1-1/2H:1V. Open cuts should not be used below the water table because of the likelihood of soil sloughing into the excavation.

The temporary excavation support system, if needed, should be selected by the Contractor and designed by an experienced registered Professional Engineer in the Commonwealth of Massachusetts and retained by the Contractor. Where excavation sides can be sloped back, they should be performed in accordance with the Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

Permanent Retaining Walls

If sheet pile walls or soldier pile walls with precast concrete panels are used for permanent retaining walls, pre-trenching or pre-drilling may be required to remove obstructions and to install piles to sufficient depths into underlying dense soils and bedrock. A minimum of 3 feet of free draining Gravel Borrow should be placed behind the walls and the walls should also have weep holes installed for drainage.

Protection of Existing Facilities

It is recommended that a geotechnical instrumentation and monitoring program be performed during construction of the project to evaluate impacts on adjacent structures. It is recommended that the program be developed to provide data for the following considerations:

- To monitor ground movements and vibration levels during construction.
- To provide early warning of potentially adverse trends by presenting sufficient data to determine the source of unanticipated ground movements, if present.
- If necessary, to plan remedial measures to limit damage to embankments and structures and to provide early warning when alternative means of protection are necessary.
- To document impacts of construction on adjacent facilities.
- To evaluate the performance and structural integrity of the constructed facilities.

We recommend the following instrumentation program to measure:

- Ground surface settlement and lateral movement adjacent to proposed construction.
- Horizontal and vertical movement of any excavation support system, and existing structures.
- Vibrations as a result of construction activities.

Vertical and horizontal survey points should be established on the adjacent structures. The monitoring points should be surveyed prior to the start of construction and monitored during construction to detect movement.

Vibration monitoring should be conducted within 100 feet of existing structures during construction activities.

We recommend conducting a pre-construction survey of structures and utilities within 100 feet of the site to document existing conditions prior to construction. Documentation should include photographs, video, sketches, and/or written comments.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

CLOSING

This report and the recommendations contained herein have been prepared for the exclusive use of MBTA and VHB and their representatives for specific application to the design and construction of the proposed Taunton Depot Station in Taunton, Massachusetts.

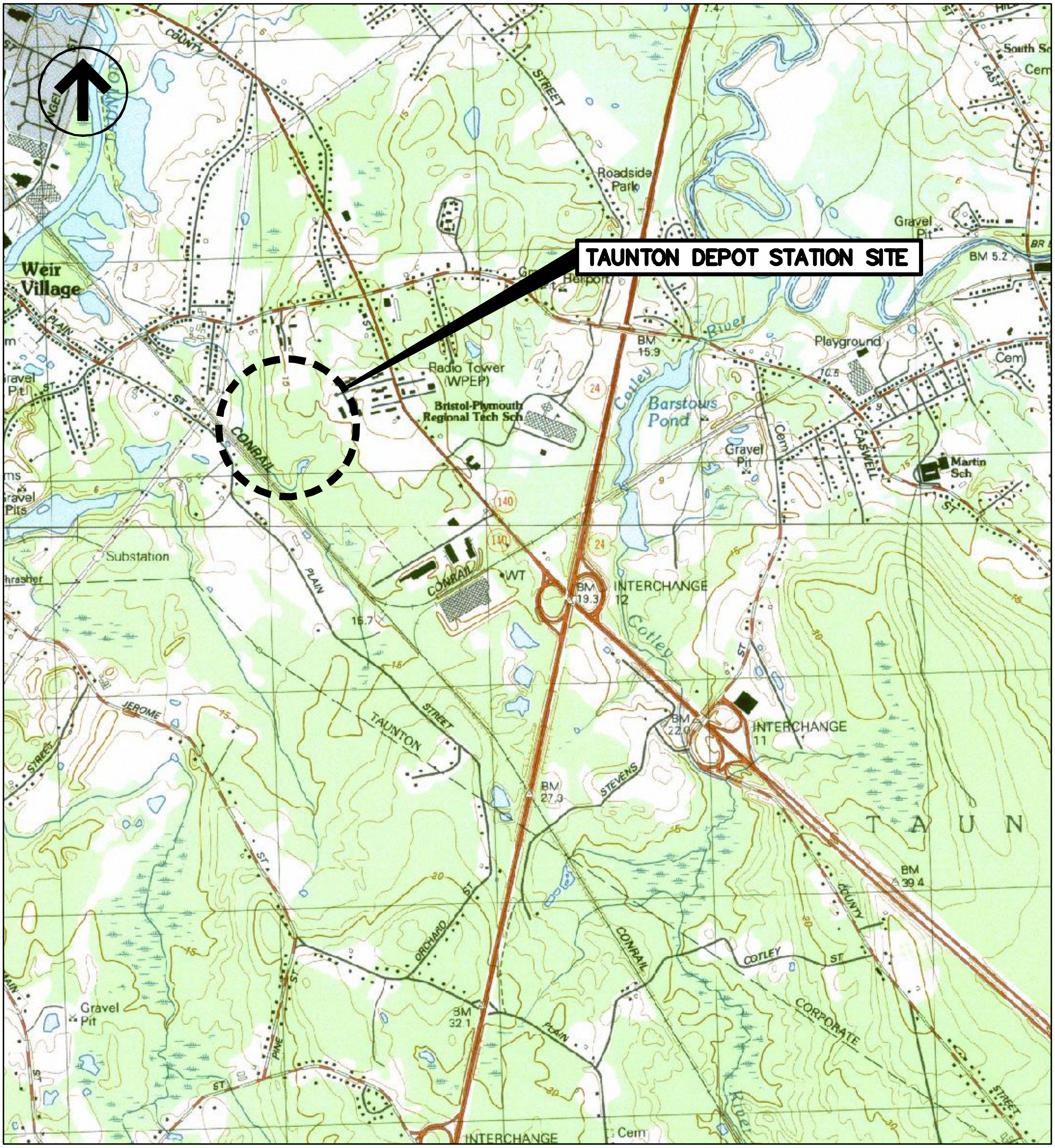
This report was prepared in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations then appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

ATTACHMENTS

FIGURE 1 – SITE LOCATION PLAN
FIGURES 2&3 – SUBSURFACE EXPLORATION PLANS
FIGURES 4&5 – SUBSURFACE SOIL PROFILES
APPENDIX A – EXPLORATION LOGS
APPENDIX B – LABORATORY DATA
APPENDIX C – GEOTECHNICAL CALCULATIONS

F:\Proj\013471\600 Discipline Files\610 Studies and Reports\2011 GIR\08 - Taunton Depot\Taunton Depot Station.doc

FIGURES

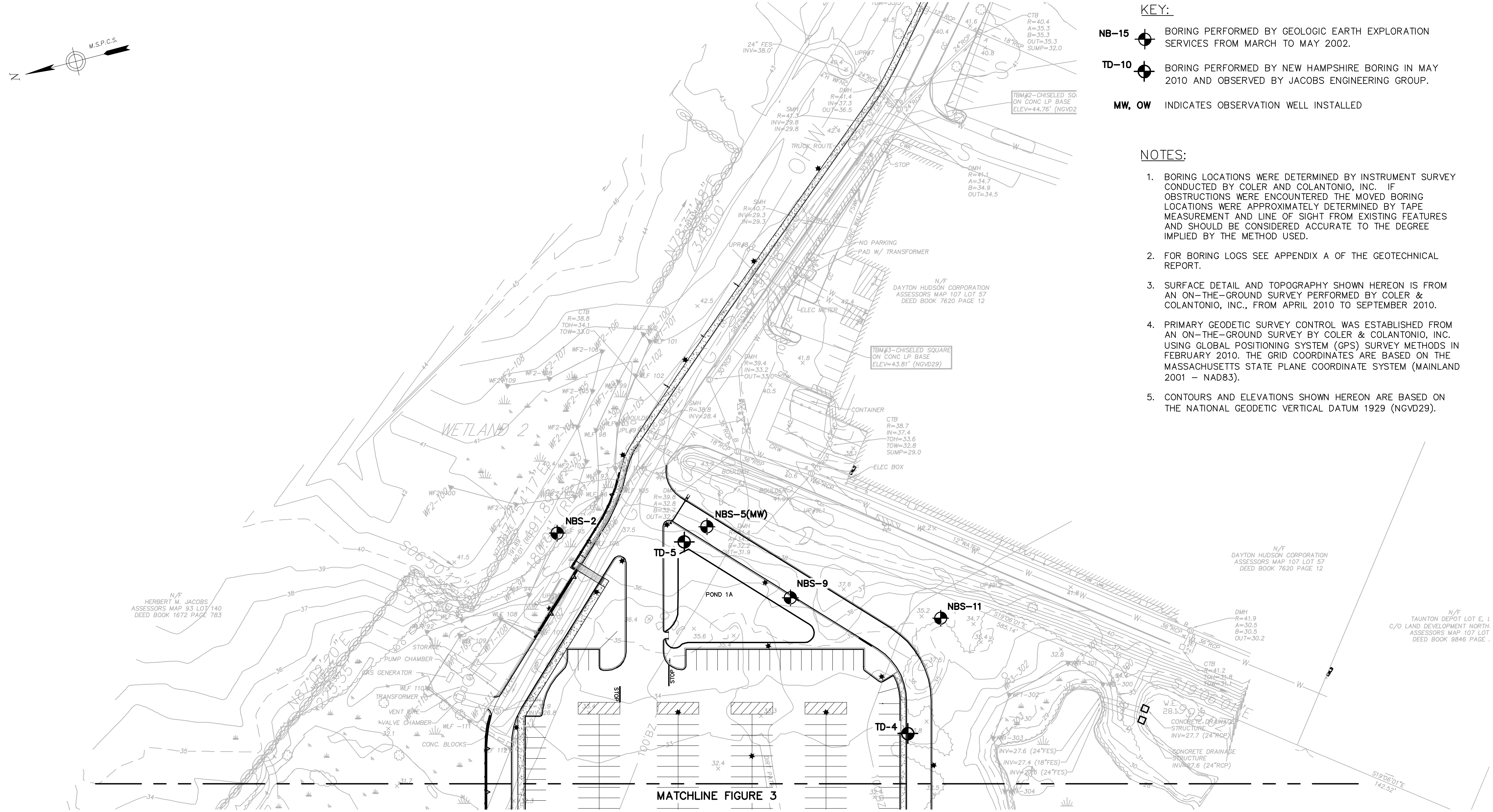


TAUNTON DEPOT STATION
PROJECT LOCUS PLAN

NOT TO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

TAUNTON DEPOT STATION
TAUNTON, MASSACHUSETTS
FIGURE 1



KEY:

NB-15	BORING PERFORMED BY GEOLOGIC EARTH EXPLORATION SERVICES FROM MARCH TO MAY 2002.
TD-10	BORING PERFORMED BY NEW HAMPSHIRE BORING IN MAY 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
MW, OW	INDICATES OBSERVATION WELL INSTALLED

NOTES:

1. BORING LOCATIONS WERE DETERMINED BY INSTRUMENT SURVEY CONDUCTED BY COLER AND COLANTONIO, INC. IF OBSTRUCTIONS WERE ENCOUNTERED THE MOVED BORING LOCATIONS WERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENT AND LINE OF SIGHT FROM EXISTING FEATURES AND SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.
2. FOR BORING LOGS SEE APPENDIX A OF THE GEOTECHNICAL REPORT.
3. SURFACE DETAIL AND TOPOGRAPHY SHOWN HEREON IS FROM AN ON-THE-GROUND SURVEY PERFORMED BY COLER & COLANTONIO, INC., FROM APRIL 2010 TO SEPTEMBER 2010.
4. PRIMARY GEODETIC SURVEY CONTROL WAS ESTABLISHED FROM AN ON-THE-GROUND SURVEY BY COLER & COLANTONIO, INC. USING GLOBAL POSITIONING SYSTEM (GPS) SURVEY METHODS IN FEBRUARY 2010. THE GRID COORDINATES ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (MAINLAND 2001 - NAD83).
5. CONTOURS AND ELEVATIONS SHOWN HEREON ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29).

TAUNTON DEPOT STATION
BORING LOCATION PLAN
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Taunton Depot.dwg Mar 26, 2012

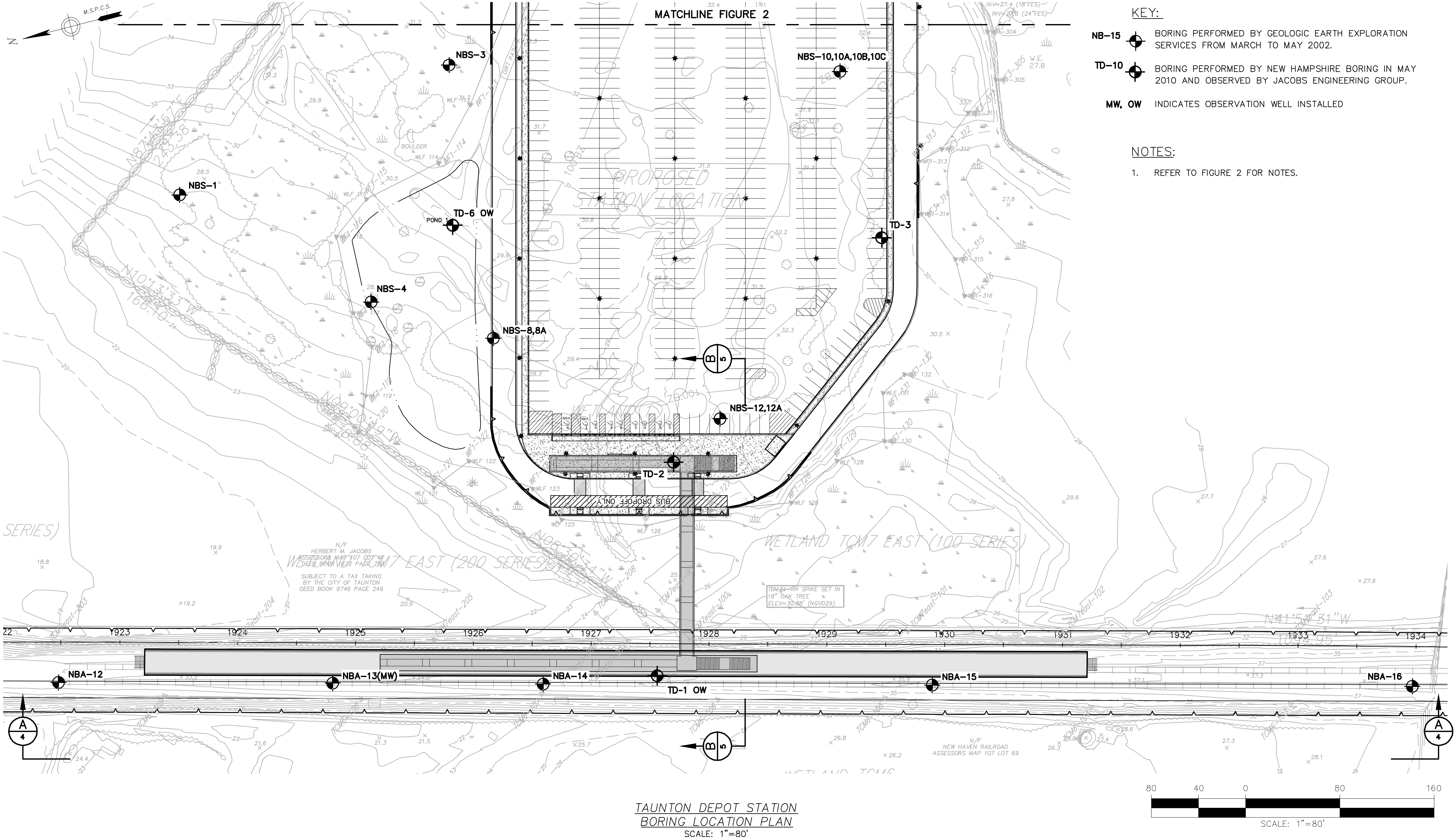
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

TAUNTON DEPOT STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: MARCH 2012

FIGURE NO: 2



KEY:

NB-15 ⊕	BORING PERFORMED BY GEOLOGIC EARTH EXPLORATION SERVICES FROM MARCH TO MAY 2002.
TD-10 ⊕	BORING PERFORMED BY NEW HAMPSHIRE BORING IN MAY 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
MW, OW	INDICATES OBSERVATION WELL INSTALLED

NOTES:

1. REFER TO FIGURE 2 FOR NOTES.

TAUNTON DEPOT STATION
BORING LOCATION PLAN
SCALE: 1"=80'

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Taunton Depot.dwg Mar 26, 2012

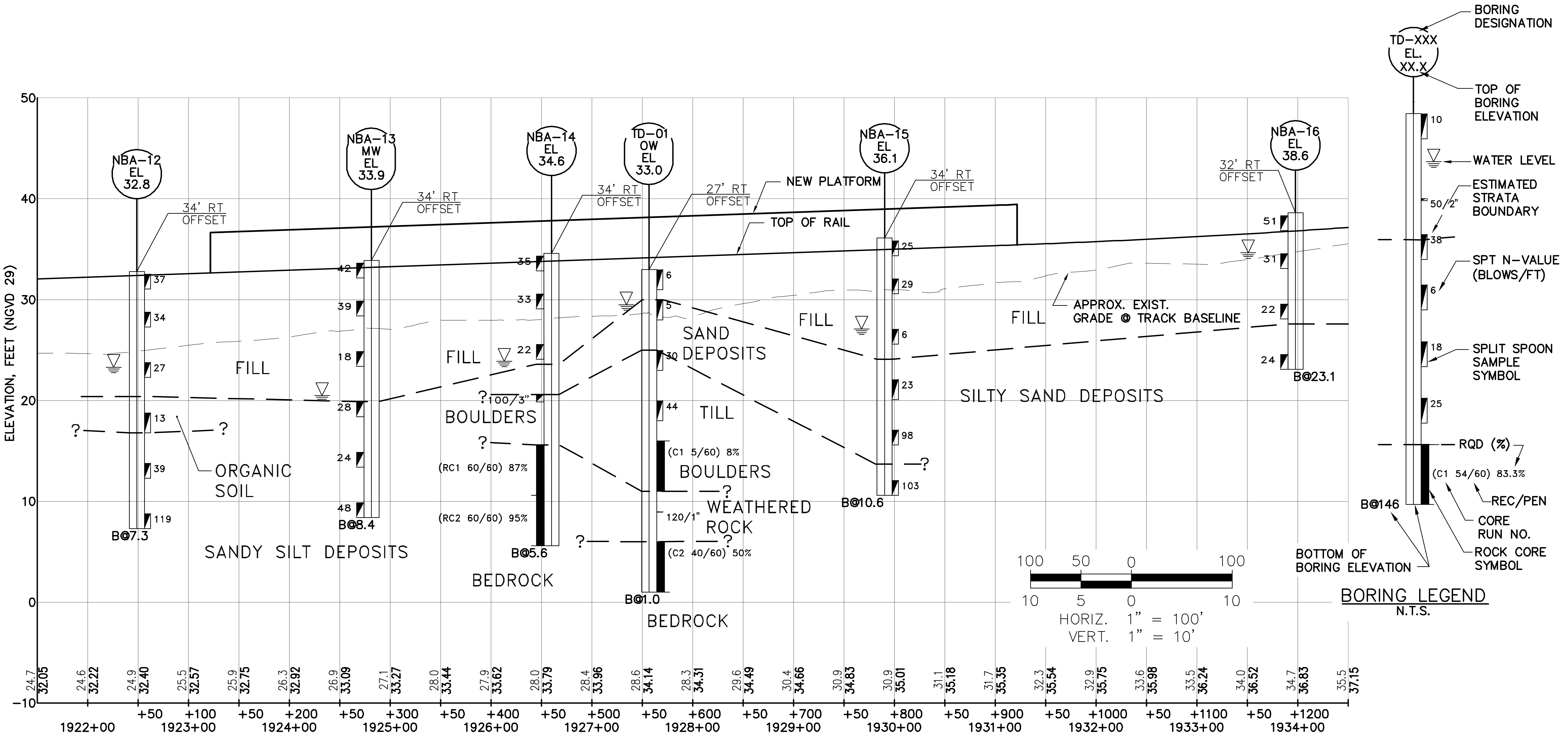
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

TAUNTON DEPOT STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: MARCH 2012

FIGURE NO: 3



F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Taunton Depot-Profile.dwg Mar 26, 2012

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

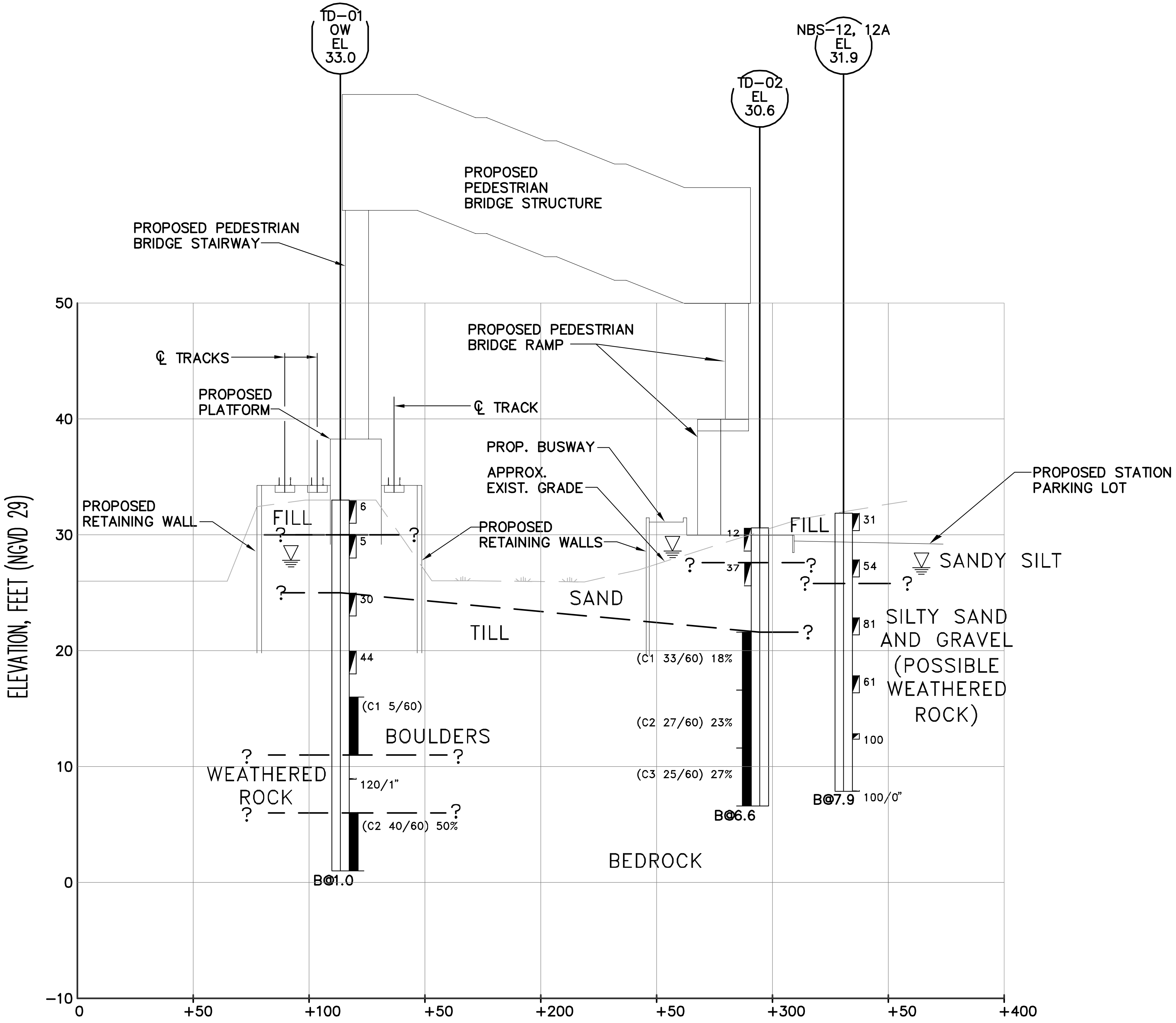
JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

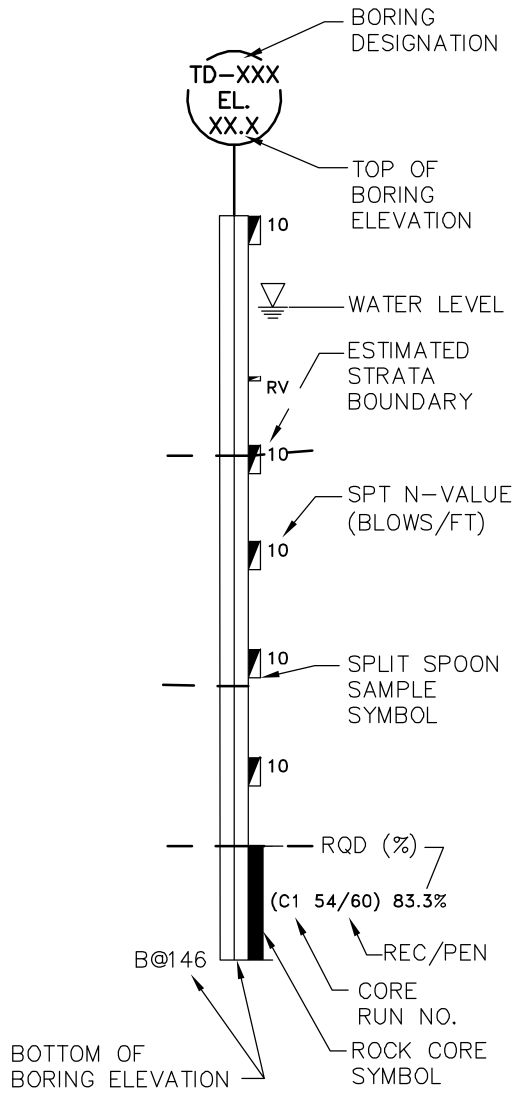
TAUNTON DEPOT STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE PROFILE A–A

DATE: MARCH 2012

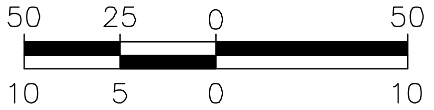
FIGURE NO: 4

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Taunton Depot-Profile.dwg Mar 29, 2012





BORING LEGEND
N.T.S.



HORIZ. 1" = 50'
VERT. 1" = 10'

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

TAUNTON DEPOT STATION
TAUNTON, MASSACHUSETTS
SUBSURFACE PROFILE B-B

DATE: MARCH 2012

FIGURE NO: 5

APPENDIX A: EXPLORATION LOGS

TD-1 TO TD-6
NBA-12 TO NBA-16
NBS-1 TO NBS-5
NBS-8 TO NBS-12

LOG OF TEST BORING

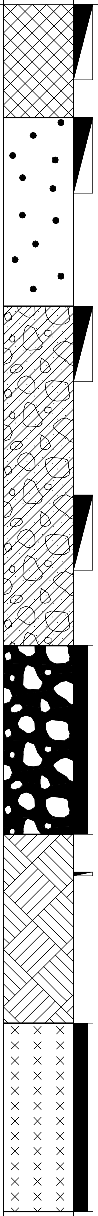
JACOBS

PROJECT	South Coast Rail	BORING NO.	TD - 001 OW
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	33
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2780610.2
						E	772564.6
						DATE START	5/4/10
						DATE END	5/4/10

METHOD OF DRILLING	
0	Wash Boring w/Casing
27	NX Rock Core
32	Terminated

GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS
5/4/2010	3.5	Upon Completion (In Casing)
7/7/2010	8	Monitoring Well Reading
9/12/2011	5.2	Monitoring Well Reading



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	5 4 2 1	S1	0 - 2	0		NO RECOVERY, from cuttings: WELL GRADED GRAVEL WITH SAND (GW); fine to coarse gravel, some fine to coarse sand, trace silt, gray, moist, FILL.
5	8 4 1 1	S2	3 - 5	4	30.0	POORLY GRADED SAND (SP); mostly fine to medium sand, trace gravel, trace silt, brown, wet.
10	24 17 13 14	S3	8 - 10	18	25.0	LEAN CLAY (CL); moderately plastic clay, some silt, trace sand, trace gravel, gray, moist, PP = 4.5 TSF, GLACIAL TILL.
15	14 31 13 21	S4	13 - 15	13		SIMILAR TO S3; frequent wet sand seams, PP = 4.5 TSF.
						Casing and split spoon refusal at 17 ft.
20		C1	17 - 22	5	16.0	BOULDERS.
25	120/1"	S5	23 - 23.1	2	11.0	WEATHERED ROCK; gray.
30	RQD=50	C2	27 - 32	40	6.0	SILTSTONE; soft, joints spaced 3 - 16", joints angled at ~10 - 20 degrees, some high angle fractures, slightly weathered, greenish-gray.
35					1.0	Bottom of Hole at 32'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	☐ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 001 OW

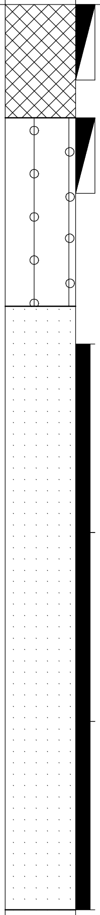
LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TD - 002
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	30.6
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2780721.2
						GRID COORD E	772708.7
						DATE START	5/5/10
						DATE END	5/5/10

METHOD OF DRILLING		GROUNDWATER READINGS DATE/TIME	DEPTH(ft)	REMARKS
0	Wash Boring w/Casing	5/5/2010	2	Upon Completion (Casing pulled)
9	NX Rock Core			
24	Terminated			



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	2 4 8 8	S1	0 - 2	16		WELL GRADED SAND (SW); fine to coarse sand, trace gravel, trace silt, light brown, dry, FILL.
3	10 15 22 23	S2	3 - 5	15	27.6	SILTY SAND (SM); mostly fine sand, little non-plastic silt, light brown, wet.
8					22.6	Top of bedrock at 8 ft, roller bit to 9 ft.
9	RQD=18	C1	9 - 14	33		SANDSTONE; hard, coarse grained, moderate weathering, gray/blue.
14	RQD=23	C2	14 - 19	27		SIMILAR TO C1.
19	RQD=27	C3	19 - 24	25		SIMILAR TO C1.
24					6.6	Bottom of Hole at 24'.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL BLOWS/FT	COHESIVE SOIL CONSISTENCY	NON-COHESIVE SOIL BLOWS/FT	NON-COHESIVE SOIL DENSITY	RELATIVE PROPORTIONS OF SOIL COMPONENTS	
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 002

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TD - 003
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	30.7
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS			
0	Wash Boring w/Casing				SPT HAMMER: 140 lb Safety	GRID N	2780717.4
13.33	Terminated	5/5/2010	2.5	Upon Completion (Casing pulled)		COORD E	772968.5
						DATE START	5/5/10
						DATE END	5/5/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 5 10 12	S1	0 - 2	12		WELL GRADED SAND WITH SILT (SW-SM); fine to coarse sand, little non-plastic silt, trace gravel, brown, dry, FILL.
		12 13 13 15	S2	3 - 5	8	27.7	SILTY SAND (SM); fine to coarse sand, little non-plastic silt, brown, wet.
5							
		15 26 19 22	S3	8 - 10	9		SIMLAR TO S2; gray, wet.
10							
		120/4"	S4	13 - 13.33	4	17.4	SILTY SAND (SM); fine to coarse sand, little non-plastic silt, dark gray, wet, weathered rock in tip of spoon.
15							Bottom of Hole at 13.33'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 003

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO. TD - 004
	LOCATION	Taunton, MA	
	OWNER	Mass.Bay Transportation Authority	
	JOB NUMBER	E2347101	SHEET 1 OF 1

INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	32.8
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS			
0	Wash Boring w/Casing			SPT HAMMER 140 lb Safety		GRID COORD N	2780857.5
15	Terminated	5/5/2010	2	Upon Completion (Casing pulled)		E	773140.5
						DATE START	5/5/10
						DATE END	5/5/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		1 2 9 10	S1	0 - 2	16		WELL GRADED SAND (SW); fine to coarse sand, trace silt, reddish-brown, dry, FILL.
		15 20 19 20	S2	3 - 5	18	29.8	WELL GRADED SAND WITH SILT (SW-SM); fine to coarse sand, little non-plastic silt, brown, wet.
5							
						25.8	Boulder encountered.
		46 17 20 18	S3	8 - 10	12	24.3	(8 - 8.5') WEATHERED BOULDER.
							(8.5 - 10') SILT (ML); non-plastic silt, dark gray, wet.
10							
		17 23 21 40	S4	13 - 15	14		SILT (ML); non-plastic silt, dark gray, wet.
15						17.8	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 004

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	TD - 005
	LOCATION	Taunton, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	P. Chou	CONTRACTOR	NH Boring		DRILLER	S. Bolduc	ELEVATION	36.9
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	TR CME 75	DATUM	NGVD 29
0	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2781096.4
15	Terminated	5/4/2010	4	Upon Completion (In Casing)			E	773134.7
							DATE START	5/4/10
							DATE END	5/4/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		12 50 41 22	S1	0 - 2	12		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine to mediuim sand, some non-plastic silt, trace gravel, brown, moist.
		8 14 14 18	S2	3 - 5	14		SILTY SAND (SM); mostly fine to mediuim sand, some non-plastic silt, trace gravel, olive, wet.
5							
		12 14 19 22	S3	8 - 10	12		SIMILAR TO S2; occasional clay seams.
10							
						23.9	
		22 17 20 24	S4	13 - 15	12		LEAN CLAY (CL); moderately plastic clay, little sand, trace silt, gray, moist, PP = 3 TSF.
15						21.9	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 005

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	TD - 006 OW
LOCATION	Taunton, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

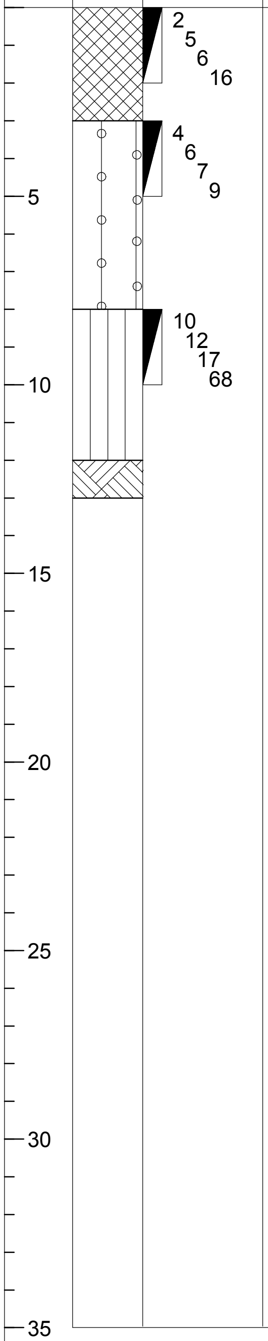
INSPECTOR	A. Barbetta	CONTRACTOR	NH Boring	DRILLER	P. Rosinha	ELEVATION	29.9
				DRILL RIG	TR CME 75	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID COORD N	2780995.1
						GRID COORD E	772732.7
						DATE START	5/5/10
						DATE END	5/5/10

METHOD OF DRILLING

0	Wash Boring w/Casing
13	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH(ft)	REMARKS
5/5/2010	1.5	Upon Completion (Casing pulled)
7/7/2010	3.5	Monitoring Well Reading
9/12/2011	1	Monitoring Well Reading



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0		2 5 6 16	S1	0 - 2	10		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel, trace silt, brownish gray, dry, FILL.
3		4 6 7 9	S2	3 - 5	12	26.9	SILTY SAND (SM); mostly fine sand, little non-plastic silt, dark gray, moist.
8		10 12 17 68	S3	8 - 10	8	21.9	SILT (ML); non-plastic silt, trace fine sand, dark gray, wet.
12						17.9	Probable top of bedrock at 12 ft, roller bit to 13 ft.
13						16.9	Bottom of Hole at 13'. Notes: Observation well screened 8 - 13 ft.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤	Auger Sample (AS)
▮	Rock Core (RC) and RQD (%) REC (%)
◩	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
▯	Undisturbed (U)-Shelby Tube, (P)-Piston
⧗	Jar Sample (JS)
⊠	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. TD - 006 OW

LOG OF TEST BORING

JACOBS	PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBA-12
	LOCATION	New Bedford Line - Taunton		
	CLIENT	Mass. Bay Transportation Authority		SHEET 1 OF 1
	JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	32.8
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B57-TR	DATUM	FT MSL

METHOD OF DRILLING		DATE/TIME	DEPTH (ft)	REMARKS			
0.0	Wash Boring w/Casing				SPT HAMMER 140 lb. Safety	GRID N	2780984
4.0	Wash Boring-Open Hole	3/12/02 1100	9.5	Upon Completion (Casing pulled)		COORD E	772220
24.0	Split Spoon Sample					DATE START	3/12/02
25.5	Terminated					DATE END	3/12/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
					32.50	3" of ballast
		14 18 19	10	SS-1		Well graded sand with gravel (SW) - mostly fine to medium sand, some fine to coarse gravel, light brown, dry (FILL) Top 2" of sample contains slag, dark brown/black (Possibly used as subballast)
5		27 19 15	18	SS-2		Silty sand (SM) - mostly fine to medium sand, some silt, trace fine to coarse gravel, trace coarse sand, brown, wet (FILL)
10		13 14 13	18	SS-3		Well graded sand with silt and gravel (SW-SM) - mostly fine to coarse sand, little fine to coarse gravel, trace to little silt, brown, wet (FILL)
					20.80	(Organic soil layer from 12.0 to 15.5 ft)
15		5 5 8 24	18	SS-4		Top 12": Organic soil with sand (OL/OH) - mostly organics, little fine sand, trace medium to coarse sand, dark brown, moist
					17.30	Bot 6": Well graded sand with silt (SW-SM) - mostly fine to medium sand, trace to little silt, gray, wet
					14.80	
20		21 12 27	18	SS-5		Sandy silt (ML) - mostly silt, some fine sand, trace medium sand, gray, wet
25		41 58 61	10	SS-6		Sandy silt (ML) - mostly silt, some fine sand, trace medium sand, gray, wet
					7.300	Boring Terminated at 25.5 ft.
30						
35						

REMARKS:

Boring located at centerline of existing tracks.

Test boring performed by GeoLogic, Inc.

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBA-12

LOG OF TEST BORING/MONITORING WELL

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBA-13 MW
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
CLIENT	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	33.9
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B57-TR	DATUM	FT MSL

METHOD OF DRILLING		DATE/TIME	DEPTH (ft)	REMARKS
0.0	Wash Boring w/Casing			
4.0	Wash Boring-Open Hole	3/13/02 1330	8.0	Upon Completion (in Casing)
24.0	Split Spoon Sample	5/21/02 1415	13.4	Monitoring well reading
25.5	Terminated			

SPT HAMMER	140 lb. Safety	
GRID	N	2780811
COORD	E	772376
DATE START		3/13/02
DATE END		3/13/02

DEPTH (ft)	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	9 18 24	8	SS-1	33.60	3' of ballast Well graded sand with gravel (SW) - mostly fine to medium sand, some fine to coarse gravel, tan, dry (FILL) (Slag in shoe)
5	13 22 17	12	SS-2		Silty sand (SM) - mostly fine to medium sand, some silt, trace coarse sand, gray, moist (FILL)
10	9 9 9	14	SS-3		Sandy silt (ML) - mostly silt, little fine sand, trace medium to coarse sand, brown, wet (FILL)
15	12 13 15	10	SS-4	19.90	Sandy silt (ML) - mostly silt, little to some fine sand, trace medium sand, gray, wet
20	3 8 16	18	SS-5		Sandy silt (ML) - mostly silt, little to some fine sand, trace medium sand, gray, wet
25	23 22 26	6	SS-6	8.40	Sandy silt with gravel (ML) - mostly silt, little fine sand, little fine to coarse gravel, gray, wet Boring Terminated at 25.5 ft.
30					
35					

REMARKS:

Boring located at centerline of existing tracks.

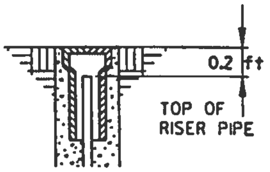
Test boring performed by GeoLogic, Inc.

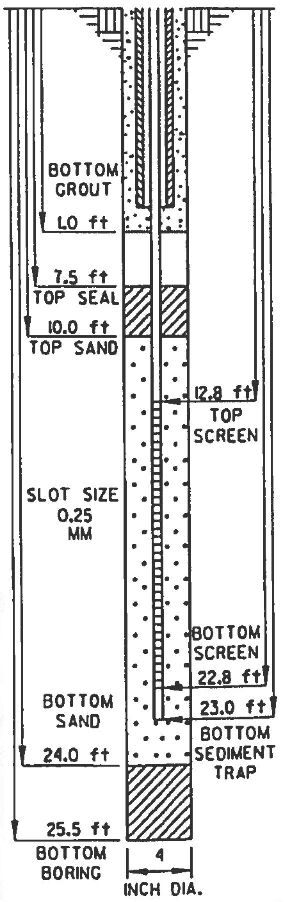
Monitoring well installed (2" Dia. PVC pipe)

WELL LOG (N. T. S.)

WELL COVER INFORMATION

☐ STANDPIPE ☒ ROADBOX





Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

• REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBA-13 MW

LOG OF TEST BORING

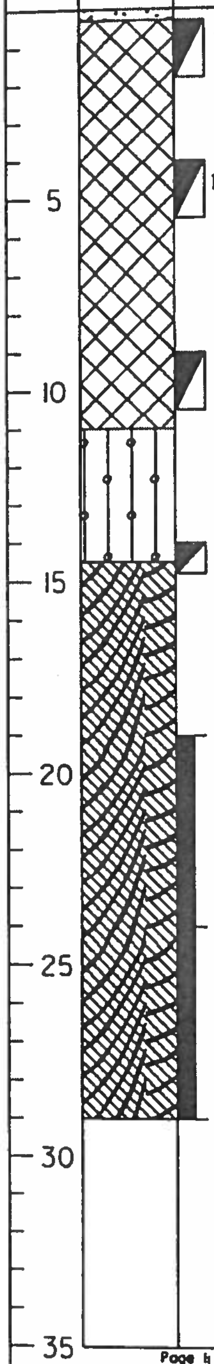
JE JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBA-14
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
CLIENT	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	34.6
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B57-TR	DATUM	FT MSL

METHOD OF DRILLING		DATE/TIME	DEPTH (ft)	REMARKS
0.0	Wash Boring w/Casing			
4.0	Wash Boring-Open Hole	3/14/02 0900	10.7	Prior to resumption of drilling
19.0	NX Rock Core			(Hole depth at 18 ft)
29.0	Terminated			

SPT HAMMER	140 lb. Safety	
GRID COORD	N	2780678
	E	772495
DATE START		3/13/02
DATE END		3/14/02



SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
			34.30	3" of ballast
9 18 17	6	SS-1		Well graded sand with gravel (SW) - mostly fine to medium sand, some fine to coarse gravel, light brown, dry (FILL) (Sand with slag in shoe tip) (Layer containing slag from 1.5 to 3.0 ft)
15 17 16	18	SS-2		Well graded sand with silt (SW-SM) - mostly fine to medium sand, trace to little silt, trace fine gravel, brown, wet (FILL)
9 10 12	5	SS-3		Well graded sand with silt (SW-SM) - mostly fine to medium sand, trace to little silt, trace fine gravel, brown, wet (FILL)
			23.60	
13 100/3"	4	SS-4	20.10	Silty sand (SM) - mostly fine sand, some silt, gray, wet (Gravel/rock lodged in shoe)
				(Rollerbit from 14.5 to 19.0 ft, drop 3" casing down hole and begin rock core)
87 RQD (%)	87 REC (%)	RC-1		Argillite: moderately hard, very slightly weathered, sound, gray, fine grained, moderately close horizontal to moderately dipping joints
95 RQD (%)	97 REC (%)	RC-2		Argillite: moderately hard, very slightly weathered, sound, gray, fine grained, close horizontal joints
			5.60	Boring Terminated at 29.0 ft.

REMARKS:
Very large boulders observed in surrounding area.
Boring located at centerline of existing tracks.
Test boring performed by GeoLogic, Inc.

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)
90 ROCK CORE (RC) AND ROD (%) REC (%)
4 5 6 SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
JAR (JS)
BAG (B)

• REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBA-14

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBA-15
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
CLIENT	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	36.1
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B57-TR	DATUM	FT MSL
				SPT HAMMER	140 lb. Safety	GRID COORD N	2780431
						GRID COORD E	772715
						DATE START	3/14/02
						DATE END	3/14/02

METHOD OF DRILLING	
0.0	Wash Boring w/Casing
4.0	Wash Boring-Open Hole
24.0	Split Spoon Sample
25.5	Terminated

DATE/TIME	DEPTH (ft)	REMARKS
3/14/02 1400	9.0	Upon Completion (In Casing)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
					35.80	3" of ballast
		7 12 13	6	SS-1		Well graded sand (SW) - mostly fine to medium sand, trace fine to coarse gravel, light brown, dry (FILL) (Sand with slag in shoe tip)
5		9 17 12	10	SS-2		Silty sand with gravel (SM) - mostly fine to coarse sand, some fine to coarse gravel, little silt, brown, wet (FILL)
10		6 4 2	2	SS-3		Well graded sand with silt and gravel (SW-SM) - mostly fine to medium sand, little fine to coarse gravel, trace to little silt, brown, wet (FILL)
					24.10	
15		11 9 14	8	SS-4		Silty sand with gravel (SM) - mostly fine to medium sand, some silt, little coarse gravel, trace coarse sand, light brown, wet (Hard drilling from 17.5 to 18.5 ft)
20		37 47 51	6	SS-5		Silty sand with gravel (SM) - mostly fine to coarse sand, some fine to coarse gravel, little silt, gray, wet
					13.10	
25		49 52 51	8	SS-6		Clayey sand with gravel (SC) - mostly fine to coarse sand, some clay, little fine to coarse gravel, gray, wet (possible weathered rock)
					10.60	Boring Terminated at 25.5 ft.
30						
35						

REMARKS:
Boring located at centerline of existing tracks.
Test boring performed by GeoLogic, Inc.

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)	90 ROCK CORE (RC) AND RQD (%) REC (%)	4 5 6 SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)	UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON	☒ JAR (JS)	☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBA-15

LOG OF TEST BORING

JACOBS	PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBA-16	
	LOCATION	New Bedford Line - Taunton			
	CLIENT	Mass. Bay Transportation Authority		SHEET 1 OF 1	
	JOB NUMBER	013471			

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION		38.6
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B57-TR	DATUM		FT MSL

METHOD OF DRILLING		DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER	140 lb. Safety	GRID	N	2780128
0.0	Wash Boring w/Casing	3/14/02 1500	3.0	Upon Completion (Casing pulled)			COORD	E	772987
4.0	Wash Boring-Open Hole						DATE START		3/14/02
14.0	Split Spoon Sample						DATE END		3/14/02
15.5	Terminated								

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
					38.30	3" of ballast
		13 23 29	6	SS-1		Well graded sand (SW) - mostly fine to medium sand, brown, dry (FILL)
5		17 7 24	4	SS-2		Well graded sand with silt and gravel (SW-SM) - mostly fine to medium sand, little fine to coarse gravel, trace to little silt, brown, wet (FILL)
10		10 11 11	6	SS-3		Well graded sand with silt and gravel (SW-SM) - mostly fine to medium sand, little fine to coarse gravel, trace to little silt, brown, wet (FILL)
					27.60	
15		12 6 18	1	SS-4		Silty sand (SM) - mostly fine sand, some silt, brown, wet
					23.10	Boring Terminated at 15.5 ft.
20						REMARKS: Boring located at centerline of existing tracks. Test boring performed by GeoLogic, Inc.
25						
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet, Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51+	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)

ROCK CORE (RC) AND ROD (%) REC (%)

SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)

UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON

JAR (JS)

BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBA-16

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-1
LOCATION	New Bedford Line - Taunton		
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		SHEET 1 OF 1

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	B. Farget	ELEVATION	27.6
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	Bombadier	DATUM	FT MSL
		DATE/TIME	DEPTH (ft)	REMARKS			
0.0	Wash Boring w/Casing			SPT HAMMER	140 lb Safety	GRID COORD N	2781185
9.0	Wash Boring-Open Hole	5/24/02 1445	0.5	Upon Completion (Casing Pulled)		E	772597
12.5	NX Rock Core					DATE START	5/24/02
15.5	Terminated					DATE END	5/24/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 6 11	14	SS-1		Wellgraded sand with silt (SW-SM) - mostly fine to medium sand, trace to little silt, brown, moist (Very hard drilling from 1.5 to 3.0 ft, probable boulder)
					24.60	
5		15 18 20	10	SS-2		Poorly graded sand (SP) - mostly fine sand, trace medium sand, brown, wet
					20.60	
10		36 16 55	12	SS-3		Silty sand with gravel (SM) - mostly fine to medium sand, some fine gravel, little silt, gray, wet (Very hard drilling from 10.5 to 12.5 ft) (Attempt rock core at 12.5 ft)
		14 RQD (%)	14 REC (%)	RC-1	15.10	Diabase - moderately hard, very slightly weathered, light gray to black, fine to medium grained (Probable boulder, lean clay in core barrel above and below rock recovery) (Core barrel jammed at 15.5 ft)
15					12.10	Boring Terminated at 15.5 ft.
20						REMARKS: Test boring performed by GeoLogic, Inc.
25						
30						
35						

Page 1: 0-35 feet. Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)	ROCK CORE (RC) AND RQD (%) REC (%)	SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)	UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON	JAR (JS)	BAG (B)

• REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-1

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail			BORING NO.	NBS-2	
LOCATION	New Bedford Line - Taunton				SHEET 1 OF 1	
OWNER	Mass. Bay Transportation Authority					
JOB NUMBER	013471					
INSPECTOR	C.Nagata					
CONTRACTOR	Earth Exploration, Inc	DRILLER	B. Forget	ELEVATION	38.0	
		DRILL RIG	Bombadier	DATUM	FT MSL	
		SPT HAMMER	140 lb Safety	GRID COORD	N	2781178
					E	773071
				DATE START	5/24/02	
				DATE END	5/24/02	

METHOD OF DRILLING

0.0	Wash Boring w/Casing
9.0	Wash Boring-Open Hole
14.0	Split Spoon Sample
15.5	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH (ft)	REMARKS
5/24/02 1030	1.7	Upon Completion (Casing Pulled)

DEPTH (ft)	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	15 19 32	18	SS-1		Well graded sand with silt and gravel (SW-SM) - mostly fine to coarse sand, little fine gravel, trace to little silt, light brown, moist
3				35.00	
5	9 11 12	18	SS-2		Silty sand (SM) - mostly fine sand, some silt, light brown-gray, wet
10	15 19 17	14	SS-3		Silty sand with gravel (SM) - mostly fine to medium sand, little silt, little fine gravel, trace clay, gray, wet
15	20 24 24	18	SS-4		Silty sand with gravel (SM) - mostly fine to medium sand, little silt, little fine gravel, trace clay, gray, wet
15.5				22.50	Boring Terminated at 15.5 ft.

REMARKS:
Test boring performed by GeoLogic, Inc.

Depth scale: 5, 10, 15, 20, 25, 30, 35

Page 1: 0-35 feet. Page 2: 35-80 feet. Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- JAR (JS)
- BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-2

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-3
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

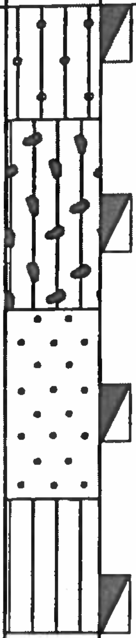
INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	31.6

METHOD OF DRILLING	
0.0	Hollow Stem Augers
15.0	Split Spoon Sample
16.5	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH (ft)	REMARKS
4/18/02 1010	4.8	During Drilling (in Augers)
4/18/02 1110	3.0	Upon Completion (Augers Pulled)

DRILL RIG	B-57 TR	DATUM	FT MSL
SPT HAMMER	140 lb Safety	GRID COORD N	2781088
		GRID COORD E	772832
		DATE START	4/18/02
		DATE END	4/18/02



DEPTH (ft)	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	2 4 9	12	SS-1	28.60	Silty sand with gravel (SM) - mostly fine to coarse sand, some fine to coarse gravel, little silt, olive brown, moist
5	30 37 22	3	SS-2	23.60	Silty gravel with sand (GM) - mostly fine gravel, some fine to coarse sand, little silt, gray, wet
10	15 40 48	18	SS-3	18.60	(Blow-in sands caused 6' drillrod of stickup prior to SS-3 sample) Poorly graded sand with gravel (SP) - mostly fine to medium sand, little fine gravel, trace coarse sand, trace fines, gray, wet
15	12 13 22	10	SS-4	15.10	Sandy silt (ML) - mostly silt, some fine to coarse sand, trace to fine gravel, gray, wet
					Boring Terminated at 16.5 ft.
20					REMARKS: Test boring performed by GeoLogic, Inc.
25					
30					
35					

Page 1: 0-35 feet. Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▥	AUGER (AS)
[90	ROCK CORE (RC) AND RQD (%) REC (%)
◪ 4 5 6	SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
▯	UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
☒	JAR (JS)
☒	BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

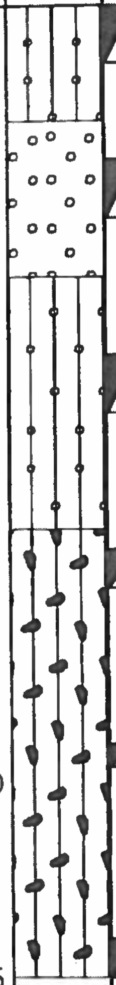
BORING NO. NBS-3

LOG OF TEST BORING

JE JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-4
LOCATION	New Bedford Line - Taunton		
OWNER	Mass. Bay Transportation Authority		SHEET 1 OF 1
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	B. Forget	ELEVATION	30.0
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	Bombadier	DATUM	FT MSL
0.0	Wash Boring w/Casing	DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER 140 lb Safety	GRID N	2781003
19.0	Wash Boring-Open Hole	5/28/02 1100	0.5	Upon Completion (Casing Pulled)		COORD E	772638
24.0	Split Spoon Sample					DATE START	5/28/02
25.0	Spoon Refusal					DATE END	5/28/02



DEPTH (ft)	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
	7 7 10	12	SS-1		Silty sand (SM) - mostly fine sand, some silt, light brown, moist
				27.00	
5	21 25 22	10	SS-2		Well graded sand with gravel (SW) - mostly fine to coarse sand, some fine gravel, trace silt, light brown, wet
				23.00	
10	37 20 26	9	SS-3		Silty sand with gravel (SM) - mostly fine sand, some silt, little fine gravel, trace coarse sand, beige, wet (Very hard drilling from 11 to 13.5 ft)
				16.50	
15	15 24 100/0"	5	SS-4		Silty gravel (GM) - mostly fine gravel, some silt, trace fine sand, beige, wet (Very hard drilling from 14 to 19 ft)
20	16 100/3"	3	SS-5		Silty gravel (GM) - mostly fine gravel, some silt, trace fine sand, beige, wet (Very hard drilling from 19 to 22.5 ft)
	23 100	6	SS-6		Silty gravel (GM) - mostly fine gravel, some silt, trace fine sand, beige, wet
25				5.00	Split Spoon Refusal at 25.0 ft. Boring Terminated.
30					
35					

REMARKS:

Test boring performed by GeoLogic, Inc.
Survey coordinates and elevations are approximate.

Page 1: 0-35 feet, Page 2: 35-80 feet,
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE		
3 - 4	SOFT	5 - 10	LOOSE	< 10%	TRACE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	15 - 25%	LITTLE
9 - 15	STIFF	31 - 50	DENSE	30 - 45%	SOME
16 - 30	VERY STIFF	51+	VERY DENSE	50 - 100%	MOSTLY
30 +	HARD				

LEGEND

AUGER (AS); ROCK CORE (RC) AND RQD (%) REC (%); SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in); UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON; JAR (JS); BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-4

LOG OF TEST BORING/MONITORING WELL

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail
LOCATION	New Bedford Line - Taunton
CLIENT	Mass. Bay Transportation Authority
JOB NUMBER	013471
CONTRACTOR	Earth Exploration, Inc
DRILLER	T.Galvin
DRILL RIG	B-57 TR
SPT HAMMER	140 lb Safety

BORING NO. NBS-5 MW

SHEET 1 OF 1

ELEVATION		38.0
DATUM		FT MSL
GRID COORD	N	2781091
	E	773156
DATE START		4/17/02
DATE END		4/17/02

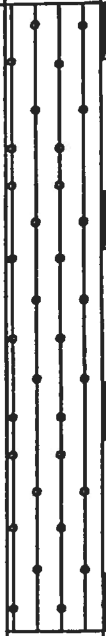
INSPECTOR C.Nagata

METHOD OF DRILLING

0.0	Hollow Stem Augers
15.0	Split Spoon Sample
16.5	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH (ft)	REMARKS
4/17/02 0954	5.5	During Drilling (in Augers)



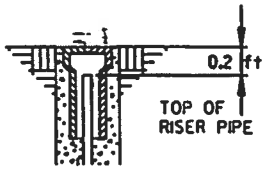
DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
0		18 14 10	8	SS-1		Silty sand (SM) - mostly fine to medium sand, some silt, trace coarse sand, trace fine gravel, organics, brown, dry
5		31 28 34	12	SS-2		Silty sand with gravel (SM) - mostly fine to medium sand, little to some silt, little fine gravel, trace coarse sand, beige, wet
10		16 22 22	10	SS-3		Silty sand (SM) - mostly fine to coarse sand, some silt, trace to little fine gravel, gray, wet
15		13 15 17	13	SS-4		Silty sand (SM) - mostly fine to coarse sand, some silt, trace to little fine gravel, gray, wet
					21.50	Boring Terminated at 16.5 ft.
20						
25						
30						
35						

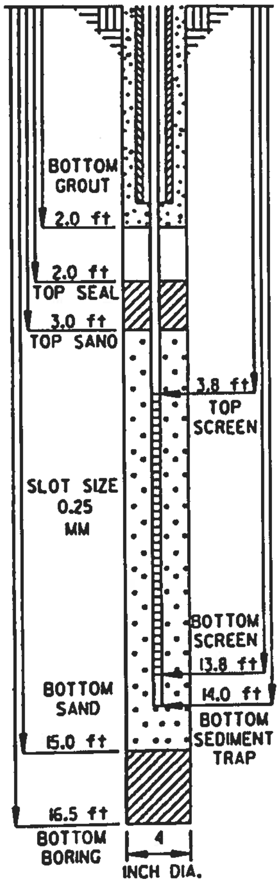
REMARKS:
Test boring performed by GeoLogic, Inc.
Monitoring well installed (2" Dia. PVC pipe)

WELL LOG (N. T. S.)

WELL COVER INFORMATION

☐ STANDPIPE ☒ ROADBOX





Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)
ROCK CORE (RC) AND ROD (%) REC (%)
SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
JAR (JS)
BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-5 MW

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-8, 8A
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

INSPECTOR	C.Nagato	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	28.8
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B-57 TR	DATUM	FT MSL
0.0	Hollow Stem Augers	DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER 140 lb Safety	GRID N	2780905
15.0	Split Spoon Sample	4/18/02 1400	5.0	Upon Completion (Augers Pulled)		COORD E	772685
16.5	Terminated					DATE START	4/18/02
						DATE END	4/18/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		13 20 20	18	SS-1		Poorly graded sand (SP) - mostly fine sand, trace silt, tan, dry
					25.80	
5		14 17 12	18	SS-2		Silty sand (SM) - mostly fine sand, little silt, brown to gray, wet
10		13 100/3"	7	SS-3		Silty sand with gravel (SM) - mostly fine sand, some silt, little fine gravel, gray, wet (Auger refusal at 11.0 ft, offset hole 10 ft to NBS-8A, soil probe to 11 ft)
					15.80	
15		12 13 22	10	SS-4		Silty gravel with sand (GM) - mostly fine gravel, some fine to coarse sand, little silt, gray, wet
					12.30	Boring Terminated at 16.5 ft.
						REMARKS: Test boring performed by GeoLogic, Inc.
20						
25						
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- 90 ROCK CORE (RC) AND ROD (%) REC (%)
- 4 5 6 SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-8, 8A

LOG OF TEST BORING

JE JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-9
LOCATION	New Bedford Line - Taunton		
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		SHEET 1 OF 1

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc		DRILLER	T.Galvin	ELEVATION	36.7
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	B-57 TR	DATUM	FT MSL
0.0	Hollow Stem Augers	DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2781002
15.0	Split Spoon Sample	4/17/02 1151	5.7	During Drilling (in augers)			COORD E	773159
16.5	Terminated	4/17/02 1230	6.0	Upon Completion (in augers)			DATE START	4/17/02
		4/17/02 1250	4.0	Upon Completion (Augers pulled)			DATE END	4/17/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		1 2 3	7	SS-1		Well graded sand (SW) - mostly fine to medium sand, trace fines, brown, top 2" of sample contains organic soil (topsoil), dry
5		30 27 20	10	SS-2		Well graded sand (SW) - mostly fine to medium sand, trace fine gravel, trace silt, brown, wet
					27.70	
10		10 14 12	5	SS-3		Silty sand (SM) - mostly fine to medium sand, little silt, beige, wet
15		8 20 25	12	SS-4		Silty sand with gravel (SM) - mostly fine to medium sand, some fine gravel, little silt, gray, wet
					20.20	Boring Terminated at 16.5 ft.
						REMARKS: Test boring performed by GeoLogic, Inc.
20						
25						
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- JAR (JS)
- BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-9

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-10,10A,B,C
LOCATION	New Bedford Line - Taunton		SHEET 1 OF 1
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	B.Forget	ELEVATION	32.2
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	Bombadier	DATUM	FT MSL

METHOD OF DRILLING		DATE/TIME	DEPTH (ft)	REMARKS		
0.0	Hollow Stem Augers/Wash Boring				SPT HAMMER: 140 lb Safety	GRID COORD N: 2780838
9.0	Wash Boring-Open Hole	4/18/02 0810	5.0	During Dilling (in augers)		E: 773050
14.0	Split Spoon Sample	5/29/02 1045	3.0	Upon Completion (Casing pulled)		DATE START: 4/18/02
14.7	Spoon Refusal					DATE END: 5/29/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
0		10 16 18	12	SS-1		Well graded sand with silt (SW-SM) - mostly fine to medium sand, trace to little silt, trace fine gravel, brown, dry (Very hard drilling 0 to 5 ft)
3					29.20	Silty gravel with sand (GM) - mostly fine to coarse gravel, some fine to medium sand, little silt, light brown, wet (Auger refusal at 5 ft, boring offset 5 ft to NBS-10A) (Auger refusal at 4 ft, boring offset 5 ft to NBS-10B) (Auger refusal at 9 ft, offset 10 ft to NBS-10C, switchover from augers to wash boring with casing)
5		100/2"	1	SS-2		
9		100/3"	0	SS-3		No recovery (Very hard drilling from 9 to 10.5 ft) (Very hard drilling from 11.5 to 13.5 ft) (High drill water loss while drilling from 13.5 to 14.0 ft)
13.5					18.70	Poorly graded gravel (GP) - mostly fine gravel, trace coarse gravel, gray, wet
14		55 100/2"	1	SS-4	17.50	Split Spoon Refusal at 14.7 ft. Boring Terminated.

Depth scale: 5, 10, 15, 20, 25, 30, 35

REMARKS:
Test boring performed by GeoLogic, Inc.

Page 1: 0-35 feet, Page 2: 35-80 feet, Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51+	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

*REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-10,10A,B,C

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	NBS-11
LOCATION	New Bedford Line - Taunton		
OWNER	Mass. Bay Transportation Authority		SHEET 1 OF 1
JOB NUMBER	013471		

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	T.Galvin	ELEVATION	34.9
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B-57 TR	DATUM	FT MSL

0.0	Hollow Stem Augers			
15.0	Split Spoon Sample			
16.2	Spoon Refusal			

DATE/TIME	DEPTH (ft)	REMARKS
4/17/02 1440	Dry	Upon Completion (in Augers)
4/17/02 1500	Dry	Augers pulled (hole caved to 12 ft)

SPT HAMMER	140 lb Safety	
GRID	N	2780900
COORD	E	773228
DATE START		4/17/02
DATE END		4/17/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 4 8	18	SS-1		Silty sand (SM) - mostly fine sand, some silt, tan-light brown, moist
5		33 34 47	14	SS-2		Silty sand with gravel (SM) - mostly fine sand, some silt, some gravel (crushed rock fragments), tan-light brown, moist (Very hard drilling from 5 to 10 ft)
10		22 32 25	5	SS-3		Silty sand with gravel (SM) - mostly fine to medium sand, some fine gravel, little silt, trace clay, gray, moist
15		41 47 100/2"	4	SS-4		Silty sand (SM) - mostly fine sand, little silt, trace clay, trace fine gravel, gray, moist
					18.69	Split Spoon Refusal at 16.2 ft. Boring Terminated. REMARKS: Test boring performed by GeoLogic, Inc.
20						
25						
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-11

LOG OF TEST BORING

JACOBS			BORING NO.	NBS-12, 12A
	PROJECT	New Bedford/Fall River Commuter Rail		
	LOCATION	New Bedford Line - Taunton		
	OWNER	Mass. Bay Transportation Authority		
	JOB NUMBER	013471		SHEET 1 OF 1

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc		DRILLER	T.Galvin	ELEVATION	31.9
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	B-57 TR	DATUM	FT MSL
0.0	Wash Boring w/Casing	DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2780717
24.0	Split Spoon Refusal	4/22/02 1400	4.0	Upon Completion of NBS-12 (Casing Pulled)			E	772762
		5/28/02 1510	4.7	Upon Completion of NBS-12A (Casing Pulled)			DATE START	4/22/02
							DATE END	5/28/02

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		9 14 17	14	SS-1		Silt with sand (ML) - mostly silt, little fine to medium sand, trace coarse sand, light brown, dry
5		18 27 27	8	SS-2		Silt (ML) - mostly silt, trace fine sand, light brown, wet (fine to medium sand in shoe)
					24.90	
10		27 51 30	7	SS-3		Silty gravel with sand (GM) - mostly fine to coarse gravel, some fine to coarse sand, little silt, gray, wet
						(Very hard drilling from 9 to 14 ft, possible boulder blocking spoon sampler, add 10 ft of casing and continue drilling)
15		10 20 41	4	SS-4		Silty gravel with sand (GM) - mostly fine to coarse gravel, some fine to coarse sand, little silt, gray, wet
						(Difficulty in drilling, offset boring to NBS-12A and resume sampling at 19 ft)
20		100	2	SS-5		Silty gravel with sand (GM) - mostly fine to coarse gravel, some fine to coarse sand, little silt, gray, wet
						(Very hard drilling from 19 to 24 ft)
		100/0"	0	SS-6	7.90	No recovery
						Split Spoon Refusal at 24.0 ft. Boring Terminated.
25						
						REMARKS: Test boring performed by GeoLogic, Inc.
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet, Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- JAR (JS)
- BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. NBS-12, 12A

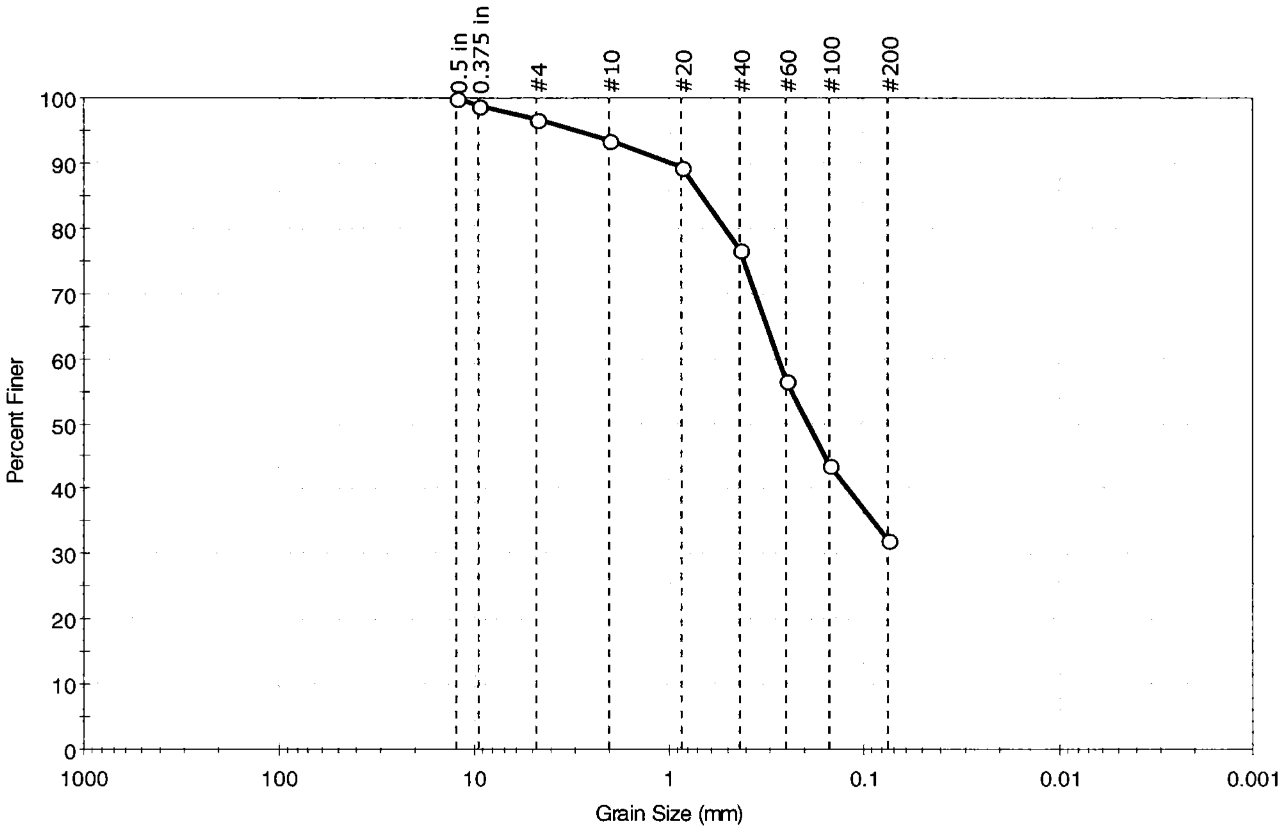
APPENDIX B: LABORATORY DATA

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	TD-5	Sample Type:	jar	Tested By:	jbr
Sample ID:	S-2	Test Date:	07/14/10	Checked By:	jdt
Depth :	3-5 ft	Test Id:	185193		

Test Comment: ---
Sample Description: Moist, olive silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	3.1	64.7	32.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	97		
#10	2.00	93		
#20	0.85	89		
#40	0.42	77		
#60	0.25	57		
#100	0.15	44		
#200	0.075	32		

Coefficients

D_{85} =0.6733 mm	D_{30} =N/A
D_{60} =0.2726 mm	D_{15} =N/A
D_{50} =0.1922 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

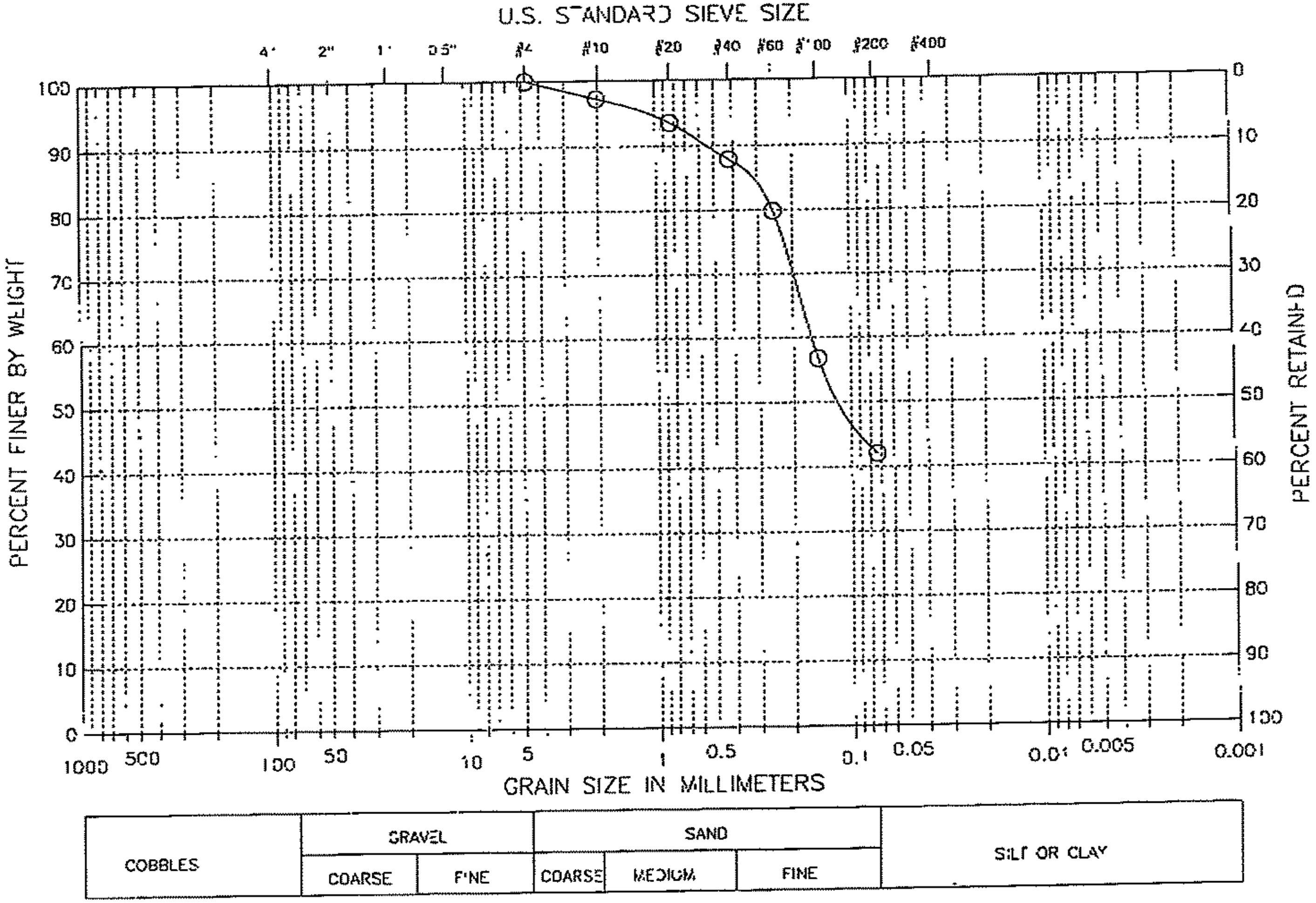
Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

printed 7/20/2010 9:50:30 AM

	Boring No. : - - - Sample No.: NBA-12 SS-2 Test Method ASTM D 422 Filename : NBA12SS2	Project : New Bedford/Fall River Commuter Rai. Project No.: GTX-3916 Location: Massachusetts Date : Thu Aug 01 2002



Classification :

Remarks :

Visual Description :
Moist, reddish yellow silty sand

Figure 19

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBA-12 SS-2
Location : Massachusetts
Soil Description : Moist, reddish yellow silty sand
Remarks :

Depth : --
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA12SS2
Elevation : ---
Tested by : srp/jx
Checked by : jdt

FINE SIEVE SET

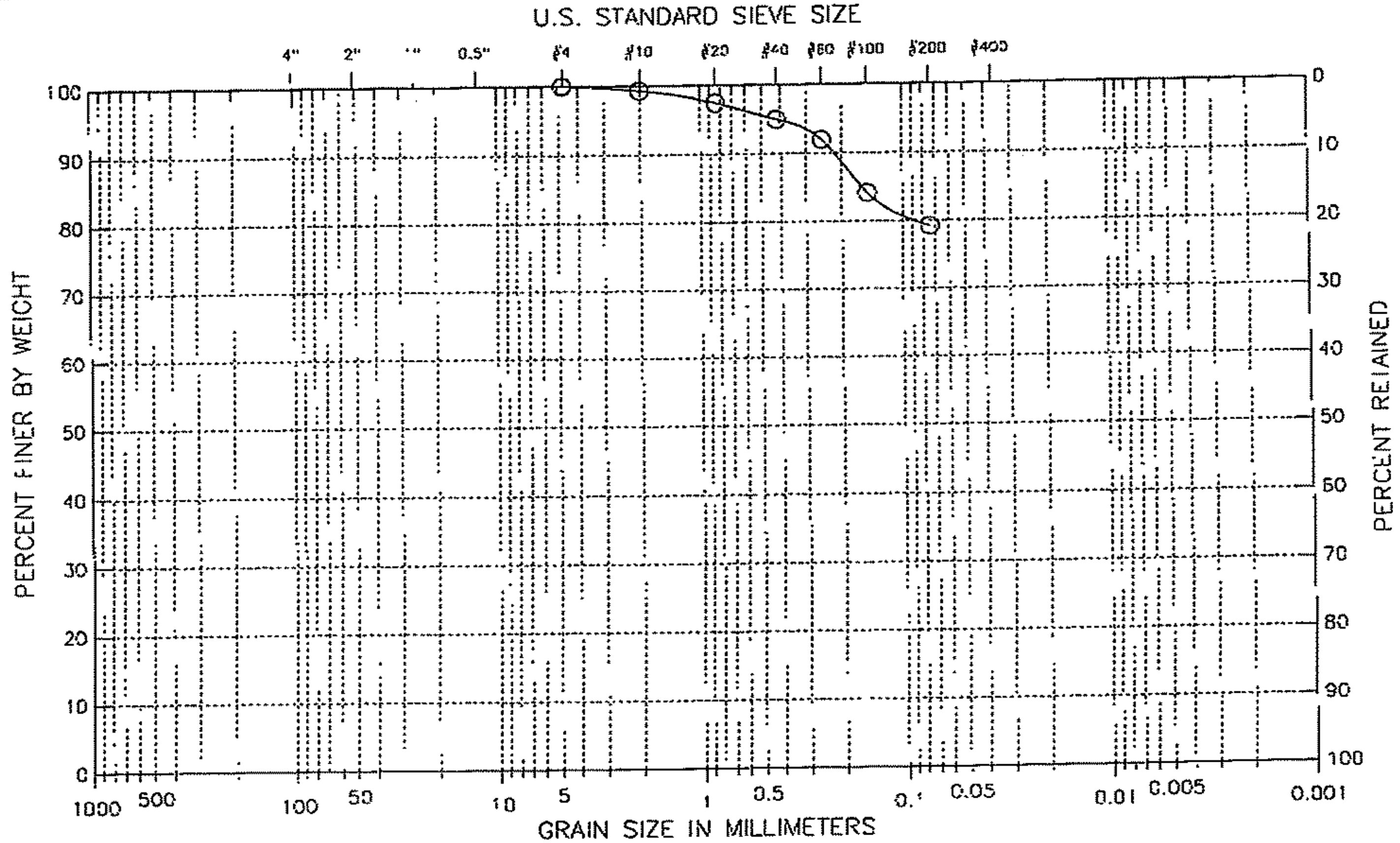
Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
				0.00	100
#4	0.187	4.76	0.00	2.20	97
#10	0.079	2.00	2.20	5.24	94
#20	0.033	0.84	3.04	9.82	88
#40	0.017	0.42	4.58	16.33	80
#60	0.010	0.25	6.51	35.05	57
#100	0.006	0.15	18.72	47.01	42
#200	0.003	0.07	11.96	81.10	0
Pan			34.09		

Total Dry Weight of Sample = 89.19

D85 : 0.3484 mm
D60 : 0.1601 mm
D50 : 0.1080 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

	Boring No. : --- Sample No.: NBA-12 SS-4 Test Method ASTM D 422 Filename : NBA12SS4	Project : New Bedford/Fall River Commuter Ro Project No.: GTX-3916 Location: Massachusetts Date : Thu Aug 01 2002



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :

Remarks :

Visual Description :
Moist, dark grayish brown sandy silt

Figure 20

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBA-12 SS-4
Location : Massachusetts
Soil Description : Moist, dark grayish brown sandy silt
Remarks :

Depth : --
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA12SS4
Elevation : ---
Tested by : srp/jx
Checked by : jdc

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Fines (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.28	0.28	99
#20	0.033	0.84	0.74	1.02	97
#40	0.017	0.42	0.98	2.00	95
#60	0.010	0.25	1.19	3.19	92
#100	0.006	0.15	3.10	6.29	84
#200	0.003	0.07	1.96	8.25	79
Pan			31.41	39.66	0

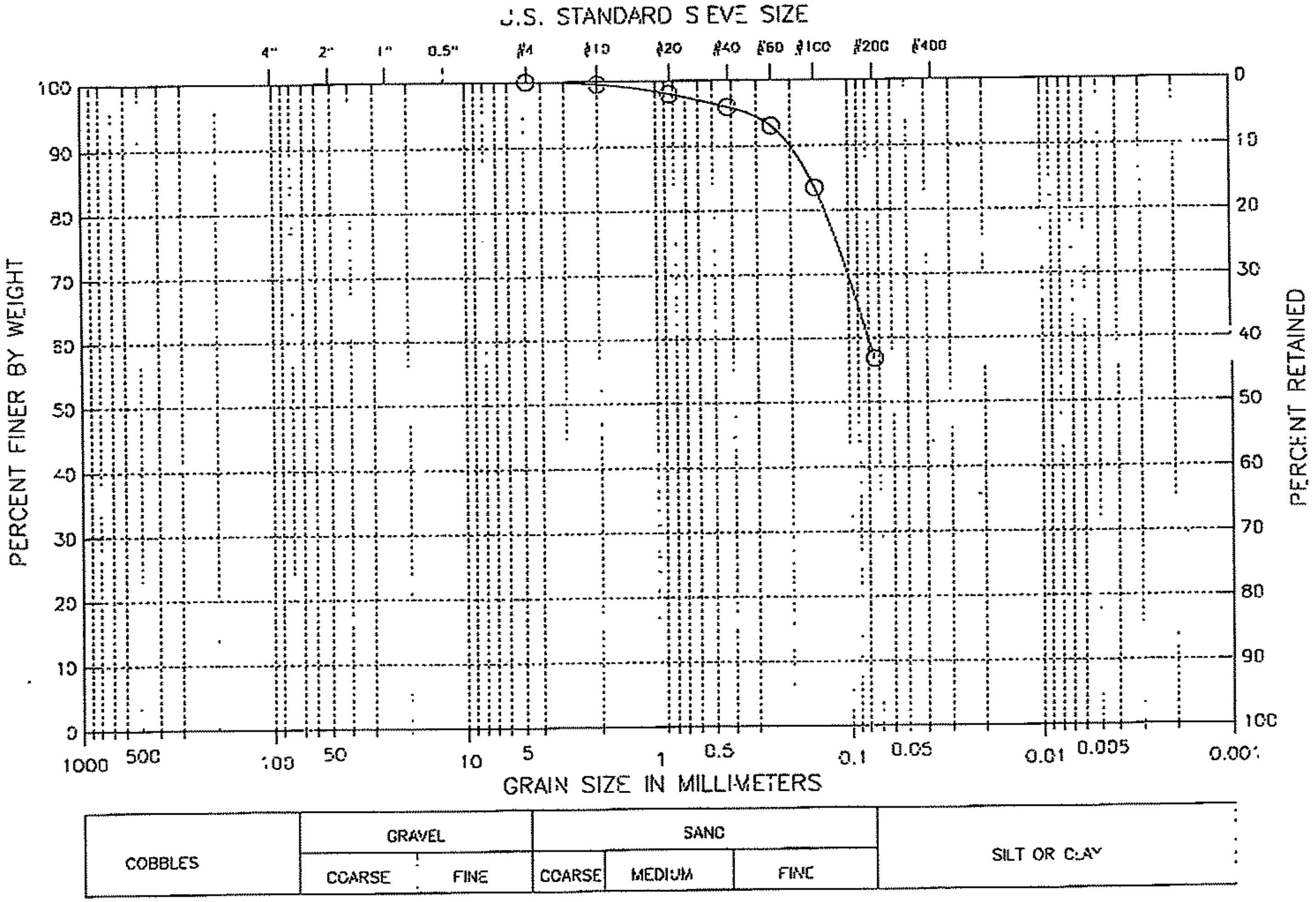
Total Dry Weight of Sample - 47.81

D85 : 0.1577 mm
D60 : N/A
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A 4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No: NBA-12 SS-5
Test Method ASTM D 422
Filename : NBA12SS5

Project : New Bedford/Fall River Commuter Ra
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



Classification :

Remarks :

Visual Description :
Moist, dark gray silty sand

Figure 2:

Page : 1

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3516
Boring No. : --
Sample No. : NBA-12 SS-5
Location : Massachusetts
Soil Description : Moist, dark gray silty sand
Remarks :

Depth : ---
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA12SS5
Elevation : ---
Tested by : syp/jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.56	0.56	100
#20	0.033	0.84	1.96	2.52	98
#40	0.017	0.42	2.54	5.06	96
#60	0.010	0.25	3.67	8.73	93
#100	0.006	0.15	12.08	20.81	83
#200	0.003	0.07	33.66	54.47	57
Pan			71.65	126.12	0

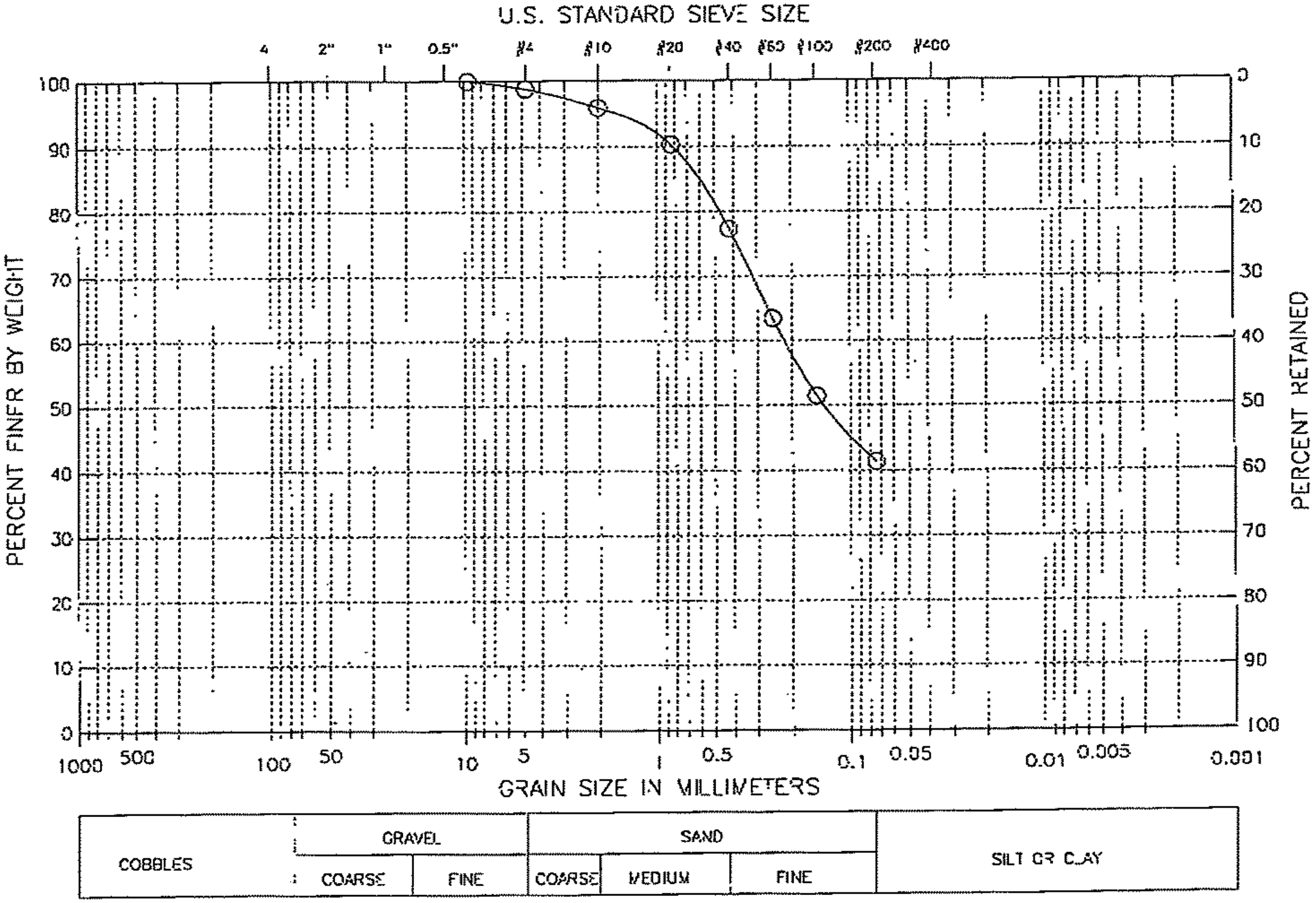
Total Dry Weight of Sample - 134.28

D85 : 0.1616 mm
D60 : 0.0805 mm
D50 : N/A
D30 : N/A
D15 . N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBA-13 SS-2
Test Method ASTM D 422
Filename : NBA13SS2

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



Classification :

Remarks :

Visual Description :
Moist, dark gray silty sand

Figure 22

Page : 1

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBA-13 SS-2
Location : Massachusetts
Soil Description : Moist, dark gray silty sand
Remarks :

Depth : ---
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA13SS2
Elevation : -
Tested by : srp/jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	1.68	1.68	99
#10	0.079	2.00	3.93	5.61	96
#20	0.033	0.84	7.81	13.42	90
#40	0.017	0.42	17.94	31.36	77
#60	0.010	0.25	19.20	50.56	63
#100	0.006	0.15	16.68	67.24	51
#200	0.003	0.07	13.92	81.16	41
Pan			57.25	138.41	0

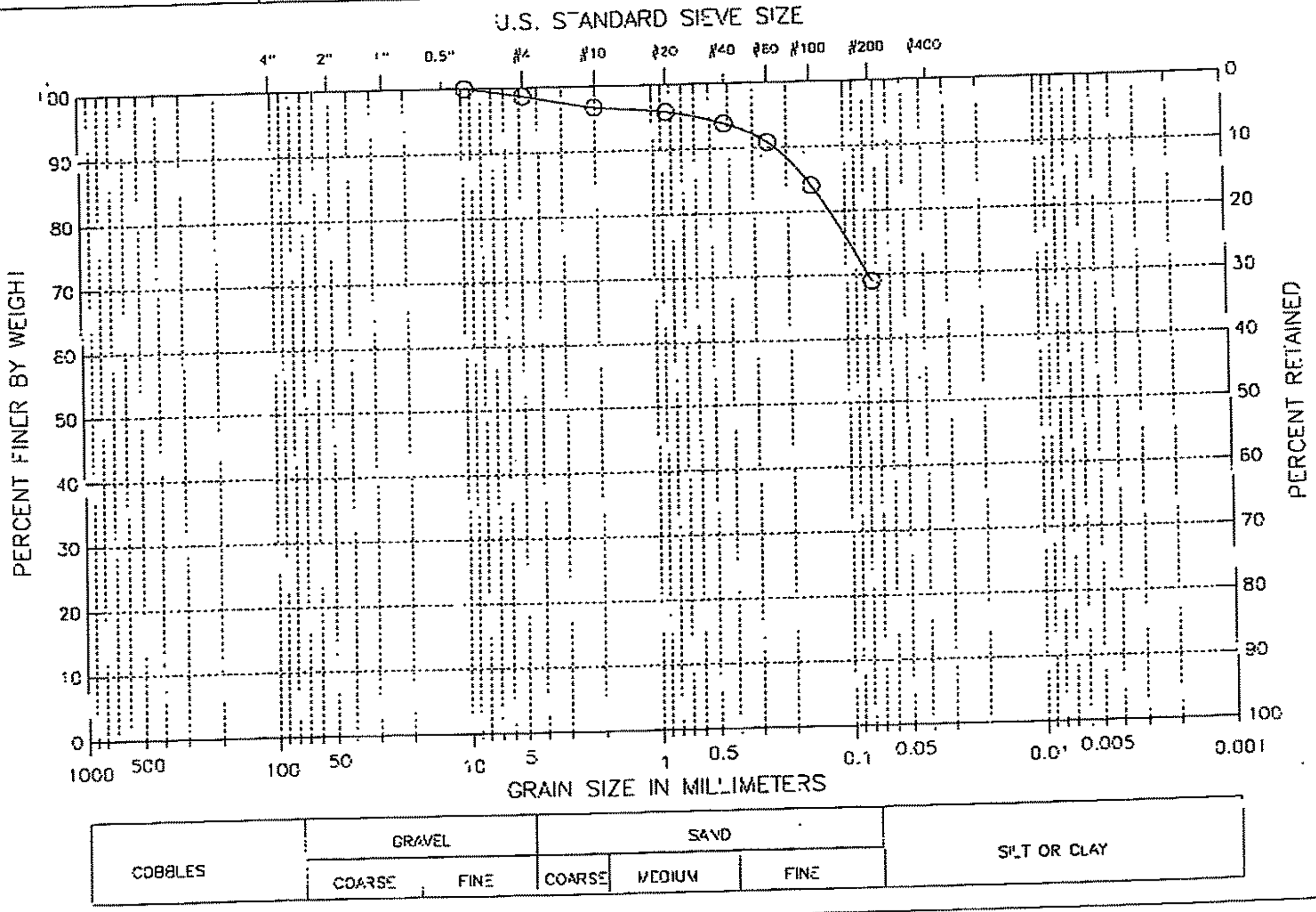
Total Dry Weight of Sample = 146.62

D85 : 0.6330 mm
D60 : 0.2154 mm
D50 : 0.1350 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBA-13 SS-3
Test Method ASTM D 422
Filename : NBA13SS3

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



Remarks :

Classification :

Visual Description :
Moist, light yellowish brown sandy silt

Figure 23

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Filename : NBA13SS3
Elevation : --
Tested by : srp/jx
Checked by : jdt

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3016
Boring No. : ---
Sample No. : NBA-13 SS-3
Location : Massachusetts
Soil Description : Moist, light yellowish brown sandy silt
Remarks :

Depth : ---
Test Date : 07/26/02
Test Method : ASTM D 422

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	1.53	1.53	99
#10	0.079	2.00	2.18	3.71	97
#20	0.033	0.84	1.07	4.78	96
#40	0.017	0.42	2.30	7.08	94
#60	0.010	0.25	3.47	10.55	91
#100	0.006	0.15	7.75	18.30	84
#200	0.003	0.07	17.31	35.61	69
Pan			79.14	114.75	0

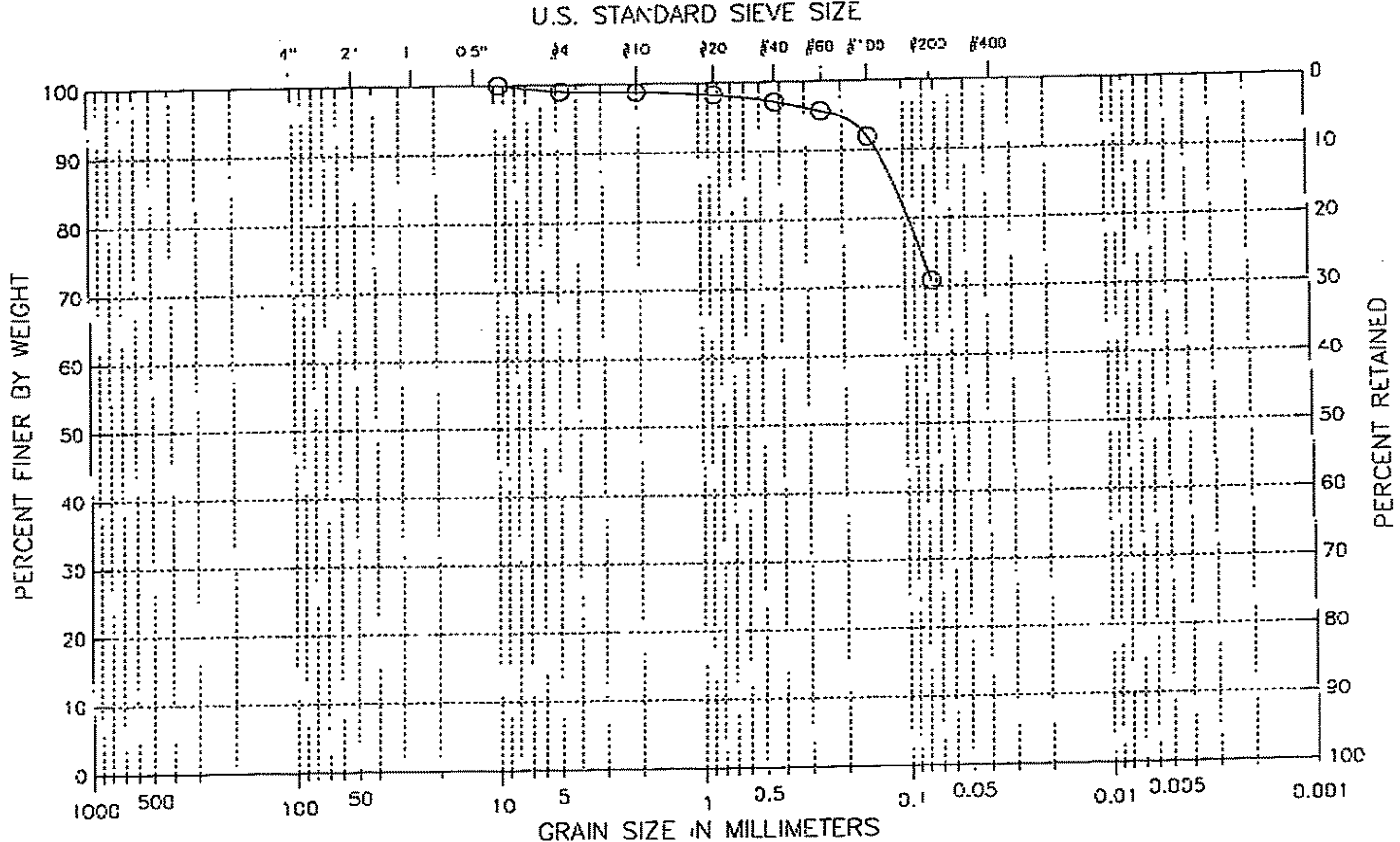
Total Dry Weight of Sample = 122.94

D85 : 0.1602 mm
D60 : N/A
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No: NBA-13 SS-5
Test Method ASTM D 422
Filename : NBA13SS5

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :

Remarks :

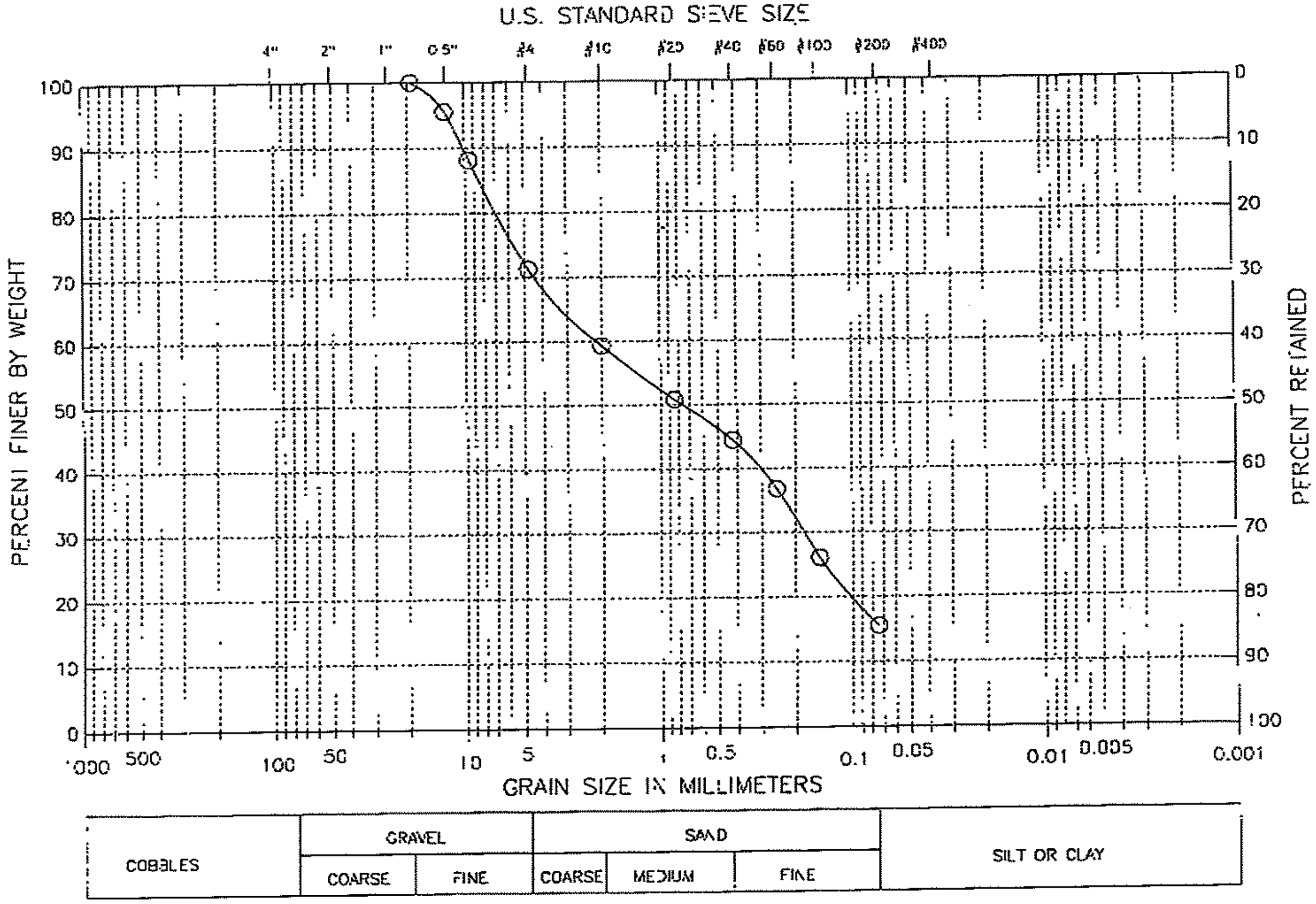
Visual Description :
Moist, pale olive sandy silt

Figure 24

```
                                                                          Page :  1
Thu Aug 01 16:11:44 2002

                          GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail                    Filename : NBA13SS5
Project No. : GTX-3916              Depth : ---                   Elevation : ---
Boring No. : ---                    Test Date : 07/26/02          Tested by : srp/jx
Sample No. : NBA-13 SS-5            Test Method : ASTM D 422      Checked by : jdt
Location : Massachusetts
Soil Description : Moist, pale olive sandy silt
Remarks :

                                           FINE SIEVE SET
Sieve          Sieve Openings          Weight      Cumulative          Percent
Mesh           Inches  Millimeters     Retained    Weight Retained     Finer
                                       (gm)        (gm)                (%)
 ---------     ----    ----------      --------    --- ----------      -------
0.375"         0.374      9.51            0.00               0.00        100
#4             0.187      4.75            0.90               0.90         99
#10            0.079      2.00            0.23               1.13         99
#20            0.033      0.84            0.49               1.62         98
#40            0.017      0.42            1.05               2.67         97
#60            0.010      0.25            1.34               4.07         96
#100           0.006      0.15            3.51               7.52         92
#200           0.003      0.07           19.68              27.20         71
Pan                                      66.05              93.25          0
     Total Dry Weight of Sample = 101.42

  D85 : 0.1184 mm
  D60 : N/A
  D50 : N/A
  D30 : N/A
  D15 : N/A
  D10 : N/A

  Soil Classification
         ASTM Group Symbol     : N/A
         ASTM Group Name       : N/A
         AASHTO Group Symbol   : A-4(0)
         AASHTO Group Name     : Silty Soils
```

Boring No. : ---
Sample No.: NBA-15 SS-2
Test Method ASTM D 422
Filename : NBA15SS2

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



Classification :

Remarks :

Visual Description :
Moist, brown sandy silty sand with gravel

Figure 25

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBA-15 SS-2
Location : Massachusetts
Soil Description : Moist, brown sandy silty sand with gravel
Remarks :

Depth : ---
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA15SS2
Elevation : ---
Tested by : srp/jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.75"	0.748	19.00	0.00	0.00	100
0.5"	0.500	12.70	3.80	3.80	96
0.375"	0.374	9.51	6.29	10.09	88
#4	0.187	4.75	14.24	24.33	71
#10	0.079	2.00	10.17	34.50	59
#20	0.033	0.84	7.24	41.74	51
#40	0.017	0.42	5.42	47.16	44
#60	0.010	0.25	6.48	53.64	37
#100	0.006	0.15	9.10	62.74	26
#200	0.003	0.07	9.01	71.75	15
			13.12	84.87	0
Pan					

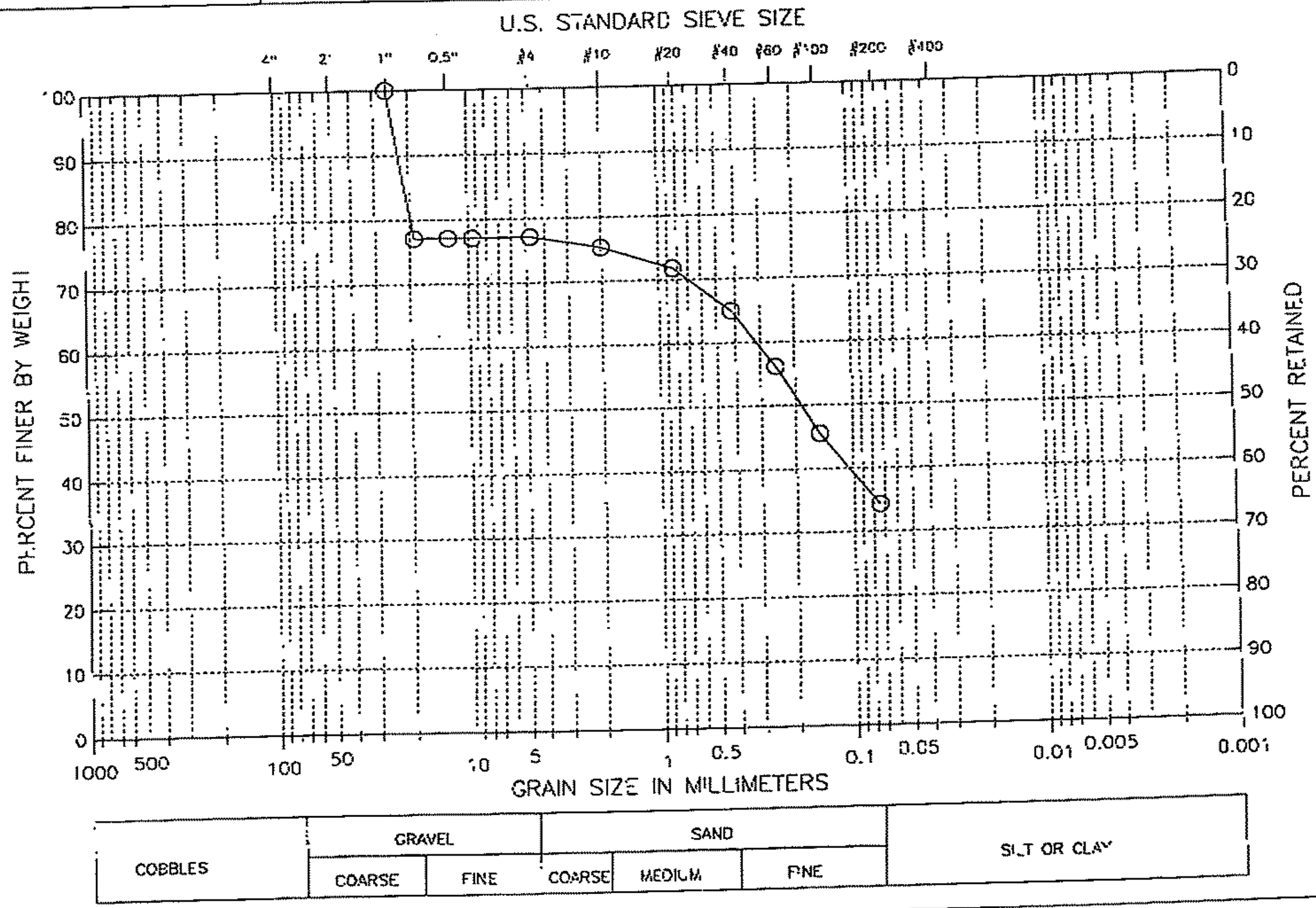
Total Dry Weight of Sample = 92.93

D85 : 8.3633 mm
D60 : 2.0961 mm
D50 : 0.7694 mm
D30 : 0.1801 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-1-b(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : ---
Sample No.: NBA-15 SS-4
Test Method ASTM D 422
Filename : NBA15SS4

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: Massachusetts
Date : Thu Aug 01 2002



Remarks :

Classification :

Visual Description :
Moist, brownish yellow silty sand with gravel

Figure 26

Thu Aug 01 16:11:44 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBA-15 SS-4
Location : Massachusetts
Soil Description : Moist, brownish yellow silty sand with gravel
Remarks :

Depth : ---
Test Date : 07/26/02
Test Method : ASTM D 422

Filename : NBA15SS4
Elevation : ---
Tested by : srp/jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1"	1.012	25.70	0.00	0.00	100
0.75"	0.748	19.00	22.04	22.04	77
0.5"	0.500	12.70	0.00	22.04	77
0.375"	0.374	9.51	0.00	22.04	77
#4	0.187	4.75	0.00	22.04	77
#10	0.079	2.00	1.77	23.81	75
#20	0.033	0.84	3.32	27.13	72
#40	0.017	0.42	6.54	33.67	65
#60	0.010	0.25	8.51	42.18	56
#100	0.006	0.15	10.22	52.40	46
#200	0.003	0.07	10.83	63.23	34
Pan			32.98	96.21	0

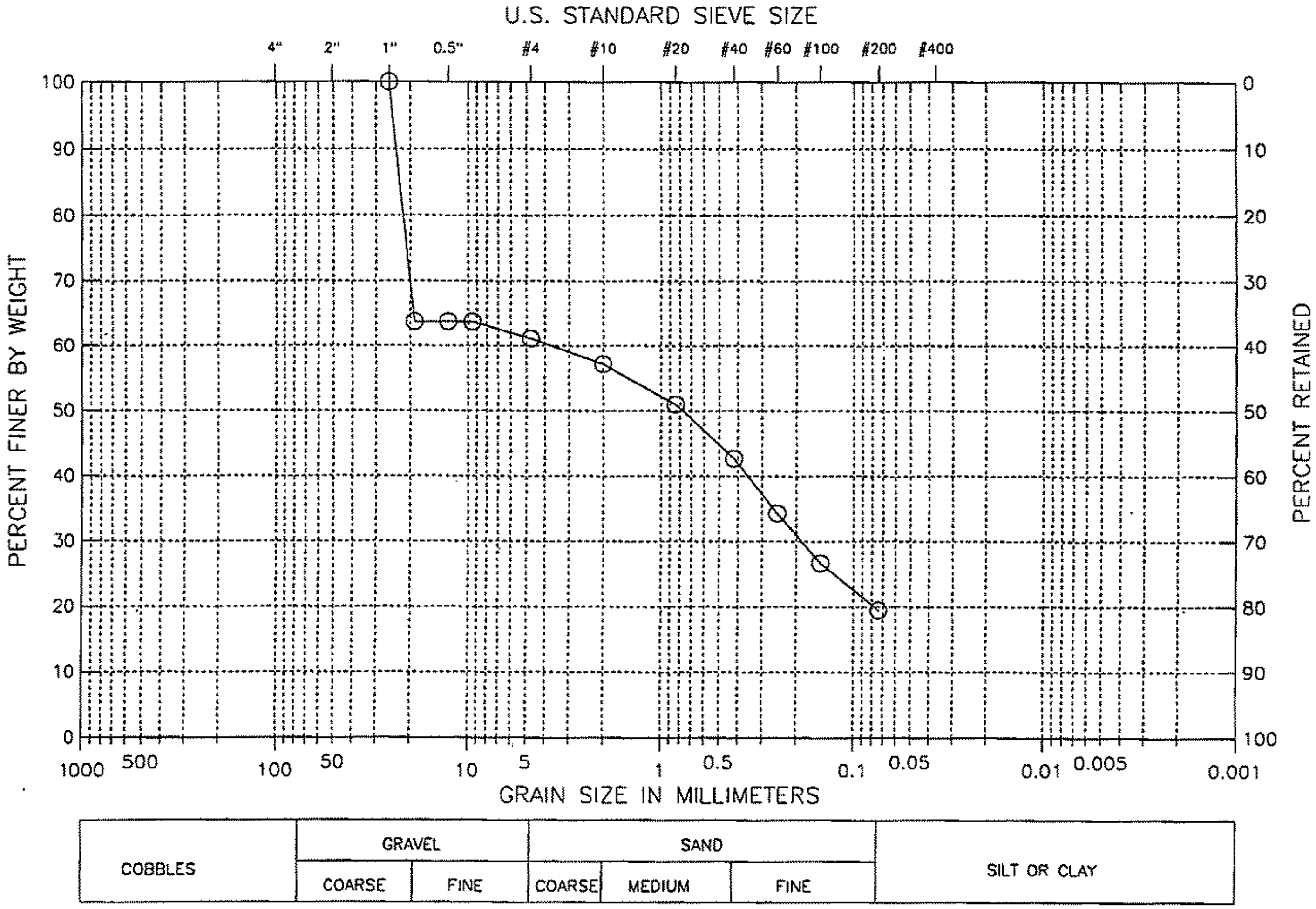
Total Dry Weight of Sample = 104.33

D85 : 21.0882 mm
D60 : 0.3132 mm
D50 : 0.1852 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

Boring No. : ---
Sample No.: NBS-3 SS-1
Test Method ASTM D 422
Filename : NBS3SS01

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Remarks :

Visual Description :
Moist, olive brown silty sand with gravel

Figure 1

Mon Jul 15 18:09:20 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-3 SS-1
Location : New Bedford, MA
Soil Description : Moist, olive brown silty sand with gravel
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS3SS01
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1"	1.012	25.70	0.00	0.00	100
0.75"	0.748	19.00	40.60	40.60	64
0.5"	0.500	12.70	0.00	40.60	64
0.375"	0.374	9.51	0.00	40.60	64
#4	0.187	4.75	2.91	43.51	61
#10	0.079	2.00	4.41	47.92	57
#20	0.033	0.84	6.96	54.88	51
#40	0.017	0.42	9.26	64.14	43
#60	0.010	0.25	9.42	73.56	34
#100	0.006	0.15	8.52	82.08	27
#200	0.003	0.07	8.03	90.11	19
Pan			21.82	111.93	0

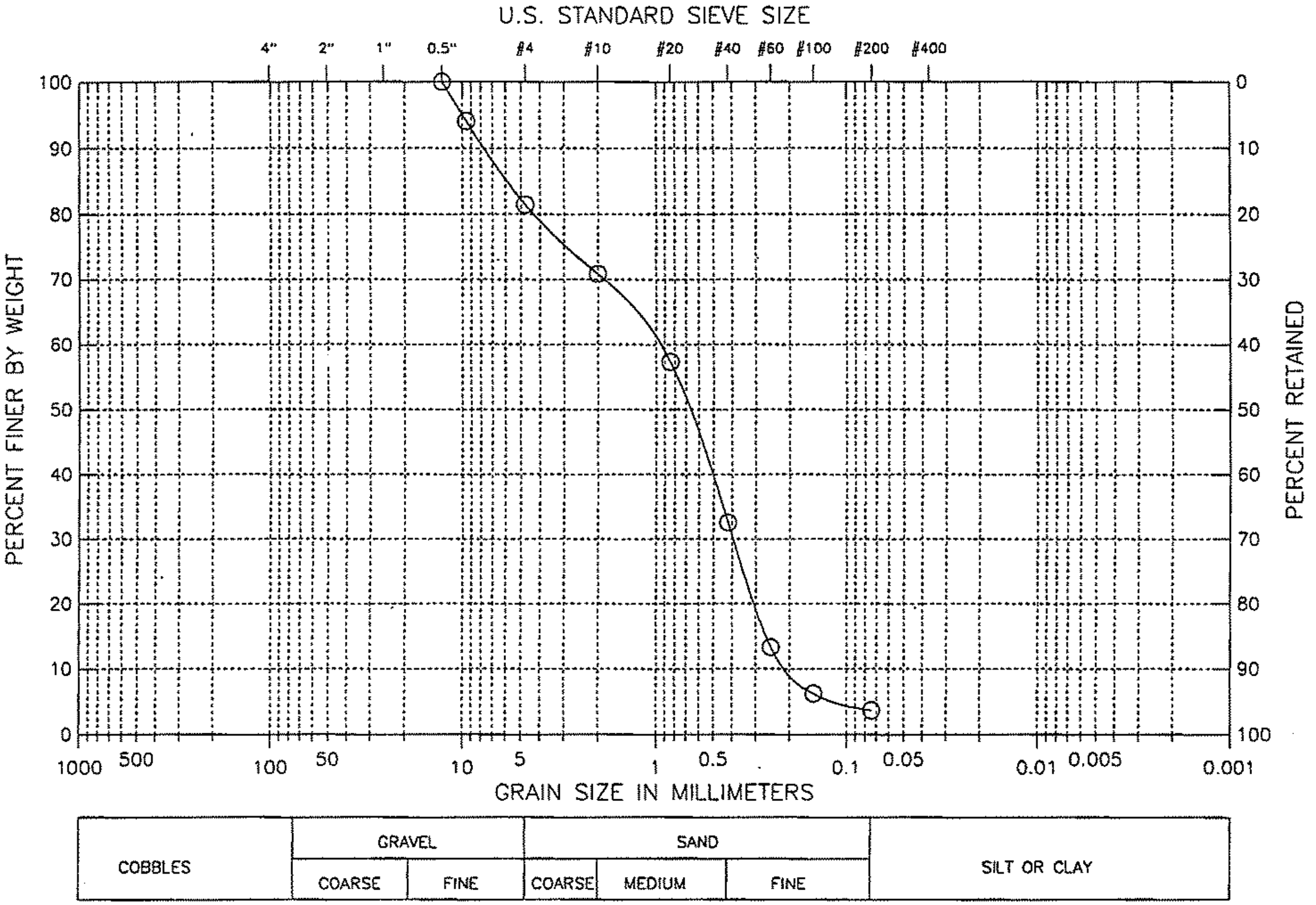
Total Dry Weight of Sample = 120.16

D85 : 22.6822 mm
D60 : 3.7084 mm
D50 : 0.7753 mm
D30 : 0.1869 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-1-b(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : ---
Sample No.: NBS-3 SS-3
Test Method ASTM D 422
Filename : NBS3SS03

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :
(SP) Poorly graded sand with gravel

Visual Description :
Very moist, olive gray sand with gravel

Remarks :

Figure 2

Mon Jul 15 18:09:20 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-3 SS-3
Location : New Bedford, MA
Soil Description : Very moist, olive gray sand with gravel
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS3SS03
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.5"	0.500	12.70	0.00	0.00	100
0.375"	0.374	9.51	8.10	8.10	94
#4	0.187	4.75	17.33	25.43	81
#10	0.079	2.00	14.54	39.97	71
#20	0.033	0.84	18.54	58.51	57
#40	0.017	0.42	34.01	92.52	33
#60	0.010	0.25	26.40	118.92	13
#100	0.006	0.15	9.72	128.64	6
#200	0.003	0.07	3.47	132.11	4
Pan			5.05	137.16	0

Total Dry Weight of Sample = 145.21

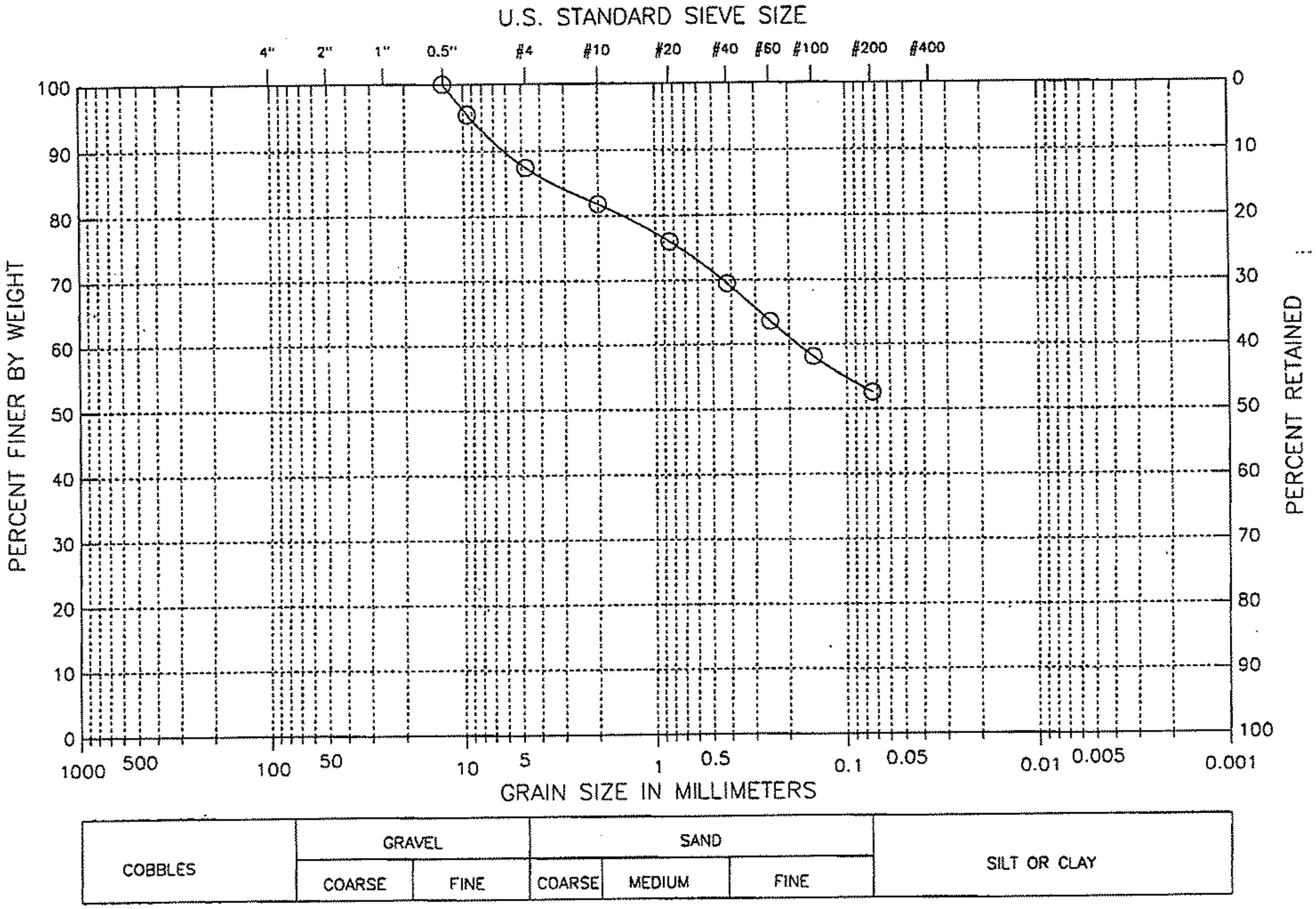
D85 : 5.7700 mm
D60 : 0.9972 mm
D50 : 0.6847 mm
D30 : 0.3921 mm
D15 : 0.2617 mm
D10 : 0.1965 mm

Soil Classification

ASTM Group Symbol : SP
ASTM Group Name : Poorly graded sand with gravel
AASHTO Group Symbol : A-1-b(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

Boring No. : ---
Sample No.: NBS-3 SS-4
Test Method ASTM D 422
Filename : NBS3SS04

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Visual Description :
Very moist, gray sandy silt

Remarks :

Figure 3

Mon Jul 15 18:09:21 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Filename : NBS3SS04
Project No. : GTX-3916
Depth : ---
Elevation : ---
Boring No. : ---
Test Date : 07/10/02
Tested by : jx
Sample No. : NBS-3 SS-4
Test Method : ASTM D 422
Checked by : jdt
Location : New Bedford, MA
Soil Description : Very moist, gray sandy silt
Remarks : ---

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.5"	0.500	12.70	0.00	0.00	100
0.375"	0.374	9.51	4.83	4.83	95
#4	0.187	4.75	8.57	13.40	87
#10	0.079	2.00	6.05	19.45	82
#20	0.033	0.84	6.22	25.67	76
#40	0.017	0.42	6.97	32.64	69
#60	0.010	0.25	6.26	38.90	64
#100	0.006	0.15	5.87	44.77	58
#200	0.003	0.07	5.94	50.71	53
Pan			56.19	106.90	0

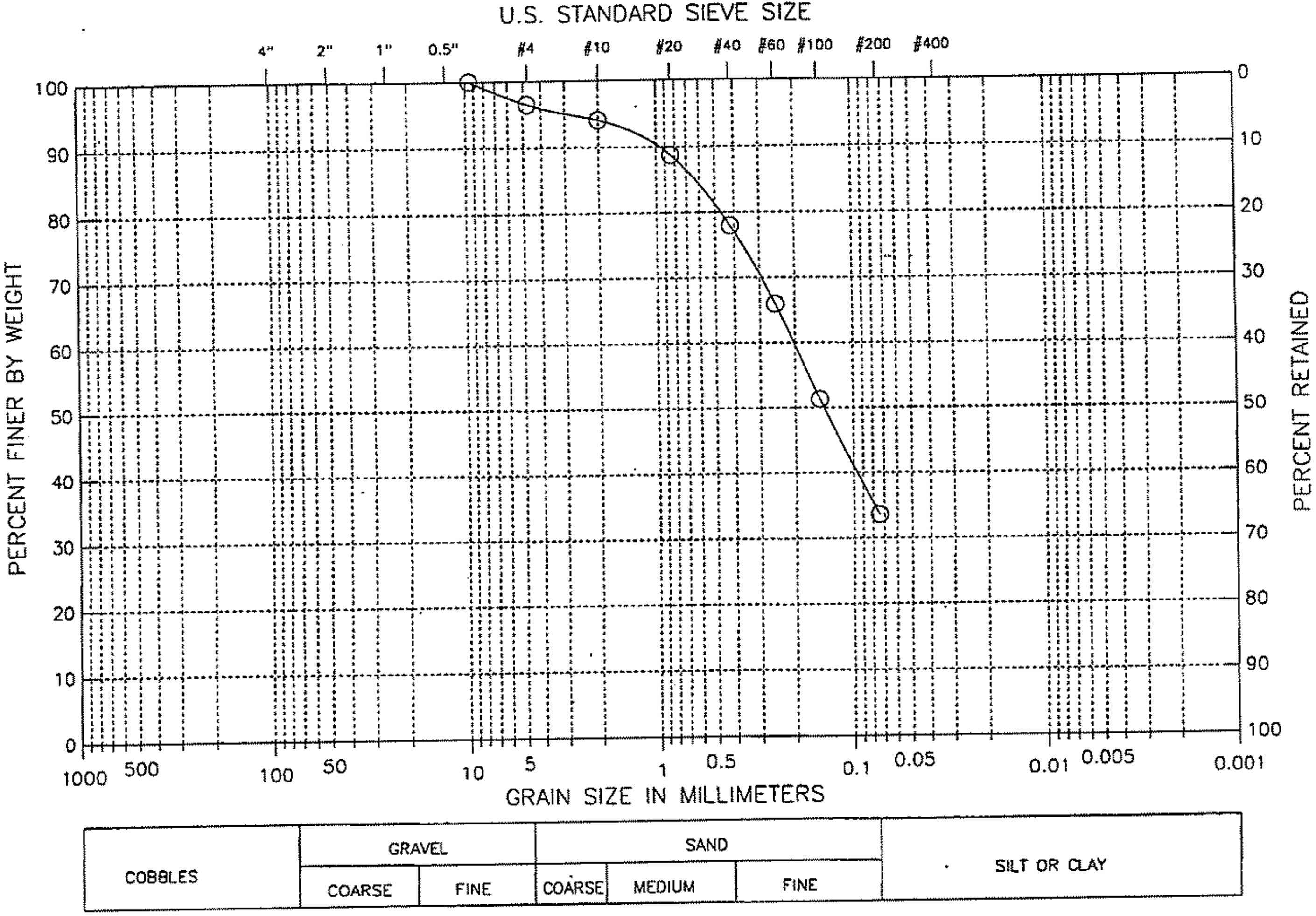
Total Dry Weight of Sample = 115.13

D85 : 3.2590 mm
D60 : 0.1779 mm
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBS-5 SS-1
Test Method ASTM D 422
Filename : NBS5SS01

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Visual Description :

Remarks :

Figure 4

Mon Jul 15 18:09:21 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-5 SS-1
Location : New Bedford, MA
Soil Description : \
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS5SS01
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings		Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
	Inches	Millimeters			
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	2.80	2.80	96
#10	0.079	2.00	1.93	4.73	94
#20	0.033	0.84	4.27	9.00	89
#40	0.017	0.42	8.60	17.60	78
#60	0.010	0.25	9.61	27.21	66
#100	0.006	0.15	11.71	38.92	51
#200	0.003	0.07	14.17	53.09	34
Pan			26.86	79.95	0

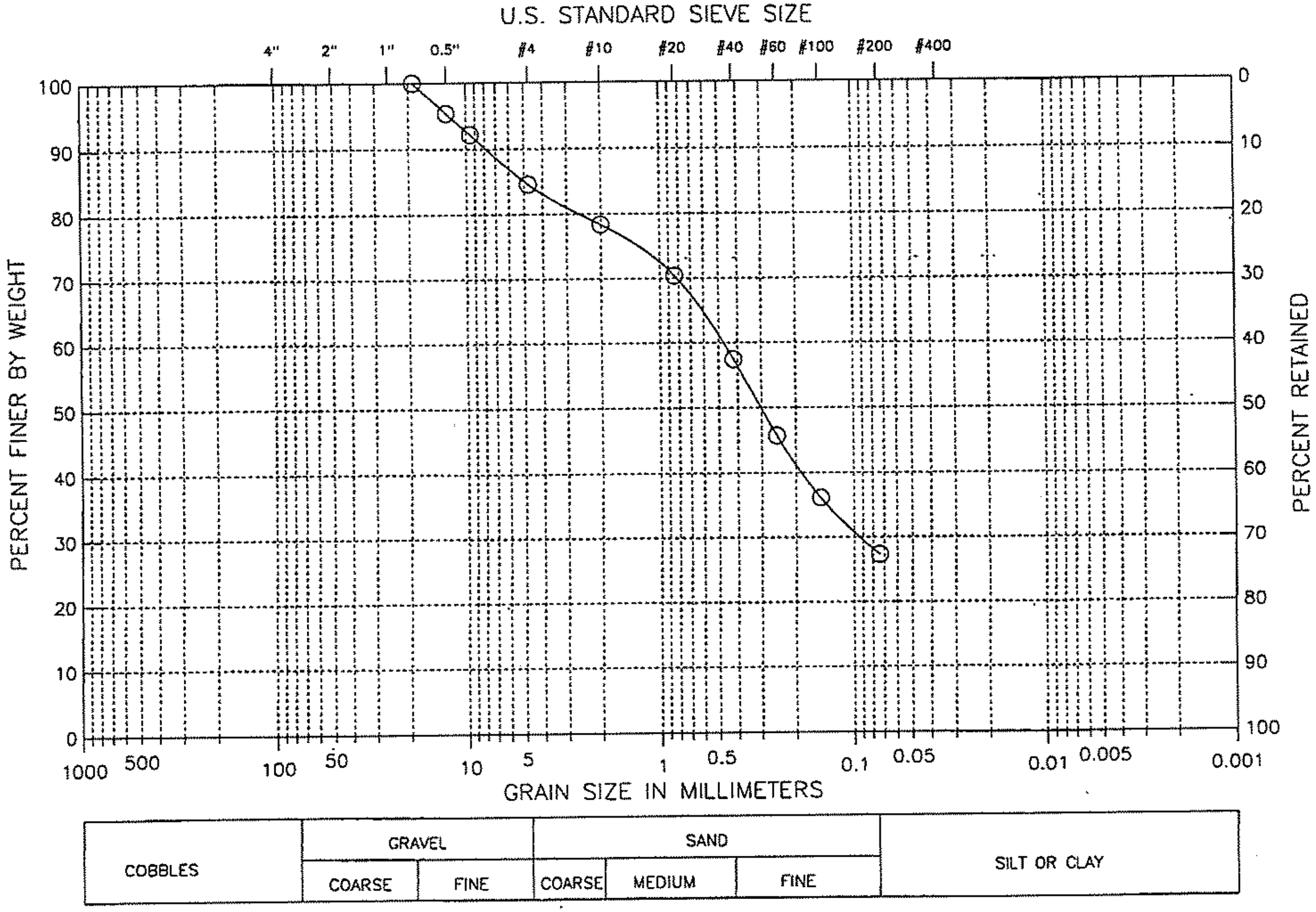
Total Dry Weight of Sample = 88.1

D85 : 0.6605 mm
D60 : 0.2025 mm
D50 : 0.1414 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

Boring No. : ---
Sample No.: NBS-5 SS-2
Test Method ASTM D 422
Filename : NBS5SS02

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Remarks :

Visual Description :
Moist, grayish brown silty sand with gravel

Figure 5

Mon Jul 15 18:09:21 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Filename : NBS5SS02
Project No. : GTX-3916
Depth : ---
Elevation : ---
Boring No. : ---
Test Date : 07/10/02
Tested by : jx
Sample No. : NBS-5 SS-2
Test Method : ASTM D 422
Checked by : jdt
Location : New Bedford, MA
Soil Description : Moist, grayish brown silty sand with gravel
Remarks : ---

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.75"	0.748	19.00	0.00	0.00	100
0.5"	0.500	12.70	6.99	6.99	95
0.375"	0.374	9.51	4.93	11.92	92
#4	0.187	4.75	11.61	23.53	85
#10	0.079	2.00	9.51	33.04	78
#20	0.033	0.84	12.17	45.21	70
#40	0.017	0.42	19.81	65.02	57
#60	0.010	0.25	17.98	83.00	46
#100	0.006	0.15	14.62	97.62	36
#200	0.003	0.07	13.43	111.05	27
Pan			41.78	152.83	0

Total Dry Weight of Sample = 160.89

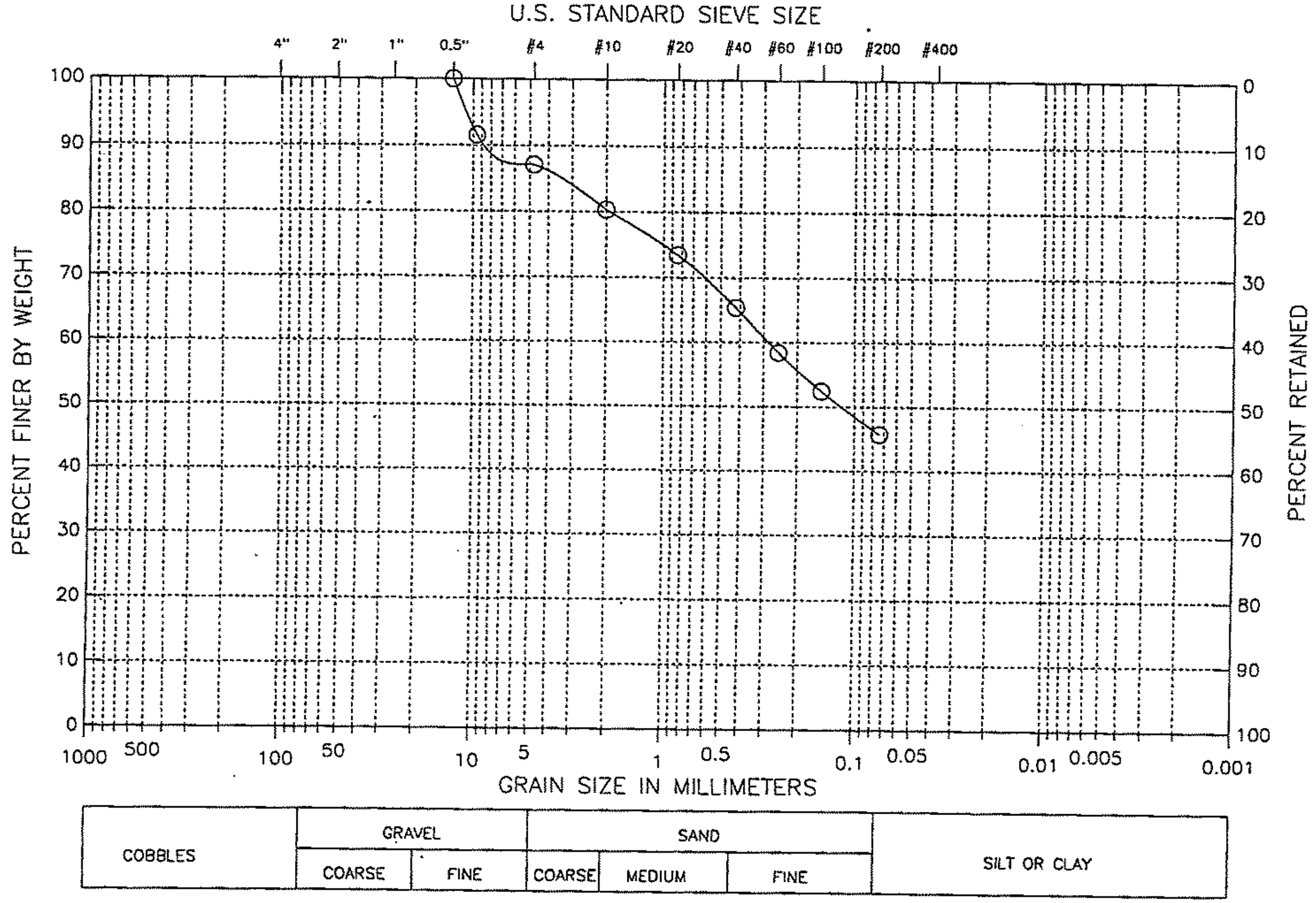
D85 : 4.9251 mm
D60 : 0.4813 mm
D50 : 0.3023 mm
D30 : 0.0915 mm
D15 : N/A
D10 : N/A

Soil Classification

ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

Boring No. : ---
Sample No: NBS-5 SS-3
Test Method ASTM D 422
Filename : NBS5SS03

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Remarks :

Visual Description :
Moist, gray silty sand

Figure 6

Mon Jul 15 18:09:21 2002 Page : 1

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-5 SS-3
Location : New Bedford, MA
Soil Description : Moist, gray silty sand
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS5SS03
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.5"	0.500	12.70	0.00	0.00	100
0.375"	0.374	9.51	12.17	12.17	92
#4	0.187	4.75	6.39	18.56	87
#10	0.079	2.00	9.80	28.36	80
#20	0.033	0.84	9.94	38.30	73
#40	0.017	0.42	11.62	49.92	65
#60	0.010	0.25	10.07	59.99	58
#100	0.006	0.15	8.60	68.59	52
#200	0.003	0.07	9.67	78.26	46
Pan			65.89	144.15	0

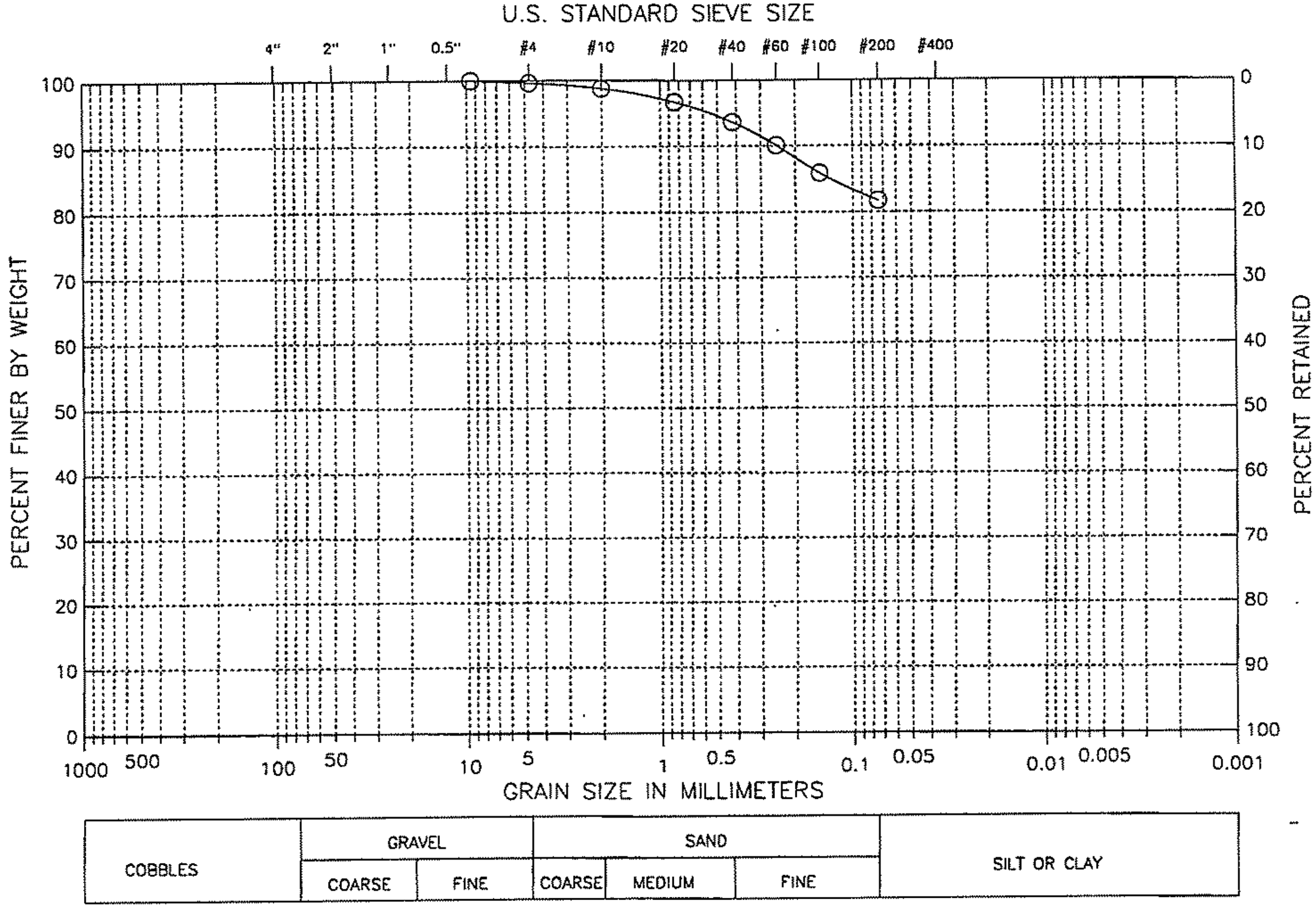
Total Dry Weight of Sample = 152.31

D85 : 3.6249 mm
D60 : 0.2819 mm
D50 : 0.1158 mm
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBS-12 SS-1
Test Method ASTM D 422
Filename : NBS12S01

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Remarks :

Visual Description :
Dry, light brown sandy silt

Figure 7

Mon Jul 15 18:09:20 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-12 SS-1
Location : New Bedford, MA
Soil Description : Dry, light brown sandy silt
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS12S01
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	0.32	0.32	100
#10	0.079	2.00	0.78	1.10	99
#20	0.033	0.84	1.90	3.00	97
#40	0.017	0.42	2.79	5.79	94
#60	0.010	0.25	3.24	9.03	90
#100	0.006	0.15	3.82	12.85	86
#200	0.003	0.07	3.82	16.67	82
Pan			74.54	91.21	0

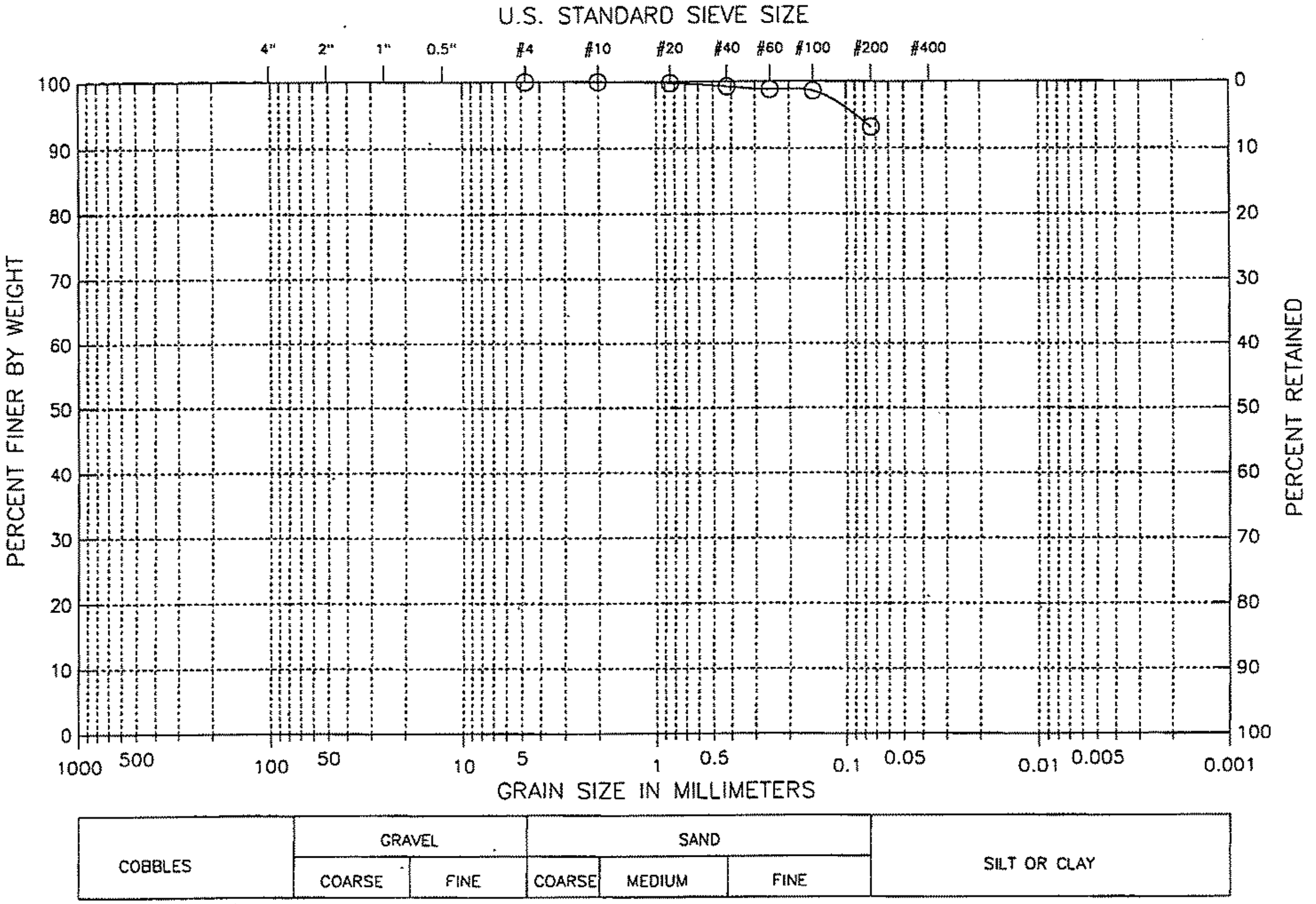
Total Dry Weight of Sample = 99.35

D85 : 0.1279 mm
D60 : N/A
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBS-12 SS-2
Test Method ASTM D 422
Filename : NBS12S02

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Visual Description :
Moist, grayish brown silt with sand

Remarks :

Figure 8

Mon Jul 15 18:09:20 2002

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-12 SS-2
Location : New Bedford, MA
Soil Description : Moist, grayish brown silt with sand
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS12S02
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.02	0.02	100
#20	0.033	0.84	0.17	0.19	100
#40	0.017	0.42	0.40	0.59	99
#60	0.010	0.25	0.34	0.93	99
#100	0.006	0.15	0.17	1.10	99
#200	0.003	0.07	4.18	5.28	93
Pan			72.06	77.34	0

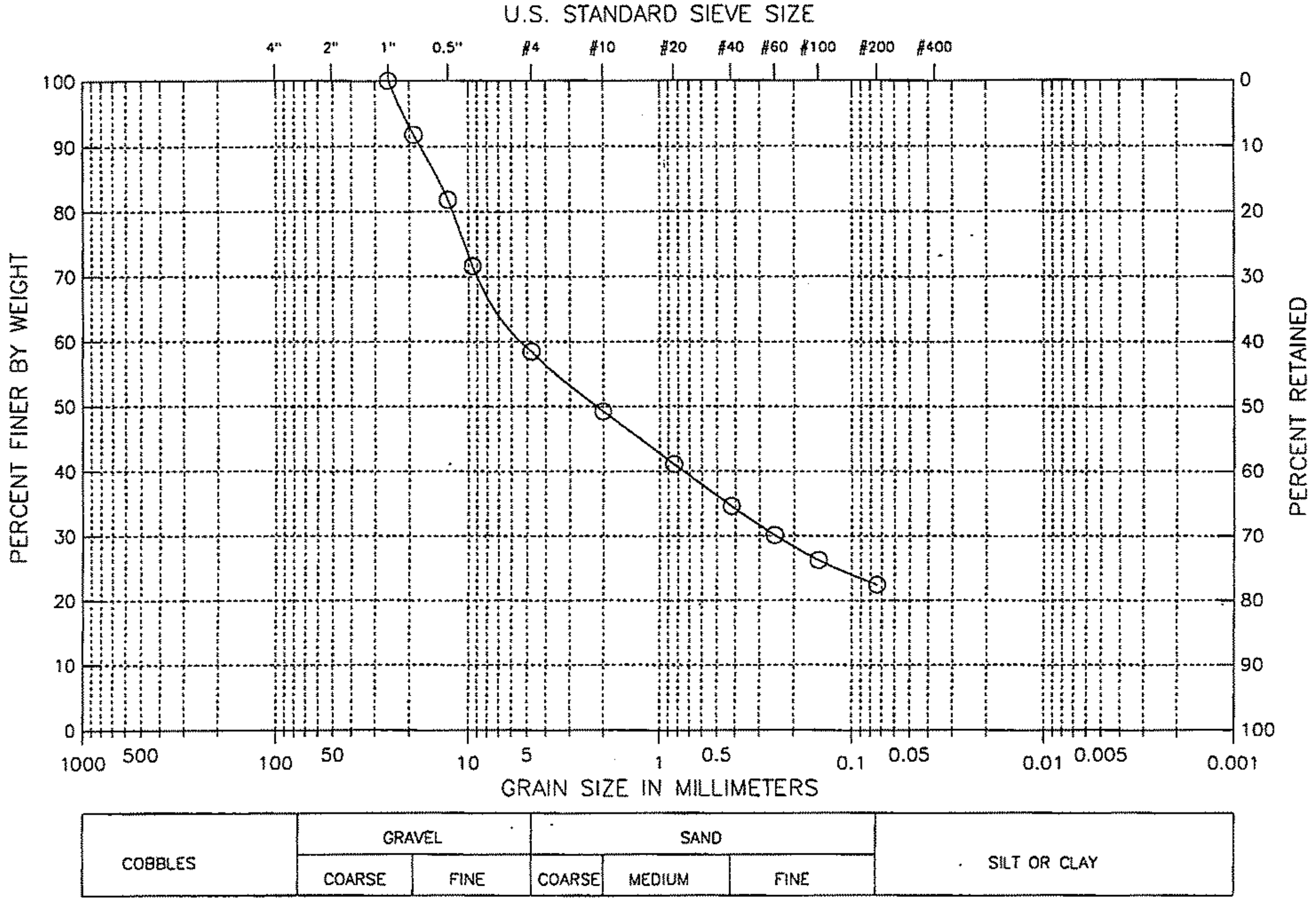
Total Dry Weight of Sample = 85.53

D85 : N/A
D60 : N/A
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-4(0)
AASHTO Group Name : Silty Soils

Boring No. : ---
Sample No.: NBS-12 SS-3
Test Method ASTM D 422
Filename : NBS12S03

Project : New Bedford/Fall River Commuter Rail
Project No.: GTX-3916
Location: New Bedford, MA
Date : Mon Jul 15 2002



Classification :

Remarks :

Visual Description :
Moist, olive gray gravel with silt and sand

Figure 9

Mon Jul 15 18:09:20 2002

Page : 1

GEOTECHNICAL LABORATORY TEST DATA

Project : New Bedford/Fall River Commuter Rail
Project No. : GTX-3916
Boring No. : ---
Sample No. : NBS-12 SS-3
Location : New Bedford, MA
Soil Description : Moist, olive gray gravel with silt and sand
Remarks : ---

Depth : ---
Test Date : 07/10/02
Test Method : ASTM D 422

Filename : NBS12S03
Elevation : ---
Tested by : jx
Checked by : jdt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
1"	1.012	25.70	0.00	0.00	100
0.75"	0.748	19.00	10.48	10.48	92
0.5"	0.500	12.70	12.80	23.28	82
0.375"	0.374	9.51	13.03	36.31	72
#4	0.187	4.75	16.81	53.12	58
#10	0.079	2.00	11.85	64.97	49
#20	0.033	0.84	10.45	75.42	41
#40	0.017	0.42	8.27	83.69	35
#60	0.010	0.25	5.76	89.45	30
#100	0.006	0.15	4.93	94.38	26
#200	0.003	0.07	4.88	99.26	22
Pan			28.72	127.98	0

Total Dry Weight of Sample = 136.2

D85 : 14.4414 mm
D60 : 5.1437 mm
D50 : 2.1483 mm
D30 : 0.2465 mm
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : N/A
ASTM Group Name : N/A
AASHTO Group Symbol : A-1-b(0)
AASHTO Group Name : Stone Fragments, Gravel and Sand

APPENDIX C: GEOTECHNICAL CALCULATIONS

- Allowable Bearing Capacity and Estimated Settlement
- Seismic Site Class Evaluation

SHEET 1 OF 2

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

CALCULATION WORKSHEET

JOB MBTA South Coast Rail
SUBJECT Taunton Depot Station
CALCULATED BY DH **DATE** 3/28/2012
CHECKED BY PC **DATE** 3/29/2012

PURPOSE: Evaluate bearing resistance for ramp/stair structure shallow foundations.

REFERENCE: AASHTO LRFD Bridge Design Specifications, 2010/AREMA Manual for Railway Engineering, 2004

ASSUMPTIONS:

- Ramp/Stair structure footing is 4 ft wide by 6 ft long.
- Bearing surface is silty sand (SM).
- Footing embedment is at least 4 feet below ground surface.
- Groundwater level is at 1 feet below surface.
- Footing eccentricity is assumed to be zero.
- Estimated soil properties (experience, geotech literature, AASHTO Table 10.4.6.2.4-1):

	γ (pcf)	ϕ
Silty Sand:	125	32

BEARING CAPACITY FACTORS (Table 10.6.3.1.2a-1):

	ϕ	N_c	N_q	N_γ
Silty Sand:	32	35.5	23.2	30.2

CALCULATE EFFECTIVE FOOTING WIDTH (B'):

$e < B/4$ (AASHTO Section 10.6.3.3)

where: B = footing width (ft) = 4
e = eccentricity (ft)

Assume maximum footing eccentricity, thus, e = 1

B' = B-2e 2

NOMINAL BEARING RESISTANCE (q_n):

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$ (AASHTO Eqn. 10.6.3.1.2a-1)

where: c = cohesion = 0
γ = total unit weight 125
D_f = depth of footing (ft) = 4 Assumed
B' = effective width of footing (ft) = 2
L = length of footing (ft) = 6
B'/L = 0.33
D_f /B' = 2.00
L/B' = 3.00
C_{wq} $C_{w\gamma}$ = groundwater correction factors (using B')
C_{wq} = 0.6 (AASHTO Table 10.6.3.1.2a-2)
$C_{w\gamma}$ = 0.5 (AASHTO Table 10.6.3.1.2a-2)

N_{cm} N_{qm} $N_{\gamma m}$ = bearing capacity factors

$N_{qm} = N_q s_q d_q i_q$ (AASHTO Eqn. 10.6.3.1.2a-3)

s_q = 1.21 (AASHTO Table 10.6.3.1.2a-3)

d_q = 1.30 (AASHTO Table 10.6.3.1.2a-4)

i_q = 1.0 (see AASHTO p. 10-62)

N_{qm} = 36.4

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

s_γ = 0.87 (AASHTO Table 10.6.3.1.2a-3)

i_γ = 1 (see AASHTO p. 10-62)

$N_{\gamma m}$ = 26.2

q_n = 12,568 psf

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

CALCULATION WORKSHEET

JOB MBTA South Coast Rail
SUBJECT Taunton Depot Station
CALCULATED BY DH **DATE** 3/28/2012
CHECKED BY PC **DATE** 3/29/2012

ALLOWABLE BEARING RESISTANCE (q_a):

$q_a = q_n$/FOS

where: FOS = factor of safety = 3 for primary loads (see AREMA 3.4.2)

q_a = 4,189 psf

use

q_a = 4.19 ksf strength limit value

Note: Based on the anticipated light loads and potentially small footing sizes, an allowable bearing capacity of 4 ksf is recommended.

Elastic Settlement Calculations:

$$S_e = \frac{(q_o\,(1 - v^2)\sqrt{A'})}{144 E_s \beta_z}$$

AASHTO eqn. 10.6.2.4.2-1

where: q_o = applied vert. stress (ksf)
v = Poisson's Ratio
E_s = Young's Modulus (ksi)
β_z = Shape/Rigidity Factor

v = Poisson's Ratio = 0.30 (AASHTO Table C10.4.6.3-1)
E_s = Young's Modulus (ksi) = 5.00 (AASHTO Table C10.4.6.3-1)
β_z = Shape/Rigidity Factor = 1.13 (AASHTO Table 10.6.2.4.2-1)

where: B' = eff. width of footing (ft) = 2 (from bearing resistance calcs)
L = length of footing (ft): 6 (from bearing resistance calcs)
A' =(B'xL) = footing area (ft^2): 12 ft^2

Settlement (S_e) for a given q_o:

q_o = applied vertical stress (ksf) = 4.00 ksf (assumed)

S_e (inches) = 0.19 inches

Authored by: DH 3/1/2012
Seismic Parameters_TD.xls

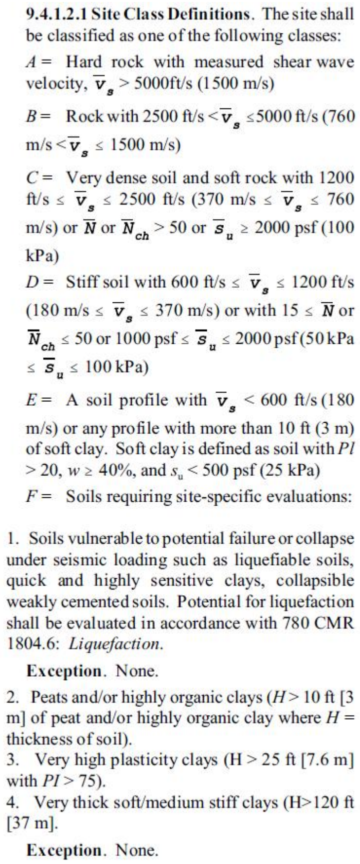
Checked by: PJM/AH 3/23/2012

Taunton Depot Station Seismic Site Class Evaluation

Based on the platform boring with the lowest average blow counts (worst case)

Boring No.	Sample No.	N Value	Di	Di/N_i	N_{bar}
TD-1	S-1	6	3	0.50	38
	S-2	5	5	1.00	
	S-3	30	5	0.17	
	S-4	44	5	0.11	
	C1	100	5	0.05	
	S-5	100	4	0.04	
	Bedrock	100	73	0.73	
Total Depth =		100			
Depth to Bedrock =		27	sum	2.60	

Per 9.4.1.2.1, 15 < N_{bar} < 50, Site Class D



9.4.1.2.1 Site Class Definitions. The site shall be classified as one of the following classes:

A = Hard rock with measured shear wave velocity, $\overline{v}_s$ > 5000ft/s (1500 m/s)

B = Rock with 2500 ft/s < $\overline{v}_s$ ≤ 5000 ft/s (760 m/s < $\overline{v}_s$ ≤ 1500 m/s)

C = Very dense soil and soft rock with 1200 ft/s ≤ $\overline{v}_s$ ≤ 2500 ft/s (370 m/s ≤ $\overline{v}_s$ ≤ 760 m/s) or $\overline{N}$ or $\overline{N}_{ch}$ > 50 or $\overline{s}_u$ ≥ 2000 psf (100 kPa)

D = Stiff soil with 600 ft/s ≤ $\overline{v}_s$ ≤ 1200 ft/s (180 m/s ≤ $\overline{v}_s$ ≤ 370 m/s) or with 15 ≤ $\overline{N}$ or $\overline{N}_{ch}$ ≤ 50 or 1000 psf ≤ $\overline{s}_u$ ≤ 2000 psf (50 kPa ≤ $\overline{s}_u$ ≤ 100 kPa)

E = A soil profile with $\overline{v}_s$ < 600 ft/s (180 m/s) or any profile with more than 10 ft (3 m) of soft clay. Soft clay is defined as soil with *PI* > 20, *w* ≥ 40%, and s_u < 500 psf (25 kPa)

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. Potential for liquefaction shall be evaluated in accordance with 780 CMR 1804.6: *Liquefaction*.

Exception. None.

2. Peats and/or highly organic clays (*H* > 10 ft [3 m] of peat and/or highly organic clay where *H* = thickness of soil).
3. Very high plasticity clays (H > 25 ft [7.6 m] with *PI* > 75).
4. Very thick soft/medium stiff clays (H>120 ft [37 m].

Exception. None.

Approx. Project Coordinates

Lat	41.877953
Long	-71.073333

Seismic Coefficients

S_S = 0.24 (Table 1604.10*)
S_1 = 0.062 (Table 1604.10*)

For Site Class D

F_A = 1.6 (See Table 9.4.1.2.4a*)
F_V = 2.4 (See Table 9.4.1.2.4b*)

Design Spectral Response Parameters

S_{MS} = Ss x F_A = 0.384
S_{M1} = S_1 x F_V = 0.149

S_{DS} = 2/3 x S_{MS} = 0.256
S_{D1} = 2/3 x S_{M1} = 0.099

Notes: * The Massachusetts State Building Code, 8th Edition (2010)

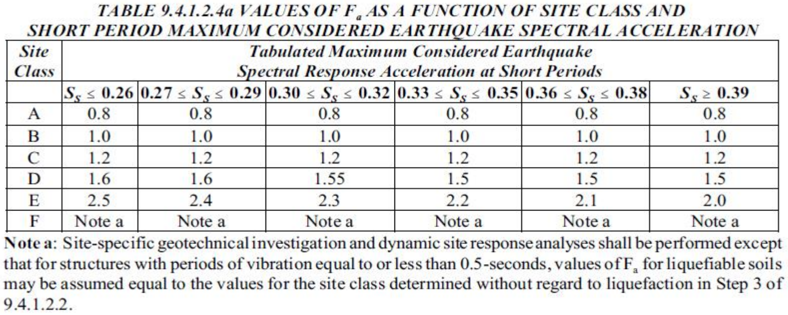


TABLE 9.4.1.2.4a VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods*					
	$S_S \le 0.26$	$0.27 \le S_S \le 0.29$	$0.30 \le S_S \le 0.32$	$0.33 \le S_S \le 0.35$	$0.36 \le S_S \le 0.38$	$S_S \ge 0.39$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5	1.5	1.5
E	2.5	2.4	2.3	2.2	2.1	2.0
F	Note a	Note a	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

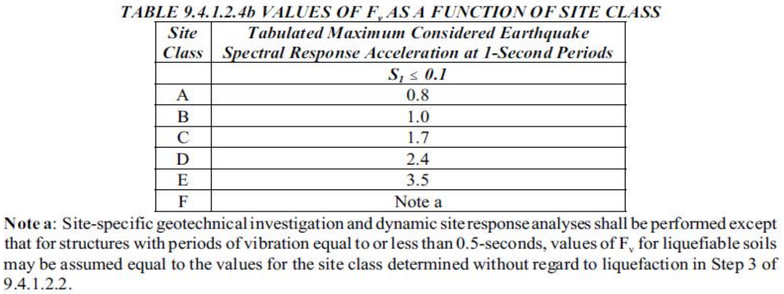


TABLE 9.4.1.2.4b VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods*
	$S_1 \le 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

TABLE 1604.10 GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

(For R-3 of three stories or less one- and two-family stand alone buildings, see 780 CMR 53.00 for snow and wind loads)

City/Town	Ground Snow Load p_g, psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Rochester	45	110	0.23	0.059
Rockland	45	110	0.26	0.064
Rockport	45	110	0.33	0.073
Rowe	65	100	0.22	0.069
Rowley	55	110	0.34	0.075
Royalston	65	100	0.25	0.070
Russell	65	100	0.23	0.066
Rutland	55	100	0.24	0.068
Salem	45	110	0.31	0.071
Salisbury	55	110	0.35	0.077
Sandisfield	65	90	0.23	0.066
Sandwich	35	120	0.22	0.058
Saugus	45	110	0.30	0.070
Savoy	65	90	0.22	0.068
Scituate	45	110	0.27	0.065
Seekonk	55	110	0.24	0.062
Sharon	55	100	0.25	0.065
Sheffield	65	90	0.23	0.066
Shelburne	65	100	0.23	0.068
Sherborn	55	100	0.26	0.066
Shirley	65	100	0.28	0.072
Shrewsbury	55	100	0.25	0.067
Shutesbury	65	100	0.23	0.068
Somerset	55	110	0.23	0.060
Somerville	45	105	0.28	0.069
South Hadley	55	100	0.23	0.066
Southampton	55	100	0.23	0.066
Southborough	55	100	0.26	0.067
Southbridge	55	100	0.23	0.064
Southwick	55	100	0.23	0.065
Spencer	55	100	0.23	0.066
Springfield	55	100	0.23	0.065
Sterling	55	100	0.26	0.069
Stockbridge	65	90	0.22	0.066
Stoneham	45	105	0.30	0.071
Stoughton	55	100	0.26	0.065
Stow	55	100	0.27	0.069
Sturbridge	55	100	0.23	0.065
Sudbury	55	100	0.27	0.069
Sunderland	65	100	0.23	0.068
Sutton	55	100	0.24	0.065
Swampscott	45	110	0.30	0.070
Swansea	55	110	0.24	0.061
Taunton	55	110	0.24	0.062
Templeton	65	100	0.25	0.070
Tewksbury	55	100	0.31	0.073
Tisbury	35	120	0.18	0.052
Tolland	65	100	0.23	0.066
Topsfield	45	110	0.33	0.074
Townsend	65	100	0.28	0.072
Truro	35	120	0.22	0.057

Stormwater Report

Freetown Station

Town of Freetown, Massachusetts

Prepared for

massDOT
Massachusetts Department of Transportation
10 Park Plaza
Boston, Massachusetts

Prepared by

VHB/**Vanasse Hangen Brustlin, Inc.**
Transportation, Land Development, Environmental Services
99 High Street
Boston, Massachusetts 02110
617 728 7777

June 2012

Table of Contents

List of Figures

List of Tables

Appendices

Checklist for Stormwater Report

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

  ☐ Credit 1

  ☐ Credit 2

  ☐ Credit 3

☒ Use of "country drainage" versus curb and gutter conveyance and pipe

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☒ Grass Channel

☐ Green Roof

☐ Other (describe): ______

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

---

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

  ☐ Name of the stormwater management system owners;

  ☐ Party responsible for operation and maintenance;

  ☐ Schedule for implementation of routine and non-routine maintenance tasks;

  ☐ Plan showing the location of all stormwater BMPs maintenance access areas;

  ☐ Description and delineation of public safety features;

  ☐ Estimated operation and maintenance budget; and

  ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

  ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;

  ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Water Quality Certification Regulations (314 CMR 9.00).

Project Description

The Applicant, MassDOT, is proposing to construct a commuter rail station along the existing Fall River Secondary tracks in Freetown, Massachusetts (the Project). As proposed, the Project requires the acquisition of approximately 7 acres of land at 165 South Main Street of which approximately 4 acres will be developed for the new station. The Project will involve a platform with canopy, ancillary landscape improvements, 173 parking spaces, a pick up/drop off area, bicycle parking facilities, and utility improvements to support this use.

The station is not considered a Land Use with Higher Potential Pollutant Loads (LUHPPL) as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because it is not a parking lot with a high-intensity use (1,000 vehicle trips per day or more).

Site Description

The project development area (the Site) consists of approximately 4 acres of currently undeveloped land (see Figures 1 and 2). The Site is bound by Assonet Mini Storage to the west, South Main Street to the northwest, woods and wetlands to the north, grassed pasture to the northeast, the Fall River Secondary tracks to the southeast, and woods and wetlands to the southwest. A telecommunications tower abuts the mini storage and is in the southwest corner of the Site. Brightman Lumber Co. is located nearby south of the Site and the Stop and Shop Distribution Center is located to the north, across South Main Street. See Figure 1, Site Locus Map and Figure 2, Site Aerial.

The wetland Resource Areas on the Site as, shown on Figures 3 and 4, are described in Table 1. The wetlands ultimately flow to the Taunton River. For additional information regarding the wetland resource areas present on the site see the Abbreviated Notice of Resource Area Delineation (ANRAD) prepared by VHB dated January 2012.

Table 1
Wetland Resource Areas

Name	*Critical Area*	*Zone 1 or Zone A*	*ORW or SRW*	*Zone II or IWPA*	*Description*
Wetland 1	No	No	No	No	PFO
Wetland 1A	No	No	No	No	PEM

Notes: Wetland Classifications: PEM = Palustrine Emergent, PFO = Palustrine Forested

According to the National Resources Conservation Service (NRCS), surface soils on the Site include Merrimac fine sandy loam, Scarboro muck, Ridgebury fine sandy loam, and Sudbury fine sandy loam, and are classified as Hydrologic Soil Groups (HSG) A, D, C, B, respectively. The majority of the soil on the Site is classified as HSG A. Based on the soil evaluation included in Appendix C, the Site is considered to be within an area of rapid infiltration (soils with a saturated hydraulic conductivity greater than 2.4 inches per hour. According to 1982 Rawls Rates, infiltration rates for the soils will be approximately 2.41 inches per hour.).

The project is not located within the 100-year flood plain as shown on FEMA Floodway Map, Town of Freetown, Massachusetts Bristol County, Community Panel numbers 25005C0263F and 25005C0264F dated July 7, 2009, included in Appendix B.

Existing Drainage Conditions

Under existing conditions, the Site consists of mostly cleared, but undeveloped land. The Site is primarily grass pasture and dirt with some dirt mounds and a few scattered trees. There is also a gravel road that goes around the mini storage to provide access to the communications tower. For existing conditions hydrologic analysis, the drainage area including the Site and the mini storage was divided into four sub drainage areas. The existing mini storage was included because site drainage flows on to this property under current conditions. All four drainage areas contribute to a single design point (Wetland 1). The following is a summary of each drainage area.

Drainage Area 1 – This 2.45-acre area comprises the portion of the Site between the mini storage lot and Wetland 1, extending from South Main Street to the existing Fall River Line track. The area consists of grassy pasture with some areas of dirt, gravel, and brush. Runoff from Drainage Area 1 sheet flows in a northerly direction to Wetland 1, on the north side of the Site.

Drainage Area 2 – This 0.95-acre area consist of grassy pasture with some sections of dirt, gravel, and brush. The area is located in the center of the Site, between the Fall River Line track and the mini storage. Runoff from this area sheet flows into Drainage Area 3 and sheet flows across the gravel lot. Runoff from Drainage Area 2 flows to Wetland 1.

Drainage Area 3 – This 3.34-acre area consists of the developed land that the Assonet Mini Storage occupies. The area is split between a paved portion with storage buildings, a gravel lot, and some grassed sections along South Main Street. There is a drainage system for paved area, while the gravel lot and grassed area sheet flows, untreated, to Wetland 1.

Drainage Area 4 – This 1.79-acre area consist of grassy pasture with some sections of dirt, gravel, and brush. The area is located on the south side of the Site, between the Fall River Line track and the mini storage. Runoff from this area sheet flows into Drainage Area 3 and is captured by the drainage system. Runoff from Drainage Area 4 flows to Wetland 1.

Figure 3 illustrates the existing drainage patterns on the Site. Table 2 below provides a summary of the existing conditions hydrologic data.

Table 2
Existing Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland 1	1	2.45	51	6.9
2	Wetland 1	1	0.95	42	8.5
3	Wetland 1	1	3.34	89	5.0
4	Wetland 1	1	1.79	71	7.4

Proposed Drainage Conditions

Figure 4 illustrates the proposed “post construction” drainage conditions for the project. As shown, the Site will be divided into five drainage areas that discharge treated stormwater to the one existing Design Point. Existing drainage and grading patterns were maintained to the maximum extent possible. The drainage from the paved areas will be captured and treated in three infiltration basins. These basins are designed to decentralize stormwater management and reduce peak runoff rates, maximize groundwater recharge and treat for water quality. The following is a summary of each drainage area.

Drainage Area 1 – This 0.99-acre area comprises the eastern portion of the parking lot and consists of a paved parking area for the station, grassed swale, and Infiltration Basin 1 to the east of the parking. Runoff from Drainage Area 1 is directed to Basin 1, which discharges to Wetland 1.

Drainage Area 2 – This 1.70-acre area in the southern portion of the Site consists of grassy pasture with some sections of dirt, gravel, and brush. The majority of Drainage Area 2 is unchanged from existing conditions. Part of the area will remain occupied by an existing telecommunications tower and gravel access drive. Runoff from Drainage Area 2 sheet flows to Drainage Area 3, the existing mini storage area, where is it captured by the existing drainage system and discharged to Wetland 1.

Drainage Area 3 – This 3.50-acre area comprises the existing mini storage area. Runoff from Drainage Area 3 discharges to Wetland 1.

Drainage Area 4 – This 0.71-acre area comprises the site access road and consists of a paved roadway, grassed swale, and Infiltration Basin 3 to the northeast of the roadway. Runoff from Drainage Area 4 is directed a grassed swale that leads to a sediment forebay and Basin 3, which discharges to Wetland 1.

Drainage Area 5 – This 1.63-acre area comprises the southwestern portion of the parking lot and consists of a paved parking area for the station, grassed swale, and Infiltration Basin 2 to the northeast of the parking. Runoff from Drainage Area 5 is directed to a swale, then through a pipe under the access drive to Basin 2, which discharges to Wetland 1.

Table 3 below provides a summary of the proposed conditions hydrologic data.

Table 3
Proposed Conditions Hydrologic Data

Drainage Area	*Discharge Location*	*Design Point*	*Area (acres)*	*Curve Number*	*Time of Concentration (min)*
1	Wetland 1	1	0.99	83	5.0
2	Wetland 1	1	1.70	71	7.4
3	Wetland 1	1	3.50	87	5.0
4	Wetland 1	1	0.71	90	5.0
5	Wetland 1	1	1.63	83	5.0

The site has been designed with a comprehensive stormwater management system in accordance with the Massachusetts Stormwater Handbook. The proposed stormwater management system has been designed to treat the half inch Water Quality Volume.

Environmentally Sensitive and Low Impact Development (LID) Techniques

Low Impact Development (LID) techniques and stormwater Best Management Practices (BMPs) implemented into the site design include:

- Minimal disturbance to existing trees and vegetation
- Infiltration basins
- Light colored pavement sidewalks
- Grassed swales

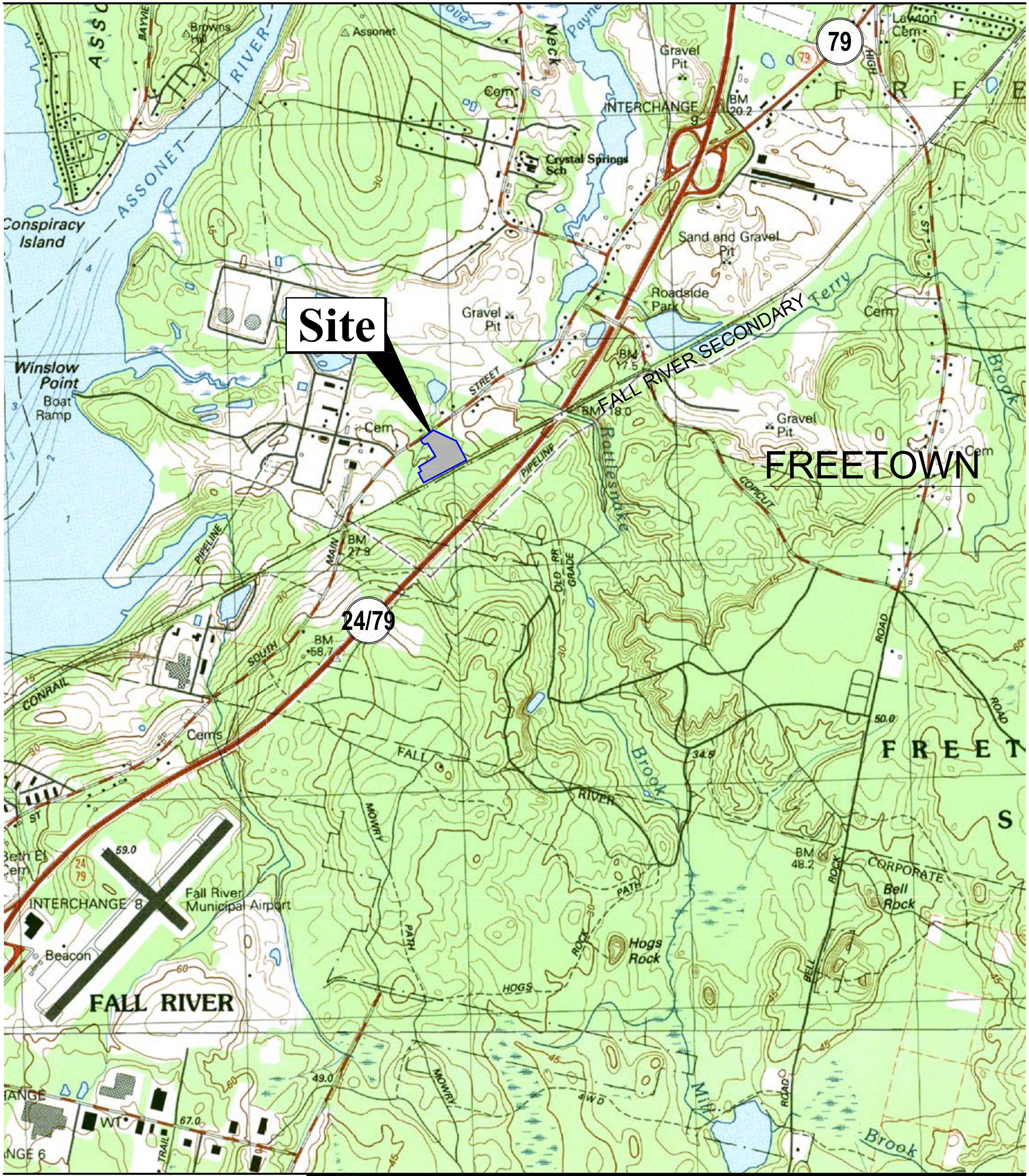
In general, stormwater runoff from impervious surfaces in the proposed drainage areas will receive treatment for stormwater quality in grassed swales and infiltration basins prior to discharge to the existing design point.

Hydraulic Analysis

The closed drainage system was designed for the 25-year storm event, in accordance with the Massachusetts Bay Transportation Authority, Railroad Operations, Commuter Rail Design Standards Manual, Volume 1.

Drainage pipes were sized using Manning's Equation for full-flow capacity and the Rational Method. Pipe sizing calculations are included in Appendix A of this report.

\\MABOS\projects\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Freetown\Stormwater Figures\Figure 1\Figure 1-Site Locus.dwg

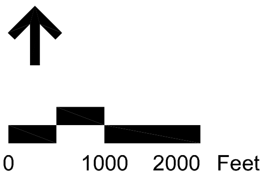


Vanasse Hangen Brustlin, Inc.

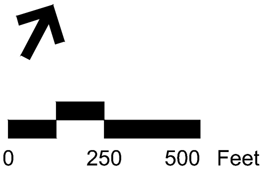
USGS Locus Map

Figure 1
May 2012

Freetown Station
South Coast Rail
Freetown, Massachusetts



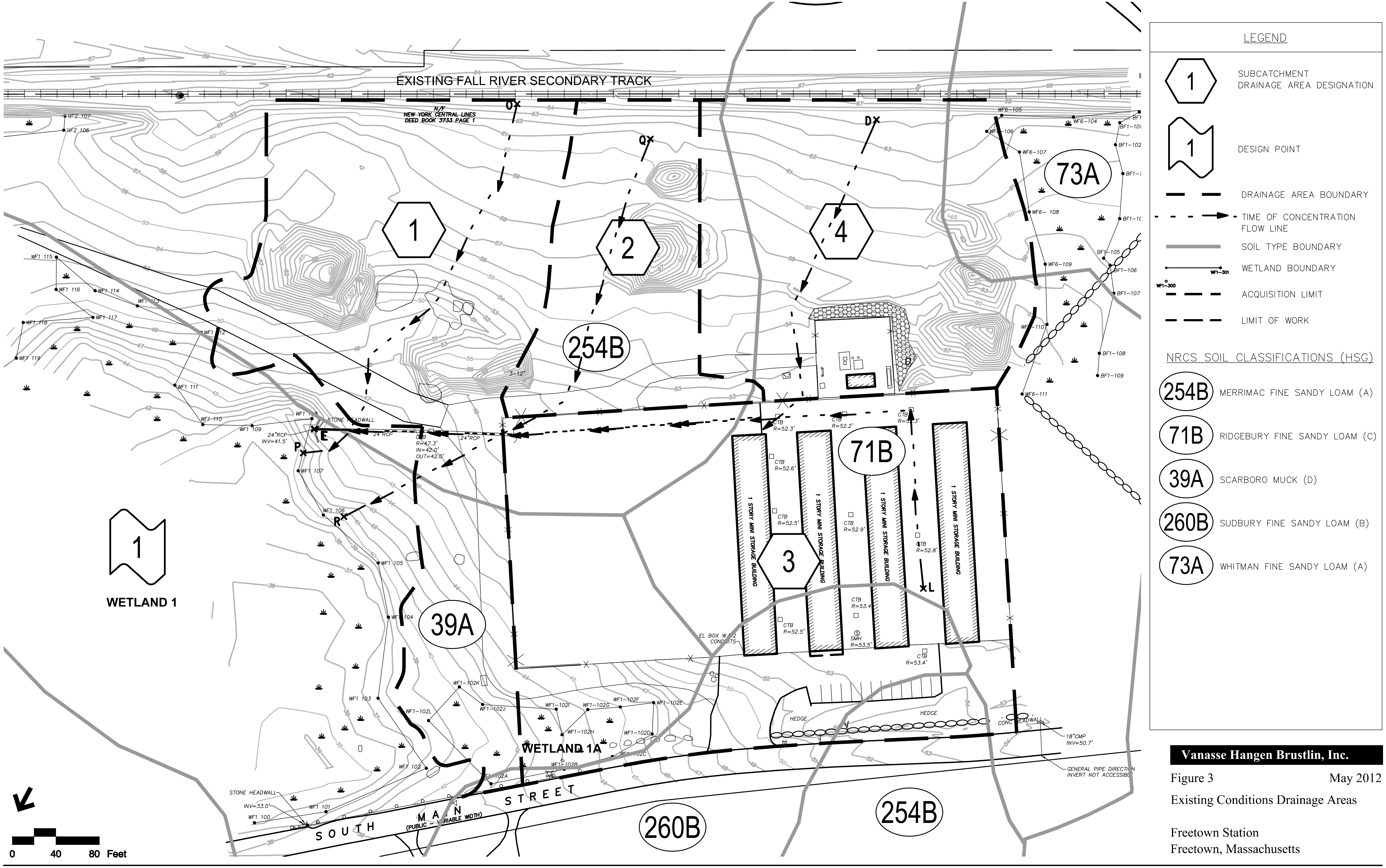
Vanasse Hangen Brustlin, Inc.



Site Aerial Map

Figure 2
May 2012

Freetown Station
South Coast Rail
Freetown, Massachusetts

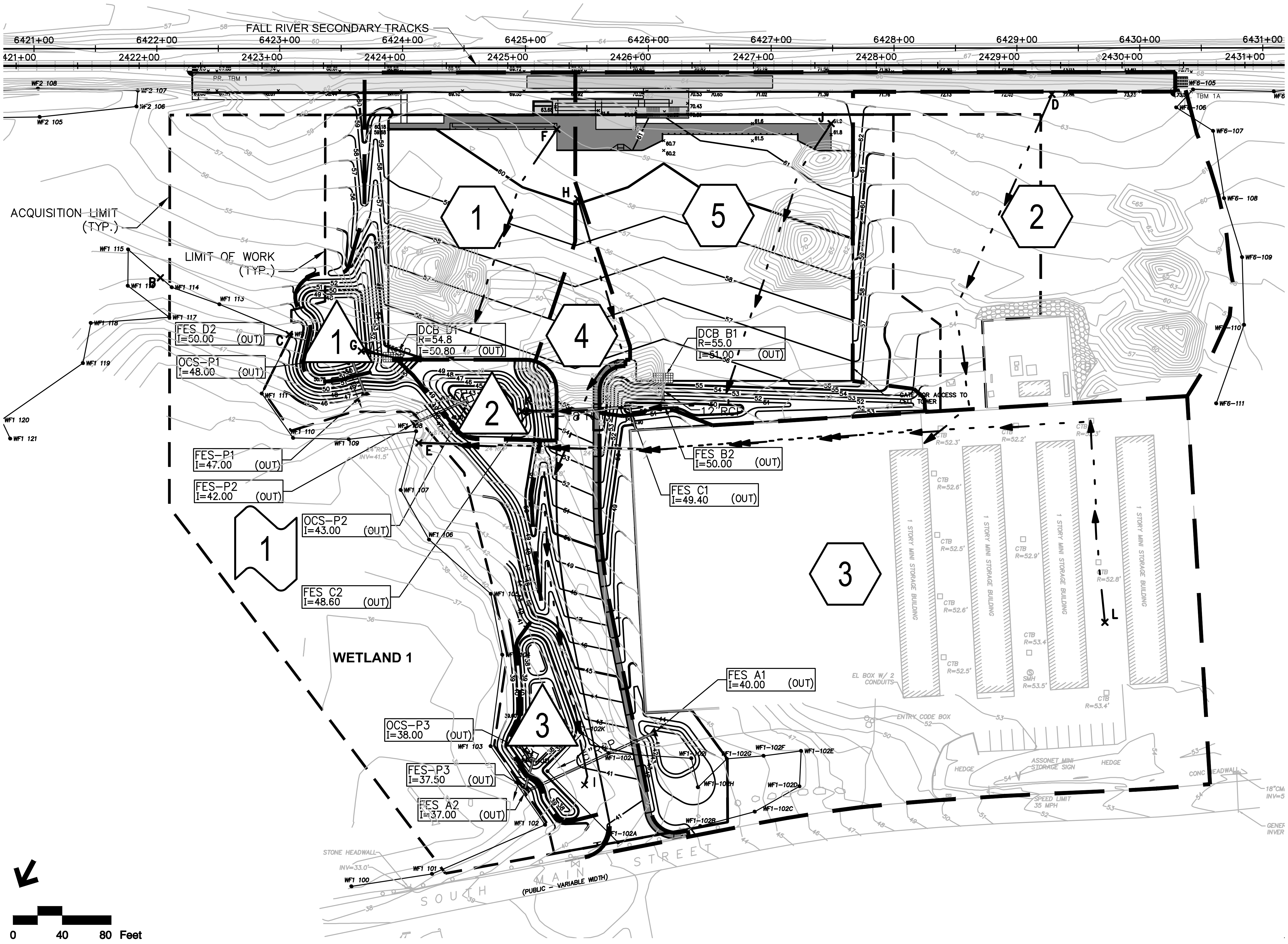


Vanasse Hangen Brustlin, Inc.

Figure 3 May 2012

Existing Conditions Drainage Areas

Freetown Station
Freetown, Massachusetts



LEGEND

SUBCATCHMENT DRAINAGE AREA DESIGNATION

POND

DESIGN POINT

DRAINAGE AREA BOUNDARY

TIME OF CONCENTRATION FLOW LINE

SOIL TYPE BOUNDARY

WETLAND BOUNDARY

ACQUISITION LIMIT

LIMIT OF WORK

Vanasse Hangen Brustlin, Inc.

Figure 4 May 2012

Proposed Conditions Drainage Areas

Freetown Station
Freetown, Massachusetts

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards at 310 CMR 10.05.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

All proposed Project stormwater outlets and conveyances have been designed to not cause erosion or scour to wetlands or receiving waters. Outlets from closed drainage systems have been designed with flared end sections and stone protection to dissipate discharge velocities. Overflows from BMPs that impound stormwater have been designed with stone to protect down gradient areas from erosion.

Computations and supporting information for the sizing and selection of materials used to protect from scour and erosion are included in Appendix A.

Standard 2: Peak Rate Attenuation

The Project has been designed to fully comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, and 100-years. The results of the analysis, as summarized in Table 4 below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions.

Computations and supporting information regarding the hydrologic modeling are included in Appendix B.

Table 4
Peak Discharge Rates (cfs*)

Design Point	*2-year*	*10-year*	*100-year*
Design Point 1: Wetland 1			
Existing	10.8	18.3	33.4
Proposed	10.4	17.3	31.8

Standard 3: Stormwater Recharge

The Project has been designed to fully comply with Standard 3.

In accordance with the Stormwater Handbook, the Required Recharge Volume for the Project is 4,676 cubic feet.

Recharge of stormwater has been provided through the use of infiltration basins, which has been sized using the static method. Each infiltration BMP has been designed to drain completely within 72 hours. Table 5 below provides a summary of the proposed infiltration BMPs utilized for the Project.

Table 5
Summary of Recharge Calculations

Infiltration BMP	*Provided Recharge Volume (cubic feet)*
Infiltration Basin P1	1,955
Infiltration Basin P2	5,205
Infiltration Basin P3	4,403
Total Provided Recharge	11,563

A Geotechnical Report is included in Appendix E.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum of 80% TSS removal for stormwater runoff from all proposed impervious surfaces.

Computations and supporting information are included in Appendix D.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a LUHPPL as defined in 3.10 CMR 10.04 and 314 CMR 9.02 because the parking lot is not classified as a high-intensity use (1,000 vehicle trips per day or more).

Standard 6: Critical Areas

The Project will not discharge stormwater near or to a critical area.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

The Project is not a redevelopment.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Controls

The Project would disturb approximately 3.9 acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP). As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) would be developed and a Notice of Intent for the CGP would be submitted by the contractor and owner at least 14 days before land disturbance begins. Recommended construction period pollution prevention and erosion and sedimentation controls were discussed in the DEIR/S. Appropriate controls will be prepared and implemented by the contractor and MassDOT (MBTA) during construction in accordance with the final design and NPDES SWPPP.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan will be developed by the MBTA during final design for the Project.

Standard 10: Prohibition of Illicit Discharges

The site was previously undeveloped and no sanitary sewer or storm drainage infrastructure is known to exist on the site. The design plans submitted with this report have been designed in full compliance with current standards. The Long-Term Pollution Prevention Plan will include measures to prevent illicit discharges.

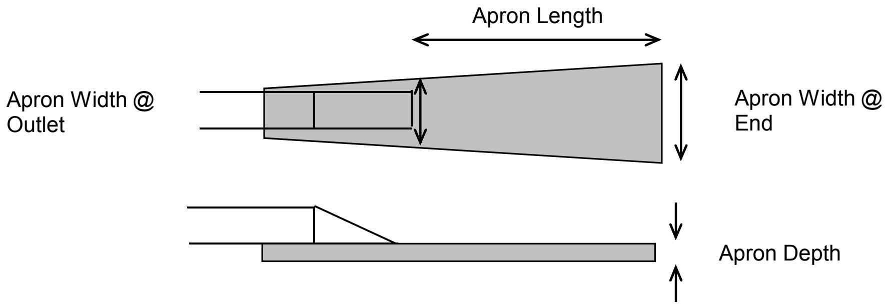
Appendix A
Standard 1 Computations and Supporting Information

Project #:	10111.34		
Project:	Freetown Station - SCR		
Location:	Freetown, MA		
Calculated by:	PAC	Date:	April 30, 2012
Checked by:	-	Date:	April 30, 2012
Title:	Riprap Outlet Protection Sizing		

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

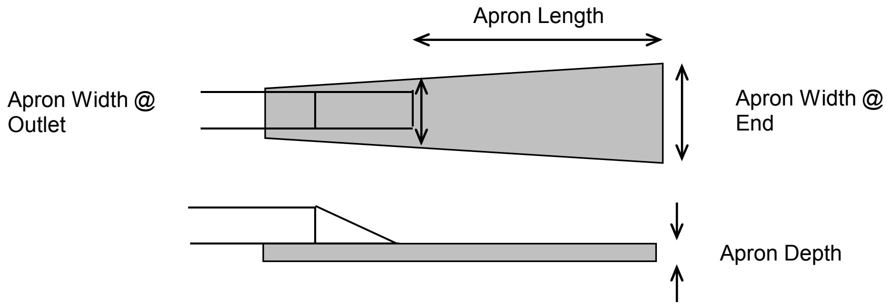
Design Element	Outlet Description FES - Pond 1
Design Storm (yr):	100
Defined Channel (yes/no)	no
Pipe Dia (D), in	15
Tail Water (Tw), ft	Tw < 0.5D
Flow (Q), cfs	1.7
Apron Width (outlet), ft	4
Apron Length, ft	17
Apron Width (end), ft	18
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111.34
Project: Freetown Station - SCR
Location: Freetown, MA
Calculated by: PAC Date: April 30, 2012
Checked by: - Date: April 30, 2012
Title: Riprap Outlet Protection Sizing

Sources: Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas
Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)

Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18)
Virginia Department of Conservation and Recreation (DCR)

Attachments: Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3

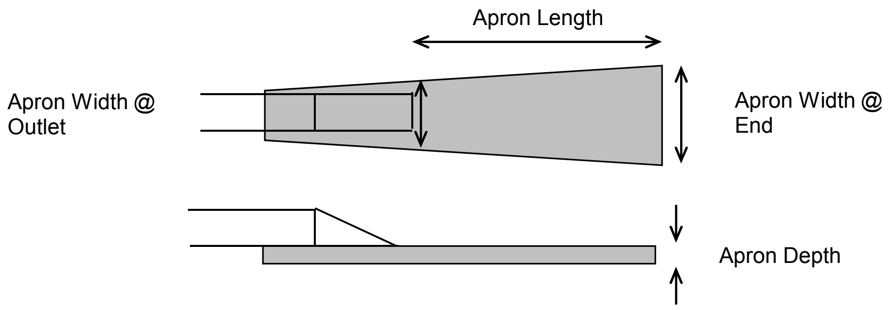


Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

	Outlet Description
Design Element	FES - Pond 2
Design Storm (yr):	100
Defined Channel (yes/no)	no
Pipe Dia (D), in	12
Tail Water (Tw), ft	Tw < 0.5D
Flow (Q), cfs	2.2
Apron Width (outlet), ft	3
Apron Length, ft	17
Apron Width (end), ft	18
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Project #: 10111.34
Project: Freetown Station - SCR
Location: Freetown, MA
Calculated by: PAC Date: April 30, 2012
Checked by: - Date: April 30, 2012
Title: Riprap Outlet Protection Sizing

Sources:	Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas Massachusetts Department of Environmental Protection - Reprinted 2003 (pp. 118-120)
	Erosion and Sediment Control Handbook - Third Edition 1992 (Chapter 3.18) Virginia Department of Conservation and Recreation (DCR)
Attachments:	Virginia DCR Erosion and Sediment Control Handbook Plate 3.18-3



Apron Width at Outlet:	Width = 3 x pipe dia. (or width of channel)	
Apron Length:	Length = From Virginia DCR Handbook - Plate 3.18-3	if Tw depth is < 1/2 dia.
	Length = From Virginia DCR Handbook - Plate 3.18-4	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = dia. + apron length	if Tw depth is < 1/2 dia.
	Width = dia. + 0.4 x apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter (d_{50}) = From Virginia DCR Handbook - Plate 3.18-3 or 4	
	Largest stone dia = 1.5 x d_{50}	
Apron Depth:	6" or 1.5 x largest stone dia	

Design Element	Outlet Description FES - Pond 3
Design Storm (yr):	100
Defined Channel (yes/no)	no
Pipe Dia (D), in	24
Tail Water (Tw), ft	Tw < 0.5D
Flow (Q), cfs	4.8
Apron Width (outlet), ft	6
Apron Length, ft	17
Apron Width (end), ft	19
Median Stone Dia., ft	0.50
Median Stone Dia., in	6
Largest Stone Dia., ft	0.75
Largest Stone Dia., in	9
Apron Depth, ft	1
Apron Depth, in	14

Vanasse Hangen Brustlin, Inc.
Transportation
Land Development
Environmental Services
99 High St., Boston, MA 02110
(617) 728-7777

Storm Drainage Computations

Name: South Coast Rail
Freetown MA
Client: MassDOT

Proj. No.: **10111.00**
Date: **5/21/2012**
Computed by: **PAC**
Checked by: **EJM**

Design Parameters:
25 **Year Storm** Boston, MA
k_e= **0.5**

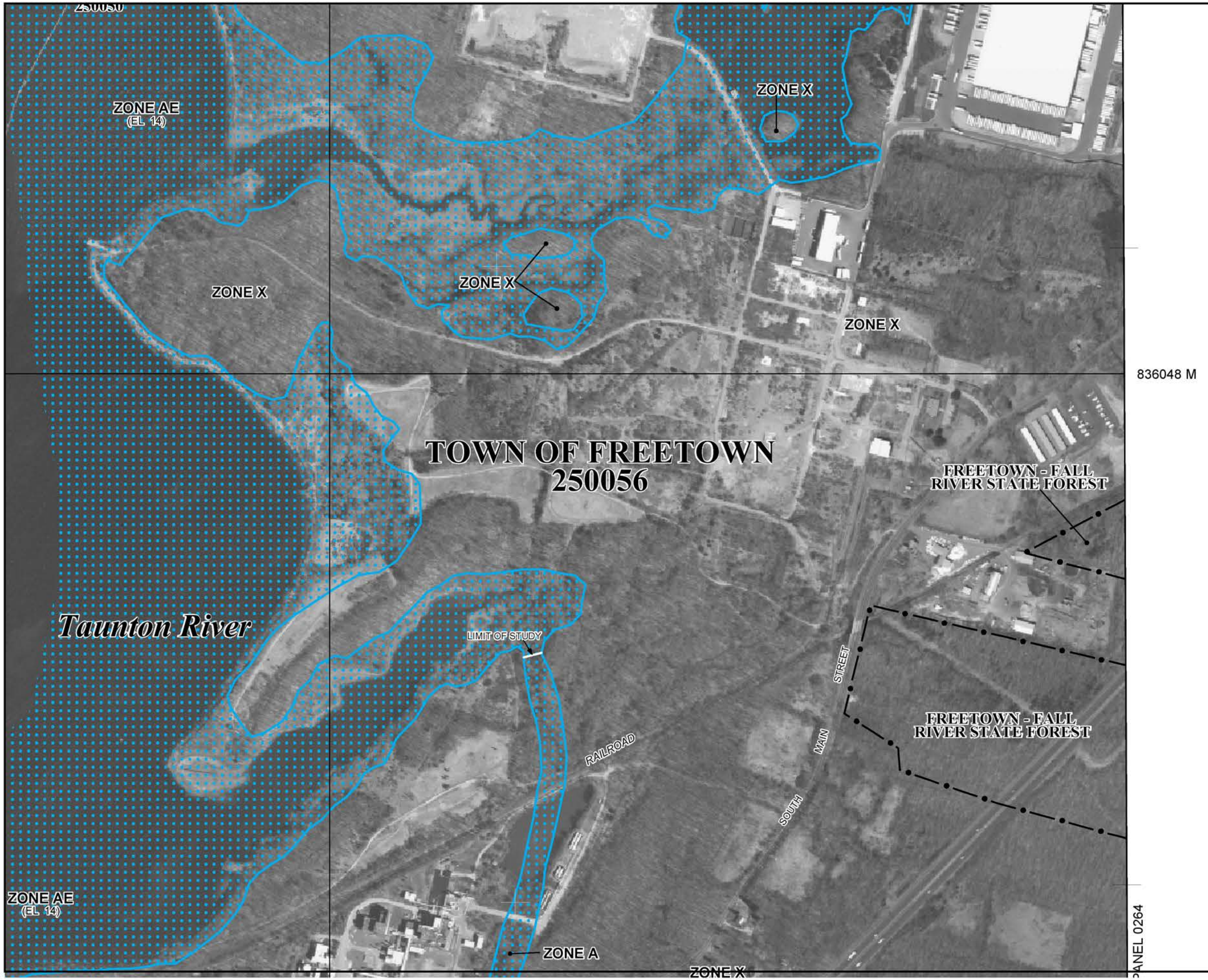
DESCRIPTION	**LOCATION**		AREA	C	C x A	SUM	**FLOW TIME (MIN)**		i*	**DESIGN**					**CAPACITY**		**PROFILE**						
	FROM	TO	(AC.)			C x A	PIPE	CONC TIME		Q cfs	V fps	n	PIPE SIZE	SLOPE	Q full ft^3/s	V full ft/s	LENGTH ft	FALL ft	RIM	INV UPPER	INV LOWER	W.S.E. ft	Freeboard ft
	FES A1	FES A2	1.65	0.71	1.18	1.18	0.26	5.0	6.0	7.1	7.7	0.013	15	0.0250	10.2	8.3	120	3.00	40.0	40.0	37.0	39.3	0.7
	DCB B1	FES B2	0.63	0.85	0.53	0.53	0.04	5.0	6.0	3.2	8.1	0.013	12	0.0500	8.0	10.1	20	1.00	55.0	51.0	50.0	50.2	4.8
	FES C1	FES C2	1.34	0.78	1.04	1.04	0.26	5.0	6.0	6.2	5.1	0.013	24	0.0100	22.6	7.2	80	0.80	49.4	49.4	48.6	49.1	0.3
	DCB D1	FES D2	0.40	0.90	0.36	0.36	0.05	5.0	6.0	2.2	6.7	0.013	12	0.0400	7.1	9.1	20	0.80	54.8	50.8	50.0	50.2	4.6

\\mabosdata\PROJECTS\10111.00\tech\FINAL_EIS_EIR\Stormwater\Data\Stations\Freetown\Appendices\Appendix A_Standard 1 Support\FR_PipeCalcs-HGLWorksheet.xls

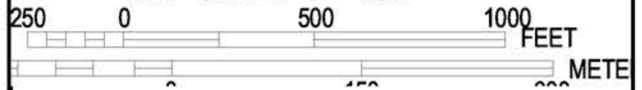
Appendix B
Standard 2 Computations and Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Bristol County. Runoff coefficients for the existing and proposed conditions, as previously shown in Tables 1 and 2 respectively, were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

FEMA Flood Maps



MAP SCALE 1" = 500'



NFIP

PANEL 0263F

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 263 OF 550
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

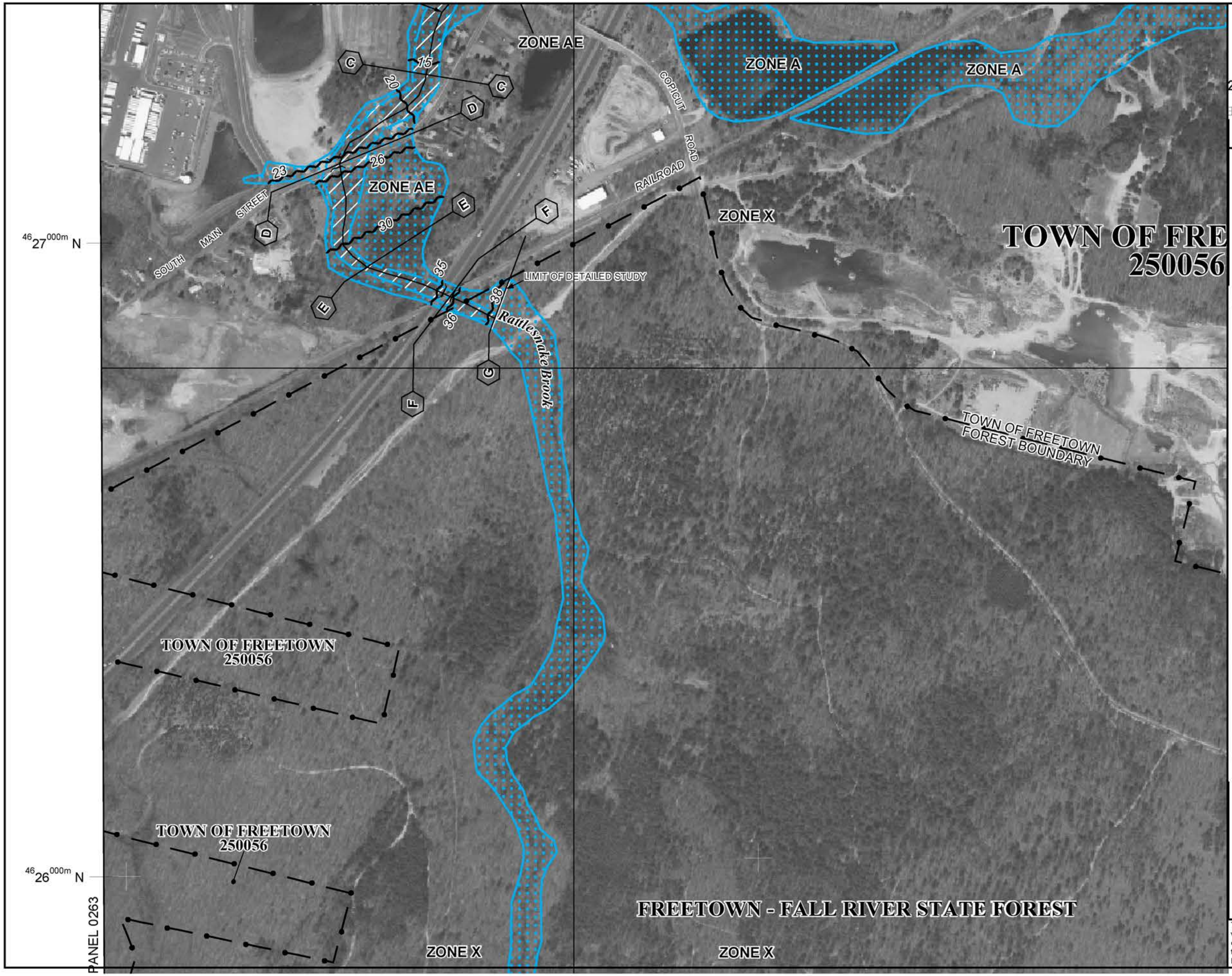
COMMUNITY	NUMBER	PANEL	SUFFIX
BERKLEY, TOWN OF	250050	0263	F
FALL RIVER, CITY OF	250055	0263	F
FREETOWN, TOWN OF	250056	0263	F
SOMERSET, TOWN OF	255220	0263	F

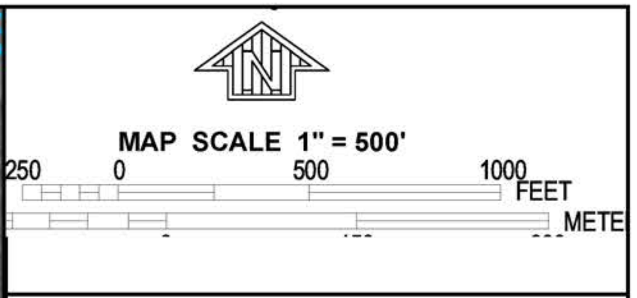
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25005C0263F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency





NFIP

PANEL 0264F

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

BRISTOL COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 264 OF 550
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
FALL RIVER, CITY OF	250055	0264	F
FREETOWN, TOWN OF	250056	0264	F

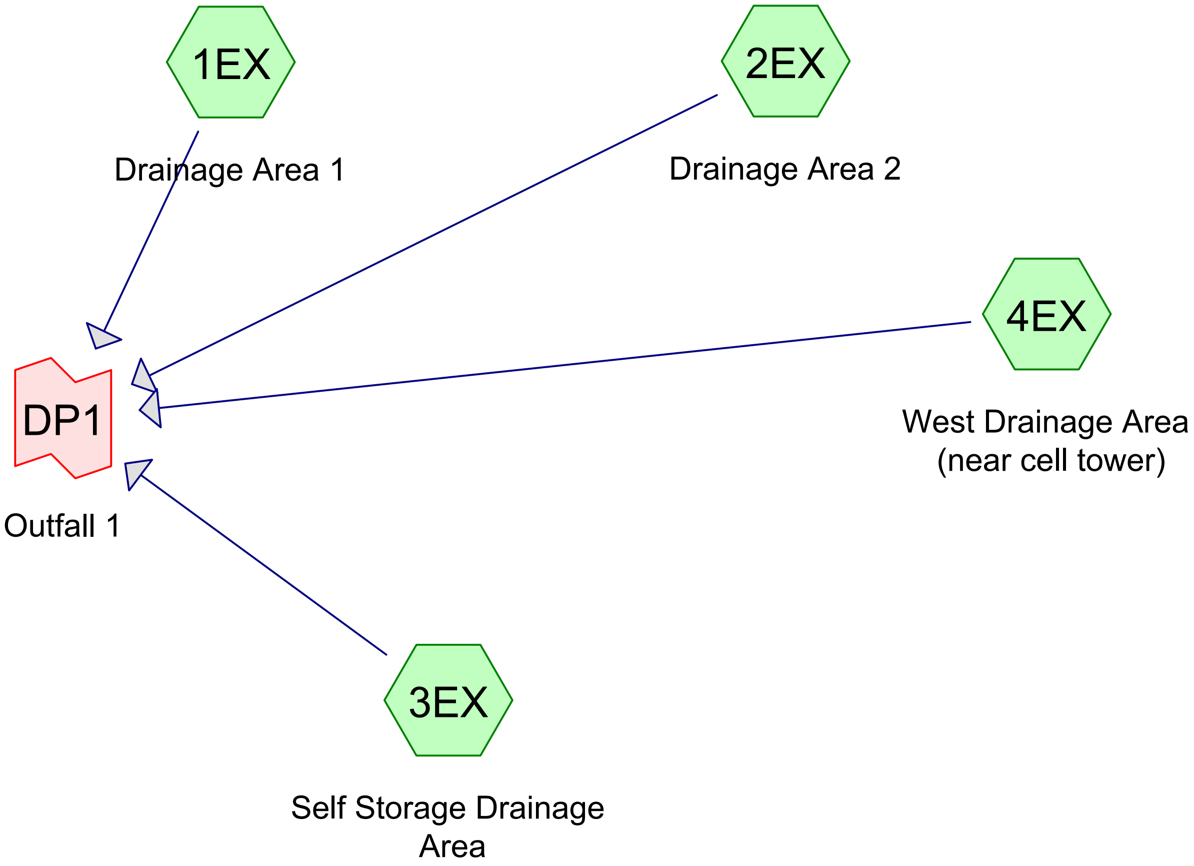
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

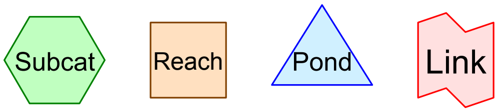
MAP NUMBER
25005C0264F

EFFECTIVE DATE
JULY 7, 2009

Federal Emergency Management Agency

HydroCAD Analysis: Existing Conditions





Routing Diagram for FREETOWN EX
Prepared by Vanasse Hangen Brustlin, Printed 5/17/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.006	39	>75% Grass cover, Good, HSG A (1EX, 2EX, 3EX, 4EX)
0.155	61	>75% Grass cover, Good, HSG B (1EX, 3EX)
1.261	74	>75% Grass cover, Good, HSG C (2EX, 3EX, 4EX)
0.571	76	Gravel roads, HSG A (1EX, 2EX, 3EX, 4EX)
0.012	77	Woods, Good, HSG D (1EX)
0.649	80	>75% Grass cover, Good, HSG D (1EX, 3EX, 4EX)
0.023	85	Gravel roads, HSG B (3EX)
0.418	89	Gravel roads, HSG C (3EX, 4EX)
0.641	91	Gravel roads, HSG D (1EX, 3EX)
0.023	98	Paved parking, HSG A (3EX)
0.350	98	Paved parking, HSG B (3EX)
0.606	98	Paved parking, HSG C (3EX)
0.111	98	Roofs, HSG B (3EX)
0.458	98	Roofs, HSG C (3EX)
0.014	98	Unconnected roofs, HSG C (4EX)
0.011	98	Water Surface, 0% imp, HSG B (1EX, 3EX)
0.220	98	Water Surface, 0% imp, HSG D (1EX, 3EX)
8.530	**69**	**TOTAL AREA**

2-Year Storm Event - Existing

```
                         Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
                              Runoff by SCS TR-20 method, UH=SCS
               Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment1EX: Drainage Area 1          Runoff Area=106,520 sf   0.00% Impervious   Runoff Depth=0.20"
                                         Flow Length=395'   Tc=6.9 min   CN=51   Runoff=0.15 cfs  0.040 af

Subcatchment2EX: Drainage Area 2           Runoff Area=41,350 sf   0.00% Impervious   Runoff Depth=0.03"
                                         Flow Length=505'   Tc=8.5 min   CN=42   Runoff=0.00 cfs  0.002 af

Subcatchment3EX: Self Storage             Runoff Area=145,620 sf  46.31% Impervious   Runoff Depth=2.26"
                                         Flow Length=715'   Tc=5.0 min   CN=89   Runoff=9.12 cfs  0.631 af

Subcatchment4EX: West Drainage Area        Runoff Area=78,080 sf   0.80% Impervious   Runoff Depth=1.00"
                             Flow Length=720'   Tc=7.4 min   UI Adjusted CN=71   Runoff=1.85 cfs  0.149 af

Link DP1: Outfall 1                                                              Inflow=10.77 cfs  0.823 af
                                                                                Primary=10.77 cfs  0.823 af

              Total Runoff Area = 8.530 ac   Runoff Volume = 0.823 af   Average Runoff Depth = 1.16"
                                         81.68% Pervious = 6.968 ac     18.32% Impervious = 1.562 ac
```

Summary for Subcatchment 1EX: Drainage Area 1

Tc is minimum recommended by tr-55 = 6 min

Runoff = 0.15 cfs @ 12.41 hrs, Volume= 0.040 af, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
3,867	76	Gravel roads, HSG A
4,856	91	Gravel roads, HSG D
78,081	39	>75% Grass cover, Good, HSG A
355	61	>75% Grass cover, Good, HSG B
14,435	80	>75% Grass cover, Good, HSG D
263	98	Water Surface, 0% imp, HSG B
4,148	98	Water Surface, 0% imp, HSG D
515	77	Woods, Good, HSG D
106,520	51	Weighted Average
106,520		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	50	0.0960	0.29		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
1.0	80	0.0330	1.27		**Shallow Concentrated Flow, SGP 3.3%** Short Grass Pasture Kv= 7.0 fps
0.5	75	0.1070	2.29		**Shallow Concentrated Flow, SGP 10.7%** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0210	1.01		**Shallow Concentrated Flow, SGP 2.1%** Short Grass Pasture Kv= 7.0 fps
0.2	50	0.1000	4.74		**Shallow Concentrated Flow, Grassed Waterway** Grassed Waterway Kv= 15.0 fps
6.9	395	Total			

Summary for Subcatchment 2EX: Drainage Area 2

Runoff = 0.00 cfs @ 16.97 hrs, Volume= 0.002 af, Depth= 0.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
3,606	76	Gravel roads, HSG A
37,545	39	>75% Grass cover, Good, HSG A
199	74	>75% Grass cover, Good, HSG C
41,350	42	Weighted Average
41,350		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0500	0.22		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
2.5	195	0.0350	1.31		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.9	135	0.0270	2.65		**Shallow Concentrated Flow, Gravel Drive & Lot** Unpaved Kv= 16.1 fps
1.1	100	0.0500	1.57		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.1000	2.21		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
8.5	505	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 9.12 cfs @ 12.07 hrs, Volume= 0.631 af, Depth= 2.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
1,002	85	Gravel roads, HSG B
13,155	89	Gravel roads, HSG C
23,087	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,246	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
5,401	39	>75% Grass cover, Good, HSG A
6,403	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
3,877	80	>75% Grass cover, Good, HSG D
218	98	Water Surface, 0% imp, HSG B
5,445	98	Water Surface, 0% imp, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
145,620	89	Weighted Average
78,190		53.69% Pervious Area
67,430		46.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, pavement** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4EX: West Drainage Area (near cell tower)

Runoff = 1.85 cfs @ 12.12 hrs, Volume= 0.149 af, Depth= 1.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
776	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Unconnected roofs, HSG C
9,897	39	>75% Grass cover, Good, HSG A
51,756	74	>75% Grass cover, Good, HSG C
9,976	80	>75% Grass cover, Good, HSG D
78,080	72	Weighted Average, UI Adjusted CN = 71
77,454		99.20% Pervious Area
626		0.80% Impervious Area
626		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Link DP1: Outfall 1

```
Inflow Area =       8.530 ac, 18.32% Impervious, Inflow Depth =  1.16"   for 2 yr storm event
Inflow      =      10.77 cfs @  12.08 hrs, Volume=          0.823 af
Primary     =      10.77 cfs @  12.08 hrs, Volume=          0.823 af, Atten= 0%, Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

10-Year Storm Event - Existing

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1EX: Drainage Area 1 Runoff Area=106,520 sf 0.00% Impervious Runoff Depth=0.64"
Flow Length=395' Tc=6.9 min CN=51 Runoff=1.09 cfs 0.131 af

Subcatchment2EX: Drainage Area 2 Runoff Area=41,350 sf 0.00% Impervious Runoff Depth=0.25"
Flow Length=505' Tc=8.5 min CN=42 Runoff=0.07 cfs 0.020 af

Subcatchment3EX: Self Storage Runoff Area=145,620 sf 46.31% Impervious Runoff Depth=3.53"
Flow Length=715' Tc=5.0 min CN=89 Runoff=13.98 cfs 0.984 af

Subcatchment4EX: West Drainage Area Runoff Area=78,080 sf 0.80% Impervious Runoff Depth=1.93"
Flow Length=720' Tc=7.4 min UI Adjusted CN=71 Runoff=3.79 cfs 0.288 af

Link DP1: Outfall 1 Inflow=18.27 cfs 1.423 af
Primary=18.27 cfs 1.423 af

Total Runoff Area = 8.530 ac Runoff Volume = 1.423 af Average Runoff Depth = 2.00"
81.68% Pervious = 6.968 ac 18.32% Impervious = 1.562 ac

Summary for Subcatchment 1EX: Drainage Area 1

Tc is minimum recommended by tr-55 = 6 min

Runoff = 1.09 cfs @ 12.14 hrs, Volume= 0.131 af, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
3,867	76	Gravel roads, HSG A
4,856	91	Gravel roads, HSG D
78,081	39	>75% Grass cover, Good, HSG A
355	61	>75% Grass cover, Good, HSG B
14,435	80	>75% Grass cover, Good, HSG D
263	98	Water Surface, 0% imp, HSG B
4,148	98	Water Surface, 0% imp, HSG D
515	77	Woods, Good, HSG D
106,520	51	Weighted Average
106,520		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	50	0.0960	0.29		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
1.0	80	0.0330	1.27		**Shallow Concentrated Flow, SGP 3.3%** Short Grass Pasture Kv= 7.0 fps
0.5	75	0.1070	2.29		**Shallow Concentrated Flow, SGP 10.7%** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0210	1.01		**Shallow Concentrated Flow, SGP 2.1%** Short Grass Pasture Kv= 7.0 fps
0.2	50	0.1000	4.74		**Shallow Concentrated Flow, Grassed Waterway** Grassed Waterway Kv= 15.0 fps
6.9	395	Total			

Summary for Subcatchment 2EX: Drainage Area 2

Runoff = 0.07 cfs @ 12.46 hrs, Volume= 0.020 af, Depth= 0.25"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
3,606	76	Gravel roads, HSG A
37,545	39	>75% Grass cover, Good, HSG A
199	74	>75% Grass cover, Good, HSG C
41,350	42	Weighted Average
41,350		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0500	0.22		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
2.5	195	0.0350	1.31		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.9	135	0.0270	2.65		**Shallow Concentrated Flow, Gravel Drive & Lot** Unpaved Kv= 16.1 fps
1.1	100	0.0500	1.57		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.1000	2.21		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
8.5	505	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 13.98 cfs @ 12.07 hrs, Volume= 0.984 af, Depth= 3.53"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
1,002	85	Gravel roads, HSG B
13,155	89	Gravel roads, HSG C
23,087	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,246	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
5,401	39	>75% Grass cover, Good, HSG A
6,403	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
3,877	80	>75% Grass cover, Good, HSG D
218	98	Water Surface, 0% imp, HSG B
5,445	98	Water Surface, 0% imp, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
145,620	89	Weighted Average
78,190		53.69% Pervious Area
67,430		46.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, pavement** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4EX: West Drainage Area (near cell tower)

Runoff = 3.79 cfs @ 12.11 hrs, Volume= 0.288 af, Depth= 1.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
776	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Unconnected roofs, HSG C
9,897	39	>75% Grass cover, Good, HSG A
51,756	74	>75% Grass cover, Good, HSG C
9,976	80	>75% Grass cover, Good, HSG D
78,080	72	Weighted Average, UI Adjusted CN = 71
77,454		99.20% Pervious Area
626		0.80% Impervious Area
626		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Link DP1: Outfall 1

Inflow Area = 8.530 ac, 18.32% Impervious, Inflow Depth = 2.00" for 10 yr storm event
Inflow = 18.27 cfs @ 12.08 hrs, Volume= 1.423 af
Primary = 18.27 cfs @ 12.08 hrs, Volume= 1.423 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

100-Year Storm Event - Existing

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1EX: Drainage Area 1 Runoff Area=106,520 sf 0.00% Impervious Runoff Depth=1.76"
Flow Length=395' Tc=6.9 min CN=51 Runoff=4.31 cfs 0.358 af

Subcatchment2EX: Drainage Area 2 Runoff Area=41,350 sf 0.00% Impervious Runoff Depth=1.00"
Flow Length=505' Tc=8.5 min CN=42 Runoff=0.64 cfs 0.079 af

Subcatchment3EX: Self Storage Runoff Area=145,620 sf 46.31% Impervious Runoff Depth=5.71"
Flow Length=715' Tc=5.0 min CN=89 Runoff=22.02 cfs 1.590 af

Subcatchment4EX: West Drainage Area Runoff Area=78,080 sf 0.80% Impervious Runoff Depth=3.72"
Flow Length=720' Tc=7.4 min UI Adjusted CN=71 Runoff=7.45 cfs 0.556 af

Link DP1: Outfall 1 Inflow=33.37 cfs 2.583 af
Primary=33.37 cfs 2.583 af

Total Runoff Area = 8.530 ac Runoff Volume = 2.583 af Average Runoff Depth = 3.63"
81.68% Pervious = 6.968 ac 18.32% Impervious = 1.562 ac

Summary for Subcatchment 1EX: Drainage Area 1

Tc is minimum recommended by tr-55 = 6 min

Runoff = 4.31 cfs @ 12.11 hrs, Volume= 0.358 af, Depth= 1.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
3,867	76	Gravel roads, HSG A
4,856	91	Gravel roads, HSG D
78,081	39	>75% Grass cover, Good, HSG A
355	61	>75% Grass cover, Good, HSG B
14,435	80	>75% Grass cover, Good, HSG D
263	98	Water Surface, 0% imp, HSG B
4,148	98	Water Surface, 0% imp, HSG D
515	77	Woods, Good, HSG D
106,520	51	Weighted Average
106,520		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	50	0.0960	0.29		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
1.0	80	0.0330	1.27		**Shallow Concentrated Flow, SGP 3.3%** Short Grass Pasture Kv= 7.0 fps
0.5	75	0.1070	2.29		**Shallow Concentrated Flow, SGP 10.7%** Short Grass Pasture Kv= 7.0 fps
2.3	140	0.0210	1.01		**Shallow Concentrated Flow, SGP 2.1%** Short Grass Pasture Kv= 7.0 fps
0.2	50	0.1000	4.74		**Shallow Concentrated Flow, Grassed Waterway** Grassed Waterway Kv= 15.0 fps
6.9	395	Total			

Summary for Subcatchment 2EX: Drainage Area 2

Runoff = 0.64 cfs @ 12.16 hrs, Volume= 0.079 af, Depth= 1.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
3,606	76	Gravel roads, HSG A
37,545	39	>75% Grass cover, Good, HSG A
199	74	>75% Grass cover, Good, HSG C
41,350	42	Weighted Average
41,350		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0500	0.22		**Sheet Flow, Sheet** Grass: Short n= 0.150 P2= 3.40"
2.5	195	0.0350	1.31		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.9	135	0.0270	2.65		**Shallow Concentrated Flow, Gravel Drive & Lot** Unpaved Kv= 16.1 fps
1.1	100	0.0500	1.57		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.1000	2.21		**Shallow Concentrated Flow, SGP** Short Grass Pasture Kv= 7.0 fps
8.5	505	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 22.02 cfs @ 12.07 hrs, Volume= 1.590 af, Depth= 5.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
1,002	85	Gravel roads, HSG B
13,155	89	Gravel roads, HSG C
23,087	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,246	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
5,401	39	>75% Grass cover, Good, HSG A
6,403	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
3,877	80	>75% Grass cover, Good, HSG D
218	98	Water Surface, 0% imp, HSG B
5,445	98	Water Surface, 0% imp, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
145,620	89	Weighted Average
78,190		53.69% Pervious Area
67,430		46.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, pavement** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4EX: West Drainage Area (near cell tower)

Runoff = 7.45 cfs @ 12.11 hrs, Volume= 0.556 af, Depth= 3.72"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
776	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Unconnected roofs, HSG C
9,897	39	>75% Grass cover, Good, HSG A
51,756	74	>75% Grass cover, Good, HSG C
9,976	80	>75% Grass cover, Good, HSG D
78,080	72	Weighted Average, UI Adjusted CN = 71
77,454		99.20% Pervious Area
626		0.80% Impervious Area
626		100.00% Unconnected

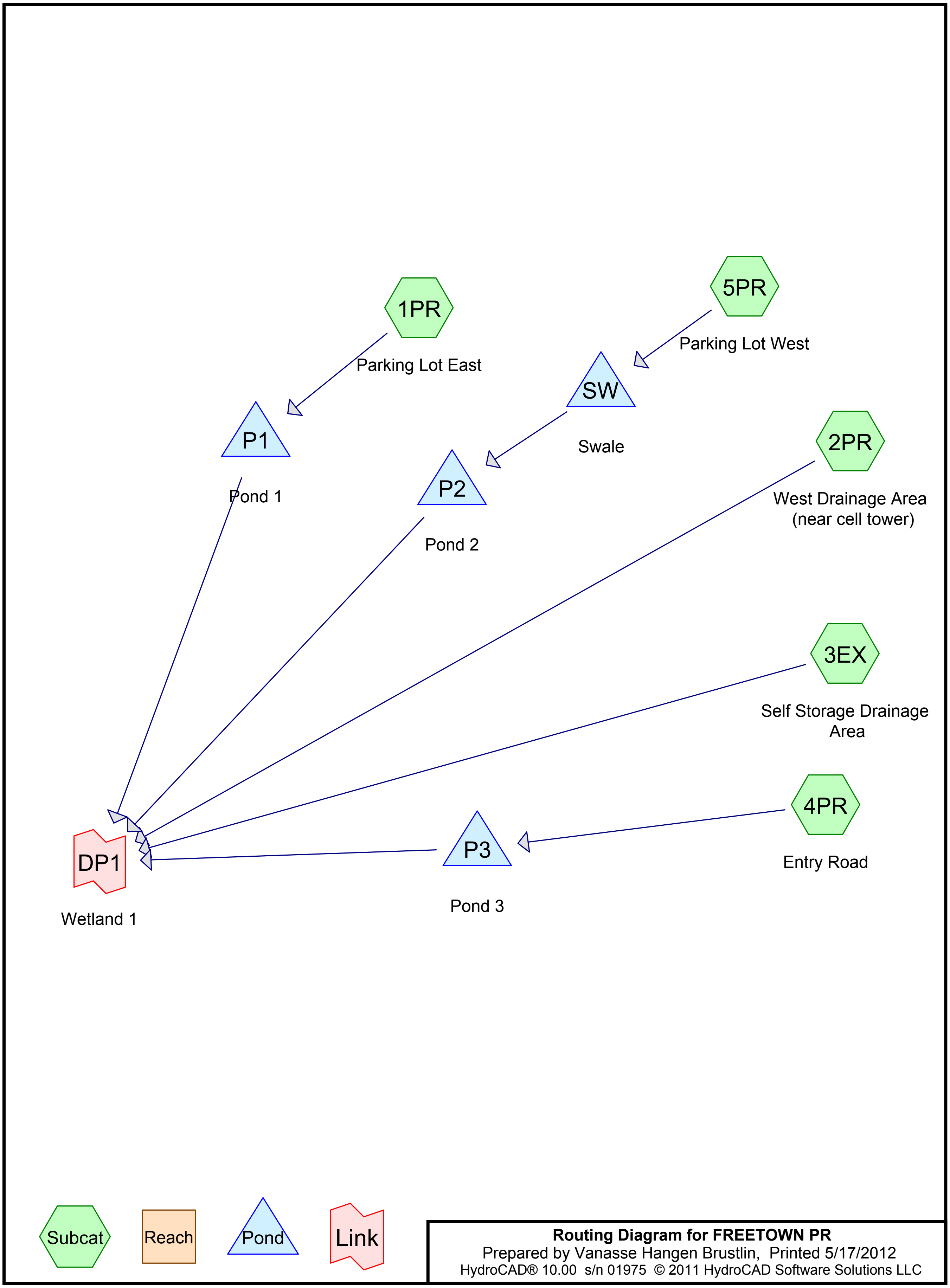
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Link DP1: Outfall 1

Inflow Area = 8.530 ac, 18.32% Impervious, Inflow Depth = 3.63" for 100 yr storm event
Inflow = 33.37 cfs @ 12.08 hrs, Volume= 2.583 af
Primary = 33.37 cfs @ 12.08 hrs, Volume= 2.583 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

HydroCAD Analysis: Proposed Conditions



Routing Diagram for FREETOWN PR
Prepared by Vanasse Hangen Brustlin, Printed 5/17/2012
HydroCAD® 10.00 s/n 01975 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.111	39	>75% Grass cover, Good, HSG A (1PR, 2PR, 3EX, 4PR, 5PR)
0.146	61	>75% Grass cover, Good, HSG B (3EX)
1.184	74	>75% Grass cover, Good, HSG C (2PR, 3EX, 5PR)
0.400	76	Gravel roads, HSG A (2PR, 3EX)
0.802	80	>75% Grass cover, Good, HSG D (1PR, 2PR, 3EX, 4PR)
0.013	85	Gravel roads, HSG B (3EX)
0.417	89	Gravel roads, HSG C (2PR, 3EX)
0.503	91	Gravel roads, HSG D (3EX)
2.090	98	Paved parking, HSG A (1PR, 3EX, 4PR, 5PR)
0.379	98	Paved parking, HSG B (3EX, 4PR)
0.606	98	Paved parking, HSG C (3EX)
0.209	98	Paved parking, HSG D (4PR)
0.111	98	Roofs, HSG B (3EX)
0.548	98	Roofs, HSG C (2PR, 3EX, 5PR)
0.013	98	Roofs, HSG D (5PR)
8.532	**83**	**TOTAL AREA**

2-Year Storm Event - Proposed

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1PR: Parking Lot East Runoff Area=43,318 sf 72.89% Impervious Runoff Depth=1.77"
Flow Length=285' Tc=5.0 min CN=83 Runoff=2.14 cfs 0.147 af

Subcatchment2PR: West Drainage Area Runoff Area=73,919 sf 0.85% Impervious Runoff Depth=1.00"
Flow Length=720' Tc=7.4 min CN=71 Runoff=1.75 cfs 0.142 af

Subcatchment3EX: Self Storage Runoff Area=152,330 sf 44.55% Impervious Runoff Depth=2.09"
Flow Length=715' Tc=5.0 min CN=87 Runoff=8.87 cfs 0.610 af

Subcatchment4PR: Entry Road Runoff Area=0.714 ac 63.45% Impervious Runoff Depth=2.35"
Flow Length=515' Tc=5.0 min CN=90 Runoff=2.02 cfs 0.140 af

Subcatchment5PR: Parking Lot West Runoff Area=70,993 sf 73.96% Impervious Runoff Depth=1.77"
Flow Length=430' Tc=5.0 min CN=83 Runoff=3.51 cfs 0.241 af

Pond P1: Pond 1 Peak Elev=49.30' Storage=2,653 cf Inflow=2.14 cfs 0.147 af
Discarded=0.14 cfs 0.129 af Primary=0.10 cfs 0.018 af Outflow=0.23 cfs 0.147 af

Pond P2: Pond 2 Peak Elev=47.22' Storage=5,691 cf Inflow=3.27 cfs 0.223 af
Discarded=0.13 cfs 0.170 af Primary=0.05 cfs 0.013 af Outflow=0.19 cfs 0.183 af

Pond P3: Pond 3 Peak Elev=39.33' Storage=4,670 cf Inflow=2.02 cfs 0.140 af
Outflow=0.08 cfs 0.039 af

Pond SW: Swale Peak Elev=50.19' Storage=393 cf Inflow=3.51 cfs 0.241 af
Discarded=0.04 cfs 0.018 af Primary=3.27 cfs 0.223 af Outflow=3.31 cfs 0.241 af

Link DP1: Wetland 1 Inflow=10.44 cfs 0.821 af
Primary=10.44 cfs 0.821 af

Total Runoff Area = 8.532 ac Runoff Volume = 1.280 af Average Runoff Depth = 1.80"
53.64% Pervious = 4.577 ac 46.36% Impervious = 3.956 ac

Summary for Subcatchment 1PR: Parking Lot East

Runoff = 2.14 cfs @ 12.08 hrs, Volume= 0.147 af, Depth= 1.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
31,576	98	Paved parking, HSG A
11,096	39	>75% Grass cover, Good, HSG A
646	80	>75% Grass cover, Good, HSG D
43,318	83	Weighted Average
11,742		27.11% Pervious Area
31,576		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0182	1.19		**Sheet Flow, grass** Smooth surfaces n= 0.011 P2= 3.40"
0.7	155	0.0316	3.61		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.5	55	0.0087	1.89		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.1	25	0.0311	8.00	6.28	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
3.0					**Direct Entry, <5 min adjustment**
5.0	285	Total			

Summary for Subcatchment 2PR: West Drainage Area (near cell tower)

Runoff = 1.75 cfs @ 12.12 hrs, Volume= 0.142 af, Depth= 1.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
804	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Roofs, HSG C
9,557	39	>75% Grass cover, Good, HSG A
48,441	74	>75% Grass cover, Good, HSG C
9,442	80	>75% Grass cover, Good, HSG D
73,919	71	Weighted Average
73,293		99.15% Pervious Area
626		0.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 8.87 cfs @ 12.07 hrs, Volume= 0.610 af, Depth= 2.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
566	85	Gravel roads, HSG B
13,112	89	Gravel roads, HSG C
21,911	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,682	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
8,625	39	>75% Grass cover, Good, HSG A
6,360	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
14,288	80	>75% Grass cover, Good, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
152,330	87	Weighted Average
84,464		55.45% Pervious Area
67,866		44.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, storage lot** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4PR: Entry Road

Runoff = 2.02 cfs @ 12.07 hrs, Volume= 0.140 af, Depth= 2.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (ac)	CN	Description
0.225	98	Paved parking, HSG A
0.019	98	Paved parking, HSG B
0.209	98	Paved parking, HSG D
0.019	39	>75% Grass cover, Good, HSG A
0.242	80	>75% Grass cover, Good, HSG D
0.714	90	Weighted Average
0.261		36.55% Pervious Area
0.453		63.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0320	1.49		**Sheet Flow, Lot (sheet)** Smooth surfaces n= 0.011 P2= 3.40"
0.4	85	0.0320	3.63		**Shallow Concentrated Flow, Lot (SCF)** Paved Kv= 20.3 fps
0.3	50	0.0140	2.40		**Shallow Concentrated Flow, along curb** Paved Kv= 20.3 fps
0.2	60	0.0500	4.54		**Shallow Concentrated Flow, Driveway 5%** Paved Kv= 20.3 fps
0.0	10	0.3300	4.02		**Shallow Concentrated Flow, swale slope** Short Grass Pasture Kv= 7.0 fps
1.3	240	0.0450	3.18		**Shallow Concentrated Flow, swale** Grassed Waterway Kv= 15.0 fps
0.1	20	0.0250	2.37		**Shallow Concentrated Flow, end of swale** Grassed Waterway Kv= 15.0 fps
2.1					**Direct Entry, <5 min adjustment**
5.0	515	Total			

Summary for Subcatchment 5PR: Parking Lot West

Runoff = 3.51 cfs @ 12.08 hrs, Volume= 0.241 af, Depth= 1.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 yr storm Rainfall=3.40"

Area (sf)	CN	Description
48,651	98	Paved parking, HSG A
3,305	98	Roofs, HSG C
552	98	Roofs, HSG D
18,305	39	>75% Grass cover, Good, HSG A
180	74	>75% Grass cover, Good, HSG C
70,993	83	Weighted Average
18,485		26.04% Pervious Area
52,508		73.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0	50	0.0080	0.86		**Sheet Flow, Impervious** Smooth surfaces n= 0.011 P2= 3.40"
0.9	180	0.0300	3.52		**Shallow Concentrated Flow, impervious parking lot** Paved Kv= 20.3 fps
0.1	20	0.3300	4.02		**Shallow Concentrated Flow, 3:1 ditch slope** Short Grass Pasture Kv= 7.0 fps
0.6	80	0.0250	2.37		**Shallow Concentrated Flow, ditch** Grassed Waterway Kv= 15.0 fps
0.4	100	0.0100	4.54	3.56	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
2.0					**Direct Entry, <5 min adjustment**
5.0	430	Total			

Summary for Pond P1: Pond 1

Inflow Area = 0.994 ac, 72.89% Impervious, Inflow Depth = 1.77" for 2 yr storm event
Inflow = 2.14 cfs @ 12.08 hrs, Volume= 0.147 af
Outflow = 0.23 cfs @ 12.88 hrs, Volume= 0.147 af, Atten= 89%, Lag= 48.2 min
Discarded = 0.14 cfs @ 12.88 hrs, Volume= 0.129 af
Primary = 0.10 cfs @ 12.88 hrs, Volume= 0.018 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 49.30' @ 12.88 hrs Surf.Area= 2,422 sf Storage= 2,653 cf

Plug-Flow detention time= 167.2 min calculated for 0.147 af (100% of inflow)
Center-of-Mass det. time= 167.2 min (996.3 - 829.2)

Volume	Invert	Avail.Storage	Storage Description
#1	48.00'	7,713 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
48.00	1,670	180.0	0	0	1,670
49.00	2,240	199.0	1,948	1,948	2,274
50.00	2,870	219.0	2,549	4,497	2,971
51.00	3,575	241.0	3,216	7,713	3,808

Device	Routing	Invert	Outlet Devices
#1	Primary	48.00'	**15.0" Round RCP_Round 15"** L= 100.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 48.00' / 47.00' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.23 sf
#2	Device 1	49.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	50.25'	**12.0" W x 6.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	50.75'	**5.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50

```
                                Coef. (English) 2.34  2.50  2.70  2.68  2.68  2.66  2.65  2.65  2.65
                                2.65  2.67  2.66  2.68  2.70  2.74  2.79  2.88
  #5    Discarded        48.00' 2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.14 cfs @ 12.88 hrs  HW=49.30'   (Free Discharge)
└─5=Exfiltration (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.10 cfs @ 12.88 hrs  HW=49.30'   (Free Discharge)
├─1=RCP_Round 15" (Passes 0.10 cfs of 4.86 cfs potential flow)
│ ├─2=Orifice/Grate (Orifice Controls 0.10 cfs @ 2.03 fps)
│ └─3=Orifice/Grate ( Controls 0.00 cfs)
└─4=Broad-Crested Rectangular Weir( Controls 0.00 cfs)

                        Summary for Pond P2: Pond 2

Inflow Area =      1.630 ac, 73.96% Impervious,  Inflow Depth =  1.64"   for  2 yr storm event
Inflow      =     3.27 cfs @  12.10 hrs,  Volume=        0.223 af
Outflow     =     0.19 cfs @  14.32 hrs,  Volume=        0.183 af,  Atten= 94%,  Lag= 133.0 min
Discarded   =     0.13 cfs @  14.32 hrs,  Volume=        0.170 af
Primary     =     0.05 cfs @  14.32 hrs,  Volume=        0.013 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 47.22' @ 14.32 hrs   Surf.Area= 2,414 sf   Storage= 5,691 cf

Plug-Flow detention time= 414.0 min calculated for 0.183 af (82% of inflow)
Center-of-Mass det. time= 345.7 min ( 1,168.1 - 822.4 )

Volume      Invert    Avail.Storage  Storage Description
  #1        43.00'        11,053 cf  Custom Stage Data (Irregular)Listed below (Recalc)

Elevation      Surf.Area      Perim.         Inc.Store        Cum.Store        Wet.Area
  (feet)         (sq-ft)      (feet)      (cubic-feet)     (cubic-feet)         (sq-ft)
   43.00             510        93.0                 0                0             510
   44.00             840       118.0               668              668             943
   45.00           1,245       141.0             1,036            1,704           1,434
   46.00           1,725       164.0             1,478            3,183           2,013
   47.00           2,280       188.0             1,996            5,179           2,708
   48.00           2,925       212.0             2,596            7,774           3,498
   49.00           3,645       237.0             3,278           11,053           4,419

Device  Routing          Invert Outlet Devices
  #1    Primary          43.00' 12.0"  Round RCP_Round  12"
                                L= 60.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                Inlet / Outlet Invert= 43.00' / 42.00'   S= 0.0167 '/'   Cc= 0.900
                                n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
  #2    Device 1         47.00' 2.0" W x 12.0" H Vert. Orifice/Grate  C= 0.600
  #3    Device 1         48.00' 12.0" W x 6.0" H Vert. Orifice/Grate  C= 0.600
  #4    Primary          48.50' 5.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                Head (feet) 0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                2.50  3.00  3.50  4.00  4.50  5.00  5.50
```

			Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#5	Discarded	43.00'	**2.410 in/hr Exfiltration over Surface area**

```
Discarded OutFlow Max=0.13 cfs @ 14.32 hrs  HW=47.22'   (Free Discharge)
└─5=Exfiltration (Exfiltration Controls 0.13 cfs)

Primary OutFlow Max=0.05 cfs @ 14.32 hrs  HW=47.22'   (Free Discharge)
├─1=RCP_Round 12" (Passes 0.05 cfs of 7.04 cfs potential flow)
│ ├─2=Orifice/Grate (Orifice Controls 0.05 cfs @ 1.50 fps)
│ └─3=Orifice/Grate ( Controls 0.00 cfs)
└─4=Broad-Crested Rectangular Weir( Controls 0.00 cfs)
```

Summary for Pond P3: Pond 3

Inflow Area = 0.714 ac, 63.45% Impervious, Inflow Depth = 2.35" for 2 yr storm event
Inflow = 2.02 cfs @ 12.07 hrs, Volume= 0.140 af
Outflow = 0.08 cfs @ 15.29 hrs, Volume= 0.039 af, Atten= 96%, Lag= 193.0 min
Primary = 0.08 cfs @ 15.29 hrs, Volume= 0.039 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 39.33' @ 15.29 hrs Surf.Area= 3,471 sf Storage= 4,670 cf

Plug-Flow detention time= 444.0 min calculated for 0.039 af (28% of inflow)
Center-of-Mass det. time= 303.8 min (1,107.4 - 803.6)

Volume	Invert	Avail.Storage	Storage Description
#1	37.50'	7,234 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
37.50	1,708	226.0	0	0	1,708
38.00	2,140	280.0	960	960	3,886
39.00	3,114	312.0	2,612	3,572	5,422
40.00	4,240	366.0	3,663	7,234	8,355

Device	Routing	Invert	Outlet Devices
#1	Primary	38.00'	**12.0" Round RCP_Round 12"** L= 25.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 38.00' / 37.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	39.25'	**12.0" W x 3.0" H Vert. Orifice/Grate** C= 0.600
#3	Primary	39.60'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.08 cfs @ 15.29 hrs HW=39.33' (Free Discharge)
1=RCP_Round 12" (Passes 0.08 cfs of 3.45 cfs potential flow)
2=Orifice/Grate (Orifice Controls 0.08 cfs @ 0.93 fps)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond SW: Swale

Inflow Area = 1.630 ac, 73.96% Impervious, Inflow Depth = 1.77" for 2 yr storm event
Inflow = 3.51 cfs @ 12.08 hrs, Volume= 0.241 af
Outflow = 3.31 cfs @ 12.10 hrs, Volume= 0.241 af, Atten= 6%, Lag= 1.6 min
Discarded = 0.04 cfs @ 12.10 hrs, Volume= 0.018 af
Primary = 3.27 cfs @ 12.10 hrs, Volume= 0.223 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 50.19' @ 12.10 hrs Surf.Area= 782 sf Storage= 393 cf

Plug-Flow detention time= 5.5 min calculated for 0.241 af (100% of inflow)
Center-of-Mass det. time= 5.5 min (834.7 - 829.2)

Volume	Invert	Avail.Storage	Storage Description
#1	49.00'	1,290 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	16	22.0	0	0	16
50.00	653	203.0	257	257	3,259
51.00	1,466	293.0	1,032	1,290	6,820

Device	Routing	Invert	Outlet Devices
#1	Primary	49.40'	**24.0" Round Culvert** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 49.40' / 48.90' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 3.14 sf
#2	Discarded	49.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.10 hrs HW=50.19' (Free Discharge)
2=Exfiltration (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=3.26 cfs @ 12.10 hrs HW=50.19' (Free Discharge)
1=Culvert (Barrel Controls 3.26 cfs @ 4.20 fps)

Summary for Link DP1: Wetland 1

Inflow Area = 8.532 ac, 46.36% Impervious, Inflow Depth = 1.15" for 2 yr storm event
Inflow = 10.44 cfs @ 12.08 hrs, Volume= 0.821 af
Primary = 10.44 cfs @ 12.08 hrs, Volume= 0.821 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

10-Year Storm Event- Proposed

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1PR: Parking Lot East Runoff Area=43,318 sf 72.89% Impervious Runoff Depth=2.95"
Flow Length=285' Tc=5.0 min CN=83 Runoff=3.55 cfs 0.244 af

Subcatchment2PR: West Drainage Area Runoff Area=73,919 sf 0.85% Impervious Runoff Depth=1.93"
Flow Length=720' Tc=7.4 min CN=71 Runoff=3.59 cfs 0.273 af

Subcatchment3EX: Self Storage Runoff Area=152,330 sf 44.55% Impervious Runoff Depth=3.33"
Flow Length=715' Tc=5.0 min CN=87 Runoff=13.94 cfs 0.971 af

Subcatchment4PR: Entry Road Runoff Area=0.714 ac 63.45% Impervious Runoff Depth=3.64"
Flow Length=515' Tc=5.0 min CN=90 Runoff=3.05 cfs 0.216 af

Subcatchment5PR: Parking Lot West Runoff Area=70,993 sf 73.96% Impervious Runoff Depth=2.95"
Flow Length=430' Tc=5.0 min CN=83 Runoff=5.82 cfs 0.400 af

Pond P1: Pond 1 Peak Elev=50.04' Storage=4,619 cf Inflow=3.55 cfs 0.244 af
Discarded=0.16 cfs 0.169 af Primary=0.23 cfs 0.075 af Outflow=0.39 cfs 0.244 af

Pond P2: Pond 2 Peak Elev=48.12' Storage=8,140 cf Inflow=5.41 cfs 0.379 af
Discarded=0.17 cfs 0.195 af Primary=0.76 cfs 0.132 af Outflow=0.92 cfs 0.327 af

Pond P3: Pond 3 Peak Elev=39.55' Storage=5,430 cf Inflow=3.05 cfs 0.216 af
Outflow=0.48 cfs 0.116 af

Pond SW: Swale Peak Elev=50.46' Storage=631 cf Inflow=5.82 cfs 0.400 af
Discarded=0.06 cfs 0.022 af Primary=5.41 cfs 0.379 af Outflow=5.47 cfs 0.400 af

Link DP1: Wetland 1 Inflow=17.31 cfs 1.567 af
Primary=17.31 cfs 1.567 af

Total Runoff Area = 8.532 ac Runoff Volume = 2.105 af Average Runoff Depth = 2.96"
53.64% Pervious = 4.577 ac 46.36% Impervious = 3.956 ac

Summary for Subcatchment 1PR: Parking Lot East

Runoff = 3.55 cfs @ 12.07 hrs, Volume= 0.244 af, Depth= 2.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
31,576	98	Paved parking, HSG A
11,096	39	>75% Grass cover, Good, HSG A
646	80	>75% Grass cover, Good, HSG D
43,318	83	Weighted Average
11,742		27.11% Pervious Area
31,576		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0182	1.19		**Sheet Flow, grass** Smooth surfaces n= 0.011 P2= 3.40"
0.7	155	0.0316	3.61		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.5	55	0.0087	1.89		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.1	25	0.0311	8.00	6.28	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
3.0					**Direct Entry, <5 min adjustment**
5.0	285	Total			

Summary for Subcatchment 2PR: West Drainage Area (near cell tower)

Runoff = 3.59 cfs @ 12.11 hrs, Volume= 0.273 af, Depth= 1.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
804	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Roofs, HSG C
9,557	39	>75% Grass cover, Good, HSG A
48,441	74	>75% Grass cover, Good, HSG C
9,442	80	>75% Grass cover, Good, HSG D
73,919	71	Weighted Average
73,293		99.15% Pervious Area
626		0.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 13.94 cfs @ 12.07 hrs, Volume= 0.971 af, Depth= 3.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
566	85	Gravel roads, HSG B
13,112	89	Gravel roads, HSG C
21,911	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,682	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
8,625	39	>75% Grass cover, Good, HSG A
6,360	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
14,288	80	>75% Grass cover, Good, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
152,330	87	Weighted Average
84,464		55.45% Pervious Area
67,866		44.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, storage lot** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4PR: Entry Road

Runoff = 3.05 cfs @ 12.07 hrs, Volume= 0.216 af, Depth= 3.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (ac)	CN	Description
0.225	98	Paved parking, HSG A
0.019	98	Paved parking, HSG B
0.209	98	Paved parking, HSG D
0.019	39	>75% Grass cover, Good, HSG A
0.242	80	>75% Grass cover, Good, HSG D
0.714	90	Weighted Average
0.261		36.55% Pervious Area
0.453		63.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0320	1.49		**Sheet Flow, Lot (sheet)** Smooth surfaces n= 0.011 P2= 3.40"
0.4	85	0.0320	3.63		**Shallow Concentrated Flow, Lot (SCF)** Paved Kv= 20.3 fps
0.3	50	0.0140	2.40		**Shallow Concentrated Flow, along curb** Paved Kv= 20.3 fps
0.2	60	0.0500	4.54		**Shallow Concentrated Flow, Driveway 5%** Paved Kv= 20.3 fps
0.0	10	0.3300	4.02		**Shallow Concentrated Flow, swale slope** Short Grass Pasture Kv= 7.0 fps
1.3	240	0.0450	3.18		**Shallow Concentrated Flow, swale** Grassed Waterway Kv= 15.0 fps
0.1	20	0.0250	2.37		**Shallow Concentrated Flow, end of swale** Grassed Waterway Kv= 15.0 fps
2.1					**Direct Entry, <5 min adjustment**
5.0	515	Total			

Summary for Subcatchment 5PR: Parking Lot West

Runoff = 5.82 cfs @ 12.07 hrs, Volume= 0.400 af, Depth= 2.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 yr storm Rainfall=4.75"

Area (sf)	CN	Description
48,651	98	Paved parking, HSG A
3,305	98	Roofs, HSG C
552	98	Roofs, HSG D
18,305	39	>75% Grass cover, Good, HSG A
180	74	>75% Grass cover, Good, HSG C
70,993	83	Weighted Average
18,485		26.04% Pervious Area
52,508		73.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0	50	0.0080	0.86		**Sheet Flow, Impervious** Smooth surfaces n= 0.011 P2= 3.40"
0.9	180	0.0300	3.52		**Shallow Concentrated Flow, impervious parking lot** Paved Kv= 20.3 fps
0.1	20	0.3300	4.02		**Shallow Concentrated Flow, 3:1 ditch slope** Short Grass Pasture Kv= 7.0 fps
0.6	80	0.0250	2.37		**Shallow Concentrated Flow, ditch** Grassed Waterway Kv= 15.0 fps
0.4	100	0.0100	4.54	3.56	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
2.0					**Direct Entry, <5 min adjustment**
5.0	430	Total			

Summary for Pond P1: Pond 1

Inflow Area = 0.994 ac, 72.89% Impervious, Inflow Depth = 2.95" for 10 yr storm event
Inflow = 3.55 cfs @ 12.07 hrs, Volume= 0.244 af
Outflow = 0.39 cfs @ 12.81 hrs, Volume= 0.244 af, Atten= 89%, Lag= 44.4 min
Discarded = 0.16 cfs @ 12.81 hrs, Volume= 0.169 af
Primary = 0.23 cfs @ 12.81 hrs, Volume= 0.075 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 50.04' @ 12.81 hrs Surf.Area= 2,898 sf Storage= 4,619 cf

Plug-Flow detention time= 172.7 min calculated for 0.244 af (100% of inflow)
Center-of-Mass det. time= 172.7 min (987.3 - 814.6)

Volume	Invert	Avail.Storage	Storage Description
#1	48.00'	7,713 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
48.00	1,670	180.0	0	0	1,670
49.00	2,240	199.0	1,948	1,948	2,274
50.00	2,870	219.0	2,549	4,497	2,971
51.00	3,575	241.0	3,216	7,713	3,808

Device	Routing	Invert	Outlet Devices
#1	Primary	48.00'	**15.0" Round RCP_Round 15"** L= 100.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 48.00' / 47.00' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.23 sf
#2	Device 1	49.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	50.25'	**12.0" W x 6.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	50.75'	**5.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50

			Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#5	Discarded	48.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.16 cfs @ 12.81 hrs HW=50.04' (Free Discharge)
↑—**5=Exfiltration** (Exfiltration Controls 0.16 cfs)

Primary OutFlow Max=0.23 cfs @ 12.81 hrs HW=50.04' (Free Discharge)
↑—**1=RCP_Round 15"** (Passes 0.23 cfs of 6.74 cfs potential flow)
  ↑—**2=Orifice/Grate** (Orifice Controls 0.23 cfs @ 4.61 fps)
  └—**3=Orifice/Grate** (Controls 0.00 cfs)
└—**4=Broad-Crested Rectangular Weir**(Controls 0.00 cfs)

Summary for Pond P2: Pond 2

Inflow Area = 1.630 ac, 73.96% Impervious, Inflow Depth = 2.79" for 10 yr storm event
Inflow = 5.41 cfs @ 12.10 hrs, Volume= 0.379 af
Outflow = 0.92 cfs @ 12.58 hrs, Volume= 0.327 af, Atten= 83%, Lag= 28.7 min
Discarded = 0.17 cfs @ 12.58 hrs, Volume= 0.195 af
Primary = 0.76 cfs @ 12.58 hrs, Volume= 0.132 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 48.12' @ 12.58 hrs Surf.Area= 3,009 sf Storage= 8,140 cf

Plug-Flow detention time= 283.5 min calculated for 0.327 af (86% of inflow)
Center-of-Mass det. time= 225.2 min (1,037.0 - 811.7)

Volume	Invert	Avail.Storage	Storage Description
#1	43.00'	11,053 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
43.00	510	93.0	0	0	510
44.00	840	118.0	668	668	943
45.00	1,245	141.0	1,036	1,704	1,434
46.00	1,725	164.0	1,478	3,183	2,013
47.00	2,280	188.0	1,996	5,179	2,708
48.00	2,925	212.0	2,596	7,774	3,498
49.00	3,645	237.0	3,278	11,053	4,419

Device	Routing	Invert	Outlet Devices
#1	Primary	43.00'	**12.0" Round RCP_Round 12"** L= 60.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 43.00' / 42.00' S= 0.0167 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	47.00'	**2.0" W x 12.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	48.00'	**12.0" W x 6.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	48.50'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50

```
                              Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                              2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32
   #5     Discarded    43.00'  2.410 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.17 cfs @ 12.58 hrs  HW=48.12'   (Free Discharge)
└─5=Exfiltration  (Exfiltration Controls 0.17 cfs)

Primary OutFlow  Max=0.75 cfs @ 12.58 hrs  HW=48.12'   (Free Discharge)
├─1=RCP_Round  12"  (Passes 0.75 cfs of 7.76 cfs potential flow)
│ ├─2=Orifice/Grate  (Orifice Controls 0.61 cfs @ 3.68 fps)
│ └─3=Orifice/Grate  (Orifice Controls 0.14 cfs @ 1.13 fps)
└─4=Broad-Crested Rectangular Weir( Controls 0.00 cfs)
```

Summary for Pond P3: Pond 3

```
Inflow Area =       0.714 ac,  63.45% Impervious,  Inflow Depth =   3.64"    for  10 yr storm event
Inflow      =       3.05 cfs @   12.07 hrs,  Volume=          0.216 af
Outflow     =       0.48 cfs @   12.54 hrs,  Volume=          0.116 af,  Atten= 84%,  Lag= 28.1 min
Primary     =       0.48 cfs @   12.54 hrs,  Volume=          0.116 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 39.55' @ 12.54 hrs   Surf.Area= 3,707 sf   Storage= 5,430 cf

Plug-Flow detention time= 262.0 min calculated for 0.116 af (53% of inflow)
Center-of-Mass det. time= 152.7 min ( 944.3 - 791.5 )

Volume        Invert     Avail.Storage   Storage Description
   #1         37.50'          7,234 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation        Surf.Area      Perim.         Inc.Store          Cum.Store          Wet.Area
    (feet)          (sq-ft)      (feet)      (cubic-feet)       (cubic-feet)           (sq-ft)
     37.50            1,708       226.0                 0                  0             1,708
     38.00            2,140       280.0               960                960             3,886
     39.00            3,114       312.0             2,612              3,572             5,422
     40.00            4,240       366.0             3,663              7,234             8,355

Device   Routing          Invert   Outlet Devices
   #1    Primary          38.00'   12.0"  Round RCP_Round  12"
                                   L= 25.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                   Inlet / Outlet Invert= 38.00' / 37.50'   S= 0.0200 '/'   Cc= 0.900
                                   n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
   #2    Device 1         39.25'   12.0" W x 3.0" H Vert. Orifice/Grate  C= 0.600
   #3    Primary          39.60'   5.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                   2.50  3.00  3.50  4.00  4.50  5.00  5.50
                                   Coef. (English)  2.38  2.54  2.69  2.68  2.67  2.67  2.65  2.66  2.66
                                   2.68  2.72  2.73  2.76  2.79  2.88  3.07  3.32
```

Primary OutFlow Max=0.48 cfs @ 12.54 hrs HW=39.55' (Free Discharge)
1=RCP_Round 12" (Passes 0.48 cfs of 3.87 cfs potential flow)
  2=Orifice/Grate (Orifice Controls 0.48 cfs @ 1.94 fps)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond SW: Swale

Inflow Area = 1.630 ac, 73.96% Impervious, Inflow Depth = 2.95" for 10 yr storm event
Inflow = 5.82 cfs @ 12.07 hrs, Volume= 0.400 af
Outflow = 5.47 cfs @ 12.10 hrs, Volume= 0.400 af, Atten= 6%, Lag= 1.7 min
Discarded = 0.06 cfs @ 12.10 hrs, Volume= 0.022 af
Primary = 5.41 cfs @ 12.10 hrs, Volume= 0.379 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 50.46' @ 12.10 hrs Surf.Area= 986 sf Storage= 631 cf

Plug-Flow detention time= 4.3 min calculated for 0.400 af (100% of inflow)
Center-of-Mass det. time= 4.3 min (818.9 - 814.6)

Volume	Invert	Avail.Storage	Storage Description
#1	49.00'	1,290 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	16	22.0	0	0	16
50.00	653	203.0	257	257	3,259
51.00	1,466	293.0	1,032	1,290	6,820

Device	Routing	Invert	Outlet Devices
#1	Primary	49.40'	**24.0" Round Culvert** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 49.40' / 48.90' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 3.14 sf
#2	Discarded	49.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.05 cfs @ 12.10 hrs HW=50.46' (Free Discharge)
2=Exfiltration (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=5.41 cfs @ 12.10 hrs HW=50.46' (Free Discharge)
1=Culvert (Barrel Controls 5.41 cfs @ 4.66 fps)

Summary for Link DP1: Wetland 1

Inflow Area = 8.532 ac, 46.36% Impervious, Inflow Depth = 2.20" for 10 yr storm event
Inflow = 17.31 cfs @ 12.08 hrs, Volume= 1.567 af
Primary = 17.31 cfs @ 12.08 hrs, Volume= 1.567 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

100-Year Storm Event – Proposed

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1PR: Parking Lot East Runoff Area=43,318 sf 72.89% Impervious Runoff Depth=5.03"
Flow Length=285' Tc=5.0 min CN=83 Runoff=5.96 cfs 0.417 af

Subcatchment2PR: West Drainage Area Runoff Area=73,919 sf 0.85% Impervious Runoff Depth=3.72"
Flow Length=720' Tc=7.4 min CN=71 Runoff=7.06 cfs 0.527 af

Subcatchment3EX: Self Storage Runoff Area=152,330 sf 44.55% Impervious Runoff Depth=5.48"
Flow Length=715' Tc=5.0 min CN=87 Runoff=22.40 cfs 1.597 af

Subcatchment4PR: Entry Road Runoff Area=0.714 ac 63.45% Impervious Runoff Depth=5.82"
Flow Length=515' Tc=5.0 min CN=90 Runoff=4.76 cfs 0.346 af

Subcatchment5PR: Parking Lot West Runoff Area=70,993 sf 73.96% Impervious Runoff Depth=5.03"
Flow Length=430' Tc=5.0 min CN=83 Runoff=9.76 cfs 0.683 af

Pond P1: Pond 1 Peak Elev=50.80' Storage=7,007 cf Inflow=5.96 cfs 0.417 af
Discarded=0.19 cfs 0.212 af Primary=1.70 cfs 0.205 af Outflow=1.89 cfs 0.417 af

Pond P2: Pond 2 Peak Elev=48.84' Storage=10,485 cf Inflow=8.98 cfs 0.656 af
Discarded=0.20 cfs 0.219 af Primary=5.26 cfs 0.373 af Outflow=5.46 cfs 0.593 af

Pond P3: Pond 3 Peak Elev=39.88' Storage=6,714 cf Inflow=4.76 cfs 0.346 af
Outflow=2.61 cfs 0.246 af

Pond SW: Swale Peak Elev=50.85' Storage=1,075 cf Inflow=9.76 cfs 0.683 af
Discarded=0.07 cfs 0.027 af Primary=8.98 cfs 0.656 af Outflow=9.05 cfs 0.683 af

Link DP1: Wetland 1 Inflow=31.84 cfs 2.947 af
Primary=31.84 cfs 2.947 af

Total Runoff Area = 8.532 ac Runoff Volume = 3.569 af Average Runoff Depth = 5.02"
53.64% Pervious = 4.577 ac 46.36% Impervious = 3.956 ac

Summary for Subcatchment 1PR: Parking Lot East

Runoff = 5.96 cfs @ 12.07 hrs, Volume= 0.417 af, Depth= 5.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
31,576	98	Paved parking, HSG A
11,096	39	>75% Grass cover, Good, HSG A
646	80	>75% Grass cover, Good, HSG D
43,318	83	Weighted Average
11,742		27.11% Pervious Area
31,576		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0182	1.19		**Sheet Flow, grass** Smooth surfaces n= 0.011 P2= 3.40"
0.7	155	0.0316	3.61		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.5	55	0.0087	1.89		**Shallow Concentrated Flow, Paved** Paved Kv= 20.3 fps
0.1	25	0.0311	8.00	6.28	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
3.0					**Direct Entry, <5 min adjustment**
5.0	285	Total			

Summary for Subcatchment 2PR: West Drainage Area (near cell tower)

Runoff = 7.06 cfs @ 12.11 hrs, Volume= 0.527 af, Depth= 3.72"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
804	76	Gravel roads, HSG A
5,049	89	Gravel roads, HSG C
626	98	Roofs, HSG C
9,557	39	>75% Grass cover, Good, HSG A
48,441	74	>75% Grass cover, Good, HSG C
9,442	80	>75% Grass cover, Good, HSG D
73,919	71	Weighted Average
73,293		99.15% Pervious Area
626		0.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	50	0.0480	0.22		**Sheet Flow, Grass** Grass: Short n= 0.150 P2= 3.40"
2.0	180	0.0470	1.52		**Shallow Concentrated Flow, Grass 4.7%** Short Grass Pasture Kv= 7.0 fps
0.1	10	0.0400	3.22		**Shallow Concentrated Flow, Gravel Drive** Unpaved Kv= 16.1 fps
0.5	30	0.0170	0.91		**Shallow Concentrated Flow, Grass 1.7%** Short Grass Pasture Kv= 7.0 fps
0.2	25	0.0080	1.82		**Shallow Concentrated Flow, Paved 0.8%** Paved Kv= 20.3 fps
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
7.4	720	Total			

Summary for Subcatchment 3EX: Self Storage Drainage Area

Runoff = 22.40 cfs @ 12.07 hrs, Volume= 1.597 af, Depth= 5.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
16,640	76	Gravel roads, HSG A
566	85	Gravel roads, HSG B
13,112	89	Gravel roads, HSG C
21,911	91	Gravel roads, HSG D
1,002	98	Paved parking, HSG A
15,682	98	Paved parking, HSG B
26,397	98	Paved parking, HSG C
8,625	39	>75% Grass cover, Good, HSG A
6,360	61	>75% Grass cover, Good, HSG B
2,962	74	>75% Grass cover, Good, HSG C
14,288	80	>75% Grass cover, Good, HSG D
4,835	98	Roofs, HSG B
19,950	98	Roofs, HSG C
152,330	87	Weighted Average
84,464		55.45% Pervious Area
67,866		44.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.94		**Sheet Flow, storage lot** Smooth surfaces n= 0.011 P2= 3.40"
0.6	115	0.0050	3.21	2.52	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
0.4	125	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.5	320	0.0200	10.18	31.99	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
0.3	105	0.0050	5.09	16.00	**Pipe Channel, RCP_Round 24"** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.013 Concrete pipe, bends & connections
2.3					**Direct Entry, <5 min adjustment**
5.0	715	Total			

Summary for Subcatchment 4PR: Entry Road

Runoff = 4.76 cfs @ 12.07 hrs, Volume= 0.346 af, Depth= 5.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (ac)	CN	Description
0.225	98	Paved parking, HSG A
0.019	98	Paved parking, HSG B
0.209	98	Paved parking, HSG D
0.019	39	>75% Grass cover, Good, HSG A
0.242	80	>75% Grass cover, Good, HSG D
0.714	90	Weighted Average
0.261		36.55% Pervious Area
0.453		63.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0320	1.49		**Sheet Flow, Lot (sheet)** Smooth surfaces n= 0.011 P2= 3.40"
0.4	85	0.0320	3.63		**Shallow Concentrated Flow, Lot (SCF)** Paved Kv= 20.3 fps
0.3	50	0.0140	2.40		**Shallow Concentrated Flow, along curb** Paved Kv= 20.3 fps
0.2	60	0.0500	4.54		**Shallow Concentrated Flow, Driveway 5%** Paved Kv= 20.3 fps
0.0	10	0.3300	4.02		**Shallow Concentrated Flow, swale slope** Short Grass Pasture Kv= 7.0 fps
1.3	240	0.0450	3.18		**Shallow Concentrated Flow, swale** Grassed Waterway Kv= 15.0 fps
0.1	20	0.0250	2.37		**Shallow Concentrated Flow, end of swale** Grassed Waterway Kv= 15.0 fps
2.1					**Direct Entry, <5 min adjustment**
5.0	515	Total			

Summary for Subcatchment 5PR: Parking Lot West

Runoff = 9.76 cfs @ 12.07 hrs, Volume= 0.683 af, Depth= 5.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 yr storm Rainfall=7.00"

Area (sf)	CN	Description
48,651	98	Paved parking, HSG A
3,305	98	Roofs, HSG C
552	98	Roofs, HSG D
18,305	39	>75% Grass cover, Good, HSG A
180	74	>75% Grass cover, Good, HSG C
70,993	83	Weighted Average
18,485		26.04% Pervious Area
52,508		73.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0	50	0.0080	0.86		**Sheet Flow, Impervious** Smooth surfaces n= 0.011 P2= 3.40"
0.9	180	0.0300	3.52		**Shallow Concentrated Flow, impervious parking lot** Paved Kv= 20.3 fps
0.1	20	0.3300	4.02		**Shallow Concentrated Flow, 3:1 ditch slope** Short Grass Pasture Kv= 7.0 fps
0.6	80	0.0250	2.37		**Shallow Concentrated Flow, ditch** Grassed Waterway Kv= 15.0 fps
0.4	100	0.0100	4.54	3.56	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Concrete pipe, bends & connections
2.0					**Direct Entry, <5 min adjustment**
5.0	430	Total			

Summary for Pond P1: Pond 1

Inflow Area = 0.994 ac, 72.89% Impervious, Inflow Depth = 5.03" for 100 yr storm event
Inflow = 5.96 cfs @ 12.07 hrs, Volume= 0.417 af
Outflow = 1.89 cfs @ 12.37 hrs, Volume= 0.417 af, Atten= 68%, Lag= 17.8 min
Discarded = 0.19 cfs @ 12.37 hrs, Volume= 0.212 af
Primary = 1.70 cfs @ 12.37 hrs, Volume= 0.205 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 50.80' @ 12.37 hrs Surf.Area= 3,427 sf Storage= 7,007 cf

Plug-Flow detention time= 151.0 min calculated for 0.417 af (100% of inflow)
Center-of-Mass det. time= 151.0 min (950.5 - 799.5)

Volume	Invert	Avail.Storage	Storage Description
#1	48.00'	7,713 cf	**Custom Stage Data (Irregular)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
48.00	1,670	180.0	0	0	1,670
49.00	2,240	199.0	1,948	1,948	2,274
50.00	2,870	219.0	2,549	4,497	2,971
51.00	3,575	241.0	3,216	7,713	3,808

Device	Routing	Invert	Outlet Devices
#1	Primary	48.00'	**15.0" Round RCP_Round 15"** L= 100.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 48.00' / 47.00' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.23 sf
#2	Device 1	49.00'	**3.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	50.25'	**12.0" W x 6.0" H Vert. Orifice/Grate** C= 0.600
#4	Primary	50.75'	**5.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50

```
                             Coef. (English)  2.34  2.50  2.70  2.68  2.68  2.66  2.65  2.65  2.65
                             2.65  2.67  2.66  2.68  2.70  2.74  2.79  2.88
  #5     Discarded     48.00'  2.410 in/hr Exfiltration over Surface area

Discarded OutFlow  Max=0.19 cfs @ 12.37 hrs  HW=50.80'   (Free Discharge)
└─5=Exfiltration  (Exfiltration Controls 0.19 cfs)

Primary OutFlow  Max=1.70 cfs @ 12.37 hrs  HW=50.80'   (Free Discharge)
├─1=RCP_Round 15"  (Passes 1.58 cfs of 8.03 cfs potential flow)
│ ├─2=Orifice/Grate  (Orifice Controls 0.31 cfs @ 6.23 fps)
│ └─3=Orifice/Grate  (Orifice Controls 1.27 cfs @ 2.54 fps)
└─4=Broad-Crested Rectangular Weir (Weir Controls 0.13 cfs @ 0.52 fps)
```

Summary for Pond P2: Pond 2

```
Inflow Area =       1.630 ac,  73.96% Impervious,  Inflow Depth =   4.83"    for  100 yr storm event
Inflow      =       8.98 cfs @   12.10 hrs,  Volume=          0.656 af
Outflow     =       5.46 cfs @   12.22 hrs,  Volume=          0.593 af,  Atten= 39%,  Lag= 6.9 min
Discarded   =       0.20 cfs @   12.22 hrs,  Volume=          0.219 af
Primary     =       5.26 cfs @   12.22 hrs,  Volume=          0.373 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 48.84' @ 12.22 hrs   Surf.Area= 3,526 sf   Storage= 10,485 cf

Plug-Flow detention time= 185.1 min calculated for 0.592 af (90% of inflow)
Center-of-Mass det. time= 138.9 min ( 938.0 - 799.1 )

Volume      Invert    Avail.Storage   Storage Description
  #1        43.00'        11,053 cf   Custom Stage Data (Irregular)Listed below (Recalc)

 Elevation       Surf.Area      Perim.         Inc.Store        Cum.Store          Wet.Area
    (feet)         (sq-ft)      (feet)      (cubic-feet)     (cubic-feet)           (sq-ft)
     43.00             510        93.0                 0                0               510
     44.00             840       118.0               668              668               943
     45.00           1,245       141.0             1,036            1,704             1,434
     46.00           1,725       164.0             1,478            3,183             2,013
     47.00           2,280       188.0             1,996            5,179             2,708
     48.00           2,925       212.0             2,596            7,774             3,498
     49.00           3,645       237.0             3,278           11,053             4,419

Device   Routing          Invert   Outlet Devices
  #1     Primary          43.00'   12.0"  Round RCP_Round  12"
                                   L= 60.0'   RCP, sq.cut end projecting,  Ke= 0.500
                                   Inlet / Outlet Invert= 43.00' / 42.00'   S= 0.0167 '/'   Cc= 0.900
                                   n= 0.013  Concrete pipe, bends & connections,  Flow Area= 0.79 sf
  #2     Device 1         47.00'   2.0" W x 12.0" H Vert. Orifice/Grate  C= 0.600
  #3     Device 1         48.00'   12.0" W x 6.0" H Vert. Orifice/Grate  C= 0.600
  #4     Primary          48.50'   5.0' long  x 4.0' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60  1.80  2.00
                                   2.50  3.00  3.50  4.00  4.50  5.00  5.50
```

			Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#5	Discarded	43.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.20 cfs @ 12.22 hrs HW=48.84' (Free Discharge)
└─**5=Exfiltration** (Exfiltration Controls 0.20 cfs)

Primary OutFlow Max=5.25 cfs @ 12.22 hrs HW=48.84' (Free Discharge)
├─**1=RCP_Round 12"** (Passes 2.76 cfs of 8.28 cfs potential flow)
│ ├─**2=Orifice/Grate** (Orifice Controls 0.92 cfs @ 5.54 fps)
│ └─**3=Orifice/Grate** (Orifice Controls 1.84 cfs @ 3.67 fps)
└─**4=Broad-Crested Rectangular Weir** (Weir Controls 2.49 cfs @ 1.46 fps)

Summary for Pond P3: Pond 3

Inflow Area = 0.714 ac, 63.45% Impervious, Inflow Depth = 5.82" for 100 yr storm event
Inflow = 4.76 cfs @ 12.07 hrs, Volume= 0.346 af
Outflow = 2.61 cfs @ 12.18 hrs, Volume= 0.246 af, Atten= 45%, Lag= 6.6 min
Primary = 2.61 cfs @ 12.18 hrs, Volume= 0.246 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 39.88' @ 12.18 hrs Surf.Area= 4,090 sf Storage= 6,714 cf

Plug-Flow detention time= 191.5 min calculated for 0.246 af (71% of inflow)
Center-of-Mass det. time= 101.1 min (880.0 - 779.0)

Volume	Invert	Avail.Storage	Storage Description
#1	37.50'	7,234 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
37.50	1,708	226.0	0	0	1,708
38.00	2,140	280.0	960	960	3,886
39.00	3,114	312.0	2,612	3,572	5,422
40.00	4,240	366.0	3,663	7,234	8,355

Device	Routing	Invert	Outlet Devices
#1	Primary	38.00'	**12.0" Round RCP_Round 12"** L= 25.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 38.00' / 37.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	39.25'	**12.0" W x 3.0" H Vert. Orifice/Grate** C= 0.600
#3	Primary	39.60'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=2.61 cfs @ 12.18 hrs HW=39.87' (Free Discharge)
↑—**1=RCP_Round 12"** (Passes 0.85 cfs of 4.43 cfs potential flow)
  ↑—**2=Orifice/Grate** (Orifice Controls 0.85 cfs @ 3.40 fps)
└—**3=Broad-Crested Rectangular Weir** (Weir Controls 1.76 cfs @ 1.28 fps)

Summary for Pond SW: Swale

Inflow Area = 1.630 ac, 73.96% Impervious, Inflow Depth = 5.03" for 100 yr storm event
Inflow = 9.76 cfs @ 12.07 hrs, Volume= 0.683 af
Outflow = 9.05 cfs @ 12.10 hrs, Volume= 0.683 af, Atten= 7%, Lag= 1.8 min
Discarded = 0.07 cfs @ 12.10 hrs, Volume= 0.027 af
Primary = 8.98 cfs @ 12.10 hrs, Volume= 0.656 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 50.85' @ 12.10 hrs Surf.Area= 1,320 sf Storage= 1,075 cf

Plug-Flow detention time= 3.4 min calculated for 0.683 af (100% of inflow)
Center-of-Mass det. time= 3.5 min (803.0 - 799.5)

Volume	Invert	Avail.Storage	Storage Description
#1	49.00'	1,290 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	16	22.0	0	0	16
50.00	653	203.0	257	257	3,259
51.00	1,466	293.0	1,032	1,290	6,820

Device	Routing	Invert	Outlet Devices
#1	Primary	49.40'	**24.0" Round Culvert** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 49.40' / 48.90' S= 0.0100 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 3.14 sf
#2	Discarded	49.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.07 cfs @ 12.10 hrs HW=50.84' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.07 cfs)

Primary OutFlow Max=8.97 cfs @ 12.10 hrs HW=50.84' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 8.97 cfs @ 5.16 fps)

Summary for Link DP1: Wetland 1

Inflow Area = 8.532 ac, 46.36% Impervious, Inflow Depth = 4.14" for 100 yr storm event
Inflow = 31.84 cfs @ 12.09 hrs, Volume= 2.947 af
Primary = 31.84 cfs @ 12.09 hrs, Volume= 2.947 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Appendix C
Standard 3 Computations and Supporting Information

Soil Evaluation and Analysis

Hydrologic Soil Group—Bristol County, Massachusetts, Southern Part
(Freetown Station)

Map Scale: 1:2,200 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

☐ Area of Interest (AOI)

Soils

☐ Soil Map Units

Soil Ratings

🟫 A

🟩 A/D

🟪 B

🟦 B/D

🟨 C

🟦 C/D

🟪 D

⬜ Not rated or not available

Political Features

● Cities

Water Features

〰 Streams and Canals

Transportation

┼┼┼ Rails

〰 Interstate Highways

〰 US Routes

〰 Major Roads

〰 Local Roads

MAP INFORMATION

Map Scale: 1:2,200 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bristol County, Massachusetts, Southern Part
Survey Area Data: Version 6, Jul 23, 2010

Date(s) aerial images were photographed: 8/14/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Southern Part (MA603)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
39A	Scarboro muck, 0 to 1 percent slopes	D	2.4	19.9%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	C	3.2	26.4%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	0.3	2.7%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	5.3	43.1%
260A	Sudbury fine sandy loam, 0 to 3 percent slopes	B	0.0	0.1%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	B	1.0	7.9%
Totals for Area of Interest			**12.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Required and Provided Recharge Volumes

Recharge Calculations

Project Name:	**Freetown Station**	**Proj. No.:**	10111.00
Project Location:	**Freetown, MA**	**Date:**	30-Apr-12
		Calculated by:	PAC
		Checked by:	

Proposed Impervious Surface Summary

Net Proposed Impervious Areas by Hydrologic Soil Group (HSG) in acres

Subcatchment	HSG A	HSG B	HSG C	HSG D	Total Area
2	0.0	0.0	0.0	0.0	0.0
3	0.7	0.0	0.0	0.0	0.7
4	0.2	0.0	0.0	0.2	0.5
5	1.1	0.0	0.1	0.0	1.2
3EX	0.0	0.0	0.0	0.0	0.0
TOTAL	**2.1**	**0.0**	**0.1**	**0.2**	**2.4**

Required Recharge Volume (Cubic Feet)

HSG	Area (acres)	Recharge Depth * (in.)	Volume (c.f.)
A	2.1	0.60	4,502
B	0.0	0.35	24
C	0.1	0.25	69
D	0.2	0.10	81
TOTAL			**4,676**

* Per 2008 Massachusetts DEP Recharge Requirement

Provided Recharge Volume (Cubic Feet)

Infiltration Volumes Provided in Infiltration Basins (below lowest overflow outlet)

Basin P1	1,955	
Basin P2	5,205	
Basin P3	4,403	
Total	**11,563**	c.f.

72-hour Drawdown Analysis

Drawdown Calculations

Project Name:	Freetown Station	**Proj. No.:**	10111.00
		Date:	5/18/2012
Project Location:	Freetown, MA	**Calculated by:**	EJM

Infiltration Basin - 1

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
48.00	1,670	0
49.00	2,240	1,955
TOTAL		**1,955**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 5.8 hours

Infiltration Basin - 2

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
43.00	510	0
44.00	840	675
45.00	1,245	1,718
46.00	1,725	3,203
47.00	2,280	5,205
TOTAL		**5,205**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 50.8 hours

Infiltration Basin - 3

Infiltration volumes provided in basin below lowest outlet.

Basin Volume Below Outlet

Elevation	Area (s.f.)	Incremental Volume (c.f.)
37.50	1,708	0
38.00	2,140	962
39.00	3,114	3,589
39.25	3,396	4,403
TOTAL		**4,403**

Assumptions:

Recharge Rate: 2.41 in/hr

Drawdown Time: 12.8 hours

Appendix D
Standard 4 Computations and Supporting Information

Water Quality Volume Calculations

VHB

Water Quality Volume Calculations

Project Name: **Freetown Station** **Proj. No.:** 10111.00
Project Location: **Freetown, MA** **Date:** 4/30/2012
Calculated by: PAC

Infiltration Basin P1
(runoff from Area 3PR)

Total Impervious Area = 0.72 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	263
Water Quality Volume	0.5	1,316

Provided:

Bioretention Basin P1	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	48.00	1,670	0
	49.00	2,240	1,955

Infiltration Basin P2
(runoff from Area 5PR)

Total Impervious Area = 1.21 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	438
Water Quality Volume	0.5	2,188

Provided:

Bioretention Basin P2	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	43.00	510	0
	44.00	840	675
	45.00	1,245	1,718
	46.00	1,725	3,203
	47.00	2,280	5,205

Infiltration Basin P3
(runoff from Area 4PR)

Total Impervious Area = 0.45 Acres

Required:

	Runoff Depth to be Treated (in.)	Required Volume (c.f.)
Forebay Volume	0.1	164
Water Quality Volume	0.5	822

Provided:

Bioretention Basin P3	Elevation	Area (s.f.)	Cumulative Volume (c.f.)
	37.50	1,708	0
	38.00	2,140	962
	39.00	3,114	3,589
	39.25	3,396	4,403

TSS Removal Worksheets

TSS Removal Calculation Worksheet

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Freetown Station**
Project Number: **10111.00**
Location: **Freetown, MA**
Discharge Point: **DP1 (Wetland 1)**
Drainage Area(s): **PR-3, PR-4, PR-5**

Sheet: **1 of 2**
Date: **28-Apr-2012**
Computed by: **PAC**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Grass Channel	**50%**	**1.00**	**0.50**	**0.50**
Infiltration Basin	**80%**	**0.50**	**0.40**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**
	0%	**0.10**	**0.00**	**0.10**

Treatment Train TSS Removal = **90%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

TSS Removal Calculation Worksheet

VHB

Vanasse Hangen Brustlin, Inc.
Consulting Engineers and Planners
101 Walnut Street
Watertown, MA 02471
(617) 924-1770

Project Name: **Freetown Station**
Project Number: **10111.00**
Location: **Freetown, MA**
Discharge Point: **-**
Drainage Area(s): **-**

Sheet: **2 of 2**
Date: **28-Apr-2012**
Computed by: **PAC**
Checked by:

A	B	C	D	E
BMP*	TSS Removal Rate*	Starting TSS Load**	Amount Removed (B*C)	Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**25%**	**1.00**	**0.25**	**0.75**
Infiltration Basin	**80%**	**0.75**	**0.60**	**0.15**
	0%	**0.15**	**0.00**	**0.15**
	0%	**0.15**	**0.00**	**0.15**
	0%	**0.15**	**0.00**	**0.15**

Treatment Train TSS Removal = **85%**

* BMP and TSS Removal Rate Values from the MassDEP Stormwater Handbook Vol. 1.
Removal rates for proprietary devices are from approved studies and/or manufacturer data (attach study or data source, or remove this sentence if not applicable).
** Equals remaining load from previous BMP (E)
*** Stormceptor sizing calculation gives a TSS removal rate of 87%. To be conservative, 75% removal is used for this calculation based upon the NJCAT study provided on the MA STEP website. (Change name of device and the claimed removal rate shown on the calc. sheet. ALSO provide backup documentation to support TSS removal rate from the MA STEP website. Remove this sentence if not applicable.)

Appendix E
Geotechnical Report

JACOBS
343 Congress Street
Boston, MA 02210

Design Memorandum

Date	January 31, 2012
To	Rick Carey, Natasha Velickovic - VHB
From	Paul Murphy, Da Ha, Peter Chou - Jacobs
Subject	MBTA South Coast Rail (New Bedford/Fall River Commuter Rail Extension) Freetown Station Geotechnical Design Memorandum Freetown, MA
Project No.	E2347101

INTRODUCTION

The South Coast Rail project will restore passenger rail transportation from South Station in Boston to the cities of Fall River and New Bedford along an existing rail freight corridor running south from Taunton to Fall River and New Bedford. The project will include the construction of several existing and new passenger stations and two terminal layover facilities. This geotechnical design memorandum presents the foundation design considerations for the new station platform at the proposed Freetown Station in Freetown, Massachusetts. The design recommendations presented in this report are based on the results of subsurface investigations performed by Jacobs in 2001 and 2010.

Existing Conditions

The proposed Freetown Station site is located off the south side of South Main Street in Freetown (Figure 1). The site is currently an undeveloped gravel lot with associated soil stockpiles on the site and some wetland areas are also present adjacent to the platform area. A self-storage facility with associated parking is located along the north side of the site, a telecommunication tower is located west of the site, and the remaining site area is surrounded by open and forested land. Existing grades at the platform location range from approximately elevation 61 to 67.6 feet (NGVD29 Datum), generally sloping downward from west to east.

Proposed Construction

Current station plans are to construct a new parking area, a new drop-off area, and an 800 foot long, 12 foot wide high level platform adjacent to the existing tracks. In addition, some track relocation is required. Access to the platform will be from a new ramp/stair structure along the north side of the tracks. Two 50-ft long platform canopies are also planned. The details of new track layout (including grading), associated sidewalks and ramps, and parking lot of the proposed station are still under development at the time of this report preparation. However, we anticipate that about 6 to 8 feet of fill is proposed at the site to raise the grade at the track level and platform area. This report focuses on the geotechnical design and recommendation for the platform only.

SCOPE OF WORK

This memorandum was prepared by Jacobs in accordance with the scope of work under the contract between Jacobs and VHB for work on the New Bedford/Fall River Commuter Rail Line Extension Project for Massachusetts Bay Transportation Authority (MBTA). The geotechnical work included the following tasks:

- Perform a geotechnical exploration and laboratory testing program;
- Report and interpret the results of the exploration and laboratory testing program; and
- Provide geotechnical recommendations for design and construction of the platform foundations.

The Jacobs scope of work did not include environmental assessment of the potential presence of any hazardous materials at the project site or potential impacts to adjacent structures during construction.

LOCAL GEOLOGY

The geologic map of Massachusetts shows the Freetown Station to be located in the Milford-Dedham zone, just south of the Narragansett Basin. The bedrock in the Milford-Dedham zone is mostly granite of Proterozoic age. The bedrock in the Narragansett Basin is lightly metamorphosed shale and sandstone of Pennsylvanian and Permian age. Bedrock was not sampled at the Freetown site. Two of the borings encountered SPT refusal at a depth of 47 and 48 feet, but the refusal could possibly be a large boulder or true bedrock. The deepest boring at the site extended to a depth of 49 feet. The bedrock is typically overlain by hard till or very dense sand and gravel.

GEOTECHNICAL EXPLORATIONS

Jacobs planned the subsurface exploration programs and retained the drilling contractors to perform the explorations. The geotechnical data reports were submitted in 2001 and 2010, respectively. Nine borings (FTS-1, FTS-4, FTS-5 to FTS-8, FR-79 MW, FR-80 and FR-81) were conducted along the proposed station platform and nine borings (FTS-09 to FTS-17) were drilled in the general vicinity of the proposed parking lot and the access road. Boring locations are shown on the Subsurface Exploration Plan (Figure 2).

The recent 2010 borings were drilled by New Hampshire Boring with either a CME-550 or D-50 ATV mounted drill rig. The 2001 borings were drilled by Earth Explorations, Inc. and NFE, Inc. with a B-57 ATV mounted drill rig. The 2010 borings were advanced through the soil by hollow-stem auger or wash boring methods using a 4-inch casing and roller bit with water. Standard penetration tests (SPT), consisting of 140-pound hammer dropping 30 inches on a standard 2-inch-diameter (OD) split-spoon sampler, were performed with a safety hammer to establish the consistency of the subsurface soils. The SPT's were typically performed at five foot intervals of depth. The obtained samples were sealed in glass jars to retain their natural moisture. Bedrock was not cored during the explorations. (Borings performed in 2001 were summarized in our previous data reports.)

The borings were observed by a representative from Jacobs. The soil samples were classified in the field in accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) by Jacobs' representative, and appropriate stratum breaks were interpolated from drilling and sampling observations. The boring logs were prepared by Jacobs based on the field classifications and laboratory testing, and are presented in Appendix A.

LABORATORY TESTING

The results of the laboratory testing were previously submitted to VHB in reports entitled "South Coast Rail, Jacobs Geotechnical Data Report", dated November 2010, and "Fall River Line, Jacobs Geotechnical Data Report", dated October 2001.

Grain size distribution analyses were performed to evaluate the gradation of the natural granular soils for potential reuse as backfill, if needed, and to classify the soils. The graduation analyses are summarized in Table 1 below and are presented in Appendix B.

Table 1: Laboratory Soil Classification Summary

BORING NO.	SAMPLE NO.	ELEVATION (FEET)	USCS SOIL CLASSIFICATION	W (%)	GRAVEL (%)	SAND (%)	FINES (%)	ORGANIC CONTENT (%)
FTS-04	S2	63.6	moist, black Silt (ML)	42.4	NT	NT	NT	4.7
FTS-11	S1	55.0	Sandy Silt (ML)	24	0	48.1	51.9	NT
FTS-13	S2	34.6	Silt (ML)	23.8	0	1.0	99.0	NT

Where: w = natural moisture content, NT = Not Tested

SUBSURFACE CONDITIONS

The subsurface conditions at the site were inferred from the boring data collected for the South Coast Rail project, with some interpretations. The subsurface conditions encountered at the station area during our 2001 and 2010 explorations generally consist of a layer of granular fill with thickness of about 0 to 3 feet, underlain by natural, loose to dense stratified silt and sand deposits, and very dense glacial till. Boulders were encountered at borings FTS-1 and FTS-6 at depths of 31 feet and 24 feet below ground surface, respectively. Apparent bedrock was encountered at a depth of about 48 feet (El. 14.2 feet) in boring FTS-1 and at a depth of about 45 feet (El. 20.6 feet) in boring FTS-4.

Organic silt was encountered at boring FTS-4 along the proposed platform at a depth of 3 to 5 feet (elevations 64.6 to 62.6 feet).

Fill materials with thicknesses varying from 0 to 7 feet were also encountered in the vicinity of the proposed parking lot area. Bedrock was not encountered in this area.

Subsurface soil conditions are summarized in Table 2 below.

Table 2: Summary of Subsurface Conditions at Borings

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Platform Borings							
FTS – 1	62.4	3.0	59.4	14.2	14.2	54.4	Boring offset 18 ft SW along tracks.
FTS – 4	67.6	3.0	64.6	20.6	18.6	62.6	
FTS – 5	61.3	0	61.3	NE	45.3	53.3	Auger Boring
FTS – 6	60.2	0	60.2	NE	33.7	57.2	Auger Boring
FTS – 7	57.4	0	57.4	NE	40.4	52.9	Auger Boring
FTS – 8	58.6	0	58.6	NE	42.6	54.1	Auger Boring
FR-79 MW	61.5	7.0	54.5	NE	41.0	49.0	Well screened from 9.2 to 19.2 ft.
FR-80	64.9	3.0	61.9	NE	44.4	52.8	
FR-81	70.2	3.0	67.2	NE	49.7	59.8	

BORING NUMBER	GROUND SURFACE ELEV. (FT)	APPROX. FILL THICKNESS (FT)	TOP OF NATURAL SOIL ELEV. (FT)	APPROX. TOP OF ROCK ELEV. (FT)	BOTTOM OF BORING ELEV. (FT)	APPROX. GROUND WATER ELEV. (FT)	REMARKS
Site Borings							
FTS – 9 OW	57.6	0	57.6	NE	32.1	52.6	Well screened from 10 to 25 ft.
FTS – 10	56.9	4.0	52.9	NE	39.9	46.9	Auger Boring
FTS – 11	56.0	0	56.0	NE	41.0	54	
FTS – 12	50.2	0	50.2	NE	33.2	42.2	Auger Boring
FTS – 13	38.6	2.0	36.6	NE	23.6	35.6	
FTS – 14	55.6	0	55.6	NE	30.6	49.6	
FTS – 15 OW	46.7	0	46.7	NE	21.7	41.7	Well screened from 10 to 20 ft.
FTS – 16 OW	37.6	0	37.6	NE	12.6	36.6	Well screened from 10 to 20 ft.
FTS – 17	60.7	0	60.7	NE	35.7	50.7	Auger Boring

NE: Not encountered at the boring during drilling.

Fill: The fill layer, where encountered, typically consists of railroad ballast, and granular, loose to medium dense sand and gravel. Clay fill was encountered at boring FR-81. The fill layer is generally about 0 to 3 feet thick in the area of the platform.

Organic Silt: A two foot thick layer of organic silt was encountered from approximately elevation 64.5 to 62.5 feet at boring FTS-4 at the west side of the platform. Boring FTS-4 is located adjacent to a wetland area. Organic soils may also be located near other wetland areas at the site.

Natural Granular Deposits: In the platform area, the natural soil deposits below the fill generally consist of predominantly silt, sandy silt and silty sand with up to 30% gravel. These deposits are loose to very dense with Standard Penetration Test (SPT) N-values ranging between 6 and 58 blows per foot (bpf).

Glacial Till: Very dense glacial till was encountered in the platform area at elevations ranging from 31.4 to 40.6 feet, and consisted of silt with 10 to 30% sand and 10 to 20% gravel.

Groundwater: Groundwater levels were measured in the test borings using a weighted tape during and at completion of drilling. The data indicated the groundwater level ranged from approximate elevations 49 to 62.6 feet along the platform alignment, and from elevations 35.6 to 54 feet in the general site area. The use of wash boring techniques for some of the borings may have artificially increased the water level readings due to the addition of water to the borings. Trapped/perched water is also commonly seen at a higher elevation within existing fill and silty materials. The longer term water level readings taken at boring FTS–09 OW on July 7, 2010 and September 13, 2011 indicated the groundwater at a depth of about 6 feet (elevation 51.6 feet) and 5 feet (elevation 52.6 feet), respectively. The longer term readings taken at borings FTS–15 OW and FTS–16 OW on July 7, 2010 indicated groundwater at a depth of about 8 feet (elevation 38.7 feet) and 1.4 feet (elevation 36.2 feet), respectively.

Groundwater levels should be expected to fluctuate with rainfall and other seasonal variations. Local and periodic variations of groundwater elevations may also be influenced by local subsurface drainage and leaking water or sewer pipes. More long-term observations would be required to evaluate true groundwater levels and their influence on planned construction. However, based upon these short-term observations and readings from the observation wells, it is anticipated that the groundwater could be within 5 to 12 feet below existing grade at the platform area and within 1 to 8 feet below existing grade in the parking lot and roadway area.

GEOTECHNICAL RECOMMENDATIONS

Based on our review of available subsurface conditions, the proposed station platforms can be supported on shallow spread footings bearing directly within either competent natural soil or structural fill placed above suitable natural soils. Platform and canopy design loads were not available at the time of this report preparation. However, it is anticipated that the station platform will be lightly (axially) loaded with limited horizontal forces from wind and seismic loads.

The following paragraphs provide project specific geotechnical recommendations for foundation soil preparation, structural fill/backfill placement, and design and construction of spread footings.

Platform Foundations - Spread Footings

Spread footings are recommended for the platform foundations, bearing on compacted structure fill or natural granular deposits. The bottom of footing elevation should be at least 4 feet below final grades for frost protection. Due to proposed site filling, bottom of footing is anticipated to be at elevations 66 to 70 feet. The existing fill and organic silt deposits are not suitable for support of the spread footings and should be removed within the zone of influence of the footings, defined by a line extending one foot horizontally from the bottom edge of footing and then down and away at a 1H:1V slope until natural soils are encountered.

The recommended allowable design bearing capacity for spread footings bearing on at least medium dense structural fill or natural silt, sandy silt or silty sand deposits is 6 ksf, provided that subgrades are prepared as described herein. This provides an adequate factor of safety against bearing failure and limits the total estimated settlement to less than one inch and the differential settlement to less than ½ inch. All footings should be at least 4 feet wide.

The structural fill material, if needed, should be free from organics and other deleterious substances and should conform to the requirements listed in the MBTA Standard Specification Section 02200 - Earthwork for Type B Gravel Borrow. The structural fill should be compacted to 95% of the maximum dry density as determined by the Modified Proctor compaction test (ASTM D1557).

All temporary open cuts required for footing construction should be in accordance with the related OSHA regulations and should have side slopes of no steeper than 1.5H:1V.

Seismic Consideration

The seismic design should comply with the requirements of the most current Massachusetts State Building Code 780 CMR and other relevant project design codes such as AREMA and AASHTO. Modification of the peak acceleration by the soils overlying bedrock depends upon the type of soil at the site. For the subsurface conditions encountered, the station platform site is classified as Seismic Site Class D soil profile in accordance with 780 CMR Chapter 1614.0 Section 9.4 Site Ground Motion. The structure could be designed for the total lateral seismic force using the equations specified in the code, or by the response spectrum method using the design spectra presented in the code. The maximum considered earthquake ground motions shall be as represented by the spectral response acceleration at short periods (Ss) and at 1-sec (S_1) obtained from Table 1604.10 of the Massachusetts State Building Code and adjusted for Site Class effects using the site coefficients of Section 9.4.1.2.4.

For Site Class D Soils at the location of this station:

S_{MS} = 0.368 and S_{M1} = 0.144

S_{DS} = 0.245 and S_{D1} = 0.096

where:

- S_{MS} is the maximum consider earthquake spectral response acceleration for short periods adjusted for site class
- S_{M1} is the maximum consider earthquake spectral response acceleration at 1-sec adjusted for site class
- S_{DS} is the design earthquake spectral response acceleration for short periods adjusted for site class
- S_{D1} is the design earthquake spectral response acceleration at 1-sec adjusted for site class

The building code also requires that the soil be evaluated for the following potential hazards: slope instability, soil liquefaction, or surface rupture due to faulting or lateral spreading. The proposed grading is relatively flat and we are not aware of any pre-existing slope instability in this area. The existing overburden soils do not appear to be subject to surface rupture due to faulting or lateral spreading.

Liquefaction

Based on the observed subsurface conditions, recorded water levels, percentage of fine contents and sample relative densities, the existing soils underlying the site are judged not susceptible to liquefaction.

CONSTRUCTION CONSIDERATIONS

Foundation Installation - Spread Footings

The existing fill and organic silt should be stripped off and removed from within the zone of influence of the platform and walkway areas down to natural granular deposits using a smooth edge excavation bucket, and replaced by compacted granular soils.

Following excavation to the top of the natural granular deposits, the exposed surface should be observed by an on-site representative of the project geotechnical engineer and be proof-compacted with at least 10 passes of a large vibratory drum roller. Any yielding areas should be observed by geotechnical personnel to assess if localized undercutting is necessary. Footing inspections should include hand auger probes by the geotechnical personnel to check for soft/weak zones. The need for undercutting and backfilling with structural fill should be closely evaluated in the field based on encountered conditions.

In areas where seepage is encountered within footing excavations, the need for placing a 3” thick lean concrete mud mat or a layer of ¾-inch crushed stone to protect the bearing surface should be evaluated in the field. Crushed stone thicker than 4 inches shall be wrapped by non-woven filter fabric.

Following observation of the bearing soils by geotechnical personnel, reinforcing steel and concrete can be placed in the excavation. It is recommended that footing reinforcing steel and concrete be placed the same day as the footing excavation is made, where possible, to avoid significant moisture content changes in the bearing soils. No water should be allowed to pond within excavations and drainage should be maintained away from foundations both during and after construction. The footing excavation should be free of loose debris at the time of footing concrete placement.

Subgrade Preparation

Prior to performing any required grading operations and excavations in the proposed structure footprints, walkway and paved areas, these areas should be stripped of topsoil, vegetation, fill, organic silt, and existing pavement, if present. The topsoil should be placed in a designated area for reuse during final grading. Following site clearing and stripping, the exposed subgrade should be proof compacted with 10 passes of a large vibratory drum roller (minimum 10,000 pound static weight). Any pockets of excessively soft, wet or disturbed soil or unsuitable soils should be removed and replaced with properly compacted fill materials. Where subgrade soils are close to the existing groundwater level or where silty subgrade soils are encountered, proof-compaction using non-vibratory methods may be considered by the geotechnical engineer.

If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches but not exceeding eighteen inches, aerated, re-compacted, and retested to provide uniform compaction. Following satisfactory compaction of the subgrade, controlled compacted fill material should be placed to bring the site to the required grade.

Fill should not be placed over frozen soil. Soil subgrades should be protected against frost both during and after construction.

Proper drainage of construction areas should be provided to protect the subgrades from the detrimental effects of weather conditions. Excavations should be made with as few passes of the backhoe bucket as possible to reduce disturbance of the subgrade. A backhoe bucket fitted with a smooth blade should be used during the final subgrade preparation, where necessary. The exposed base should be kept free of standing water at all times. The site should be graded to carry any surface runoff away from the work areas. Construction traffic should be controlled to prevent excessive stresses and disturbance to the subgrade.

If pavements are not constructed immediately after grading, the subgrade should be shaped so as to prevent ponding. If there is a substantial lapse in time between grading and paving, or if the subgrade is disturbed, it should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during proof-rolling or initial construction should be removed and replaced with compacted granular fill.

Within the proposed paved areas, and extending a distance of five feet beyond the edge on all sides, excavate existing granular fill soils to a depth of two feet below existing site grades. It may be possible to reuse the existing granular fill, depending on the suitability of the material, as described herein.

Fill Placement and Compaction

Fill materials most likely will be obtained by importing granular fill materials from off-site borrow sources. However, it may be possible to reuse existing site granular fill material provided that it can be properly placed and compacted. The gradation shall be in accordance with MBTA Standard Specification Section 02200-Earthwork for Type B Gravel Borrow.

All structural fill should be free of organics, demolition debris or other deleterious substances. The fill material should have a plasticity index (PI) less than 4 and a liquid limit (LL) less than 10, and contain fragments less than 4 inches in maximum dimension. Each lift should be compacted to the specified density prior to placing any subsequent lift. All materials to be used as structural fill should be tested in the laboratory to determine their project suitability and compaction characteristics.

The fill should be systematically compacted to the following percentages of the maximum dry density:

Table 3: Fill Compaction Requirements

DESCRIPTION	MINIMUM PERCENT COMPACTION (ASTM D-1557)
General Site Fills, Structural Fill (Below Footings and Slabs)	95
Behind Retaining Walls	92
Landscape Area	90

Soils which exhibit a well-defined moisture content–dry density relationship should be compacted to within plus or minus two percentage points of the optimum moisture content as determined by the Modified Proctor test (ASTM D-1557).

Where fill materials are placed against an existing embankment slope, the slope should be benched as the fill is brought up in layers. Benching should be of a sufficient width to permit placing and compaction of fill material upon the existing embankment materials. Typically, benches are between four to eight feet wide. Each bench cut should begin at the intersection of the existing embankment and the vertical side of the previous bench. Trench backfills over pipelines or utility structures should be performed so as not to adversely impact the underlying utilities. In fill areas, the backfill material, compaction method, and degree of compaction requirements should be similar to that for the fill adjacent to the trench.

Construction Dewatering

All excavations should be performed in the dry condition. Discharge of pumped water should be performed in accordance with all federal, state and/or local regulations which may require a discharge permit and possible filtration and chemical testing of the water prior to discharge.

Permanent Slopes

Permanent slopes with loamed and seeded surfaces should not be steeper than 2-1/2 horizontal to 1 vertical (2-1/2H:1V) without slope protection to limit erosion and surficial sloughing of the slope. Additional analyses may be required to assess the stability of slopes steeper than 2-1/2H:1V as the station design is finalized.

Excavation Slopes and Shoring

The slopes of temporary open cuts should be no steeper than 1-1/2H:1V. Open cuts should not be used below the water table because of the likelihood of soil sloughing into the excavation.

The temporary excavation support system, if needed, should be selected by the Contractor and designed by an experienced Professional Engineer registered in the Commonwealth of Massachusetts and retained by the Contractor. Where excavation sides can be sloped back, they should be performed in accordance with the Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

Protection of Existing Facilities

It is recommended that a geotechnical instrumentation and monitoring program be performed during construction of the project to evaluate impacts on adjacent structures. It is recommended that the program be developed to provide data for the following considerations:

- To monitor ground movements and vibration levels during construction.
- To provide early warning of potentially adverse trends by presenting sufficient data to determine the source of unanticipated ground movements, if present.
- If necessary, to plan remedial measures to limit damage to embankments and structures and to provide early warning when alternative means of protection are necessary.
- To document impacts of construction on adjacent facilities.
- To evaluate the performance and structural integrity of the constructed facilities.

We recommend the following instrumentation program to measure:

- Ground surface settlement and lateral movement adjacent to proposed construction.
- Horizontal and vertical movement of any excavation support system, and existing structures.
- Vibrations as a result of construction activities.

Vertical and horizontal survey points should be established on the adjacent structures. The monitoring points should be surveyed prior to the start of construction and monitored during construction to detect movement.

Vibration monitoring shall be conducted within 100 feet of existing structures during construction activities.

We recommend conducting a pre-construction survey of structures and utilities within 100 feet of the site to document existing conditions prior to construction. Documentation should include photographs, video, sketches, and/or written comments.

Specific instrumentation and monitoring requirements shall be based on the proposed construction sequence, duration of construction, and performance criteria. Initial measurements should be established well in advance of construction so that baseline data can be developed. This information will be invaluable for providing early warning of adverse trends and for assessing the need for mitigating measures.

CLOSING

This report and the recommendations contained herein have been prepared for the exclusive use of MBTA and VHB and their representatives for specific application to the design and construction of the proposed Freetown Station in Freetown, Massachusetts.

This report was prepared in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made. The analysis, design and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations available at the time of this report. Subsurface stratification variations between borings are anticipated. The reported groundwater levels only represent the water levels at the time noted on the logs. The nature and extent of variations between these explorations may not become evident until construction. If significant variations then appear, or if there are changes in the nature, design or location of the proposed structure, it may be necessary to reevaluate the recommendations of this report.

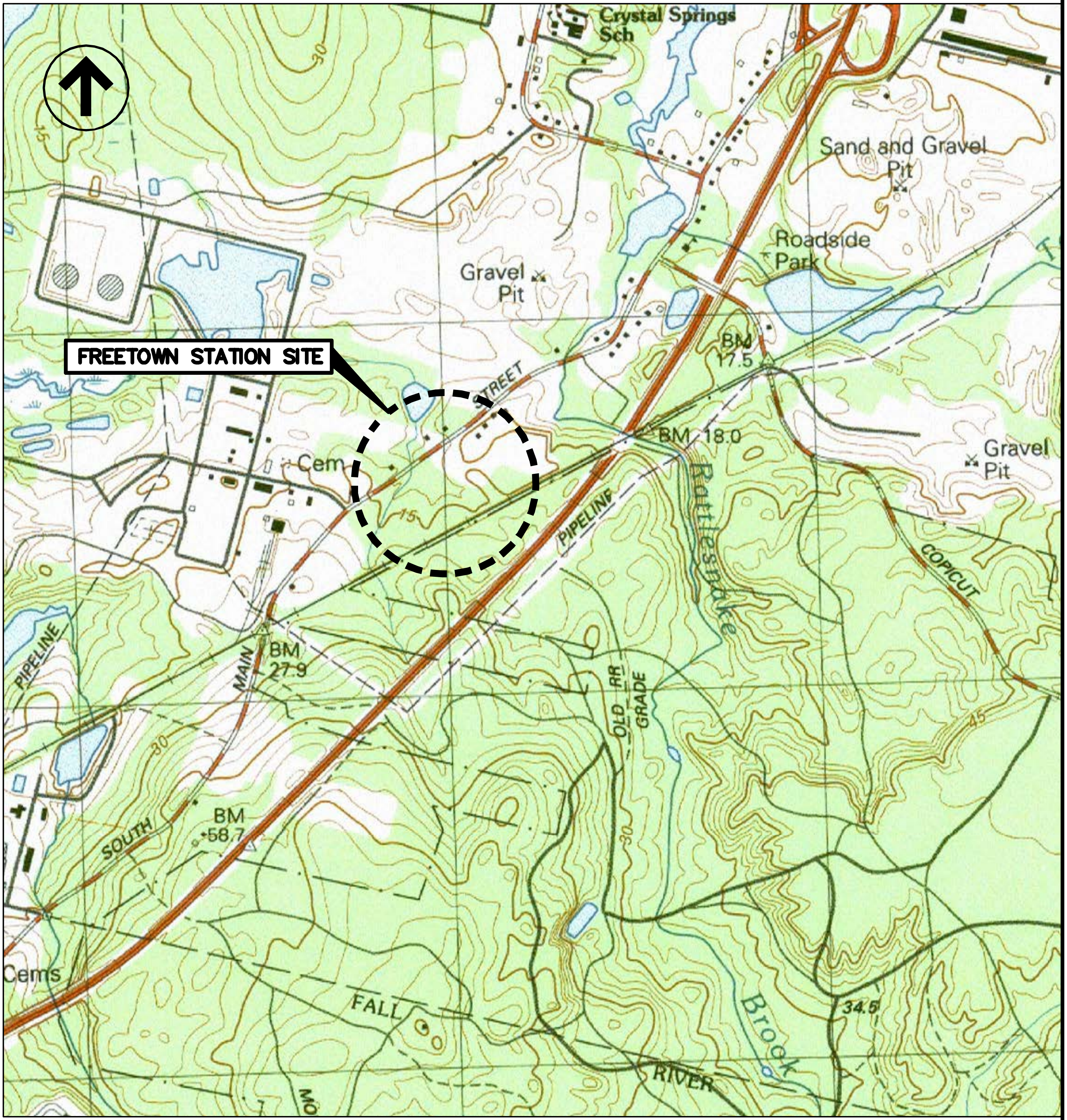
ATTACHMENTS

FIGURE 1 – SITE LOCATION PLAN
FIGURE 2 – SUBSURFACE EXPLORATION PLAN
FIGURE 3 – SUBSURFACE SOIL PROFILES

APPENDIX A – EXPLORATION LOGS
APPENDIX B – LABORATORY DATA
APPENDIX C – GEOTECHNICAL CALCULATIONS

F:\Proj\013471\600 Discipline Files\610 Studies and Reports\2011 GIR\06 - Freetown Station\ Freetown Station.doc

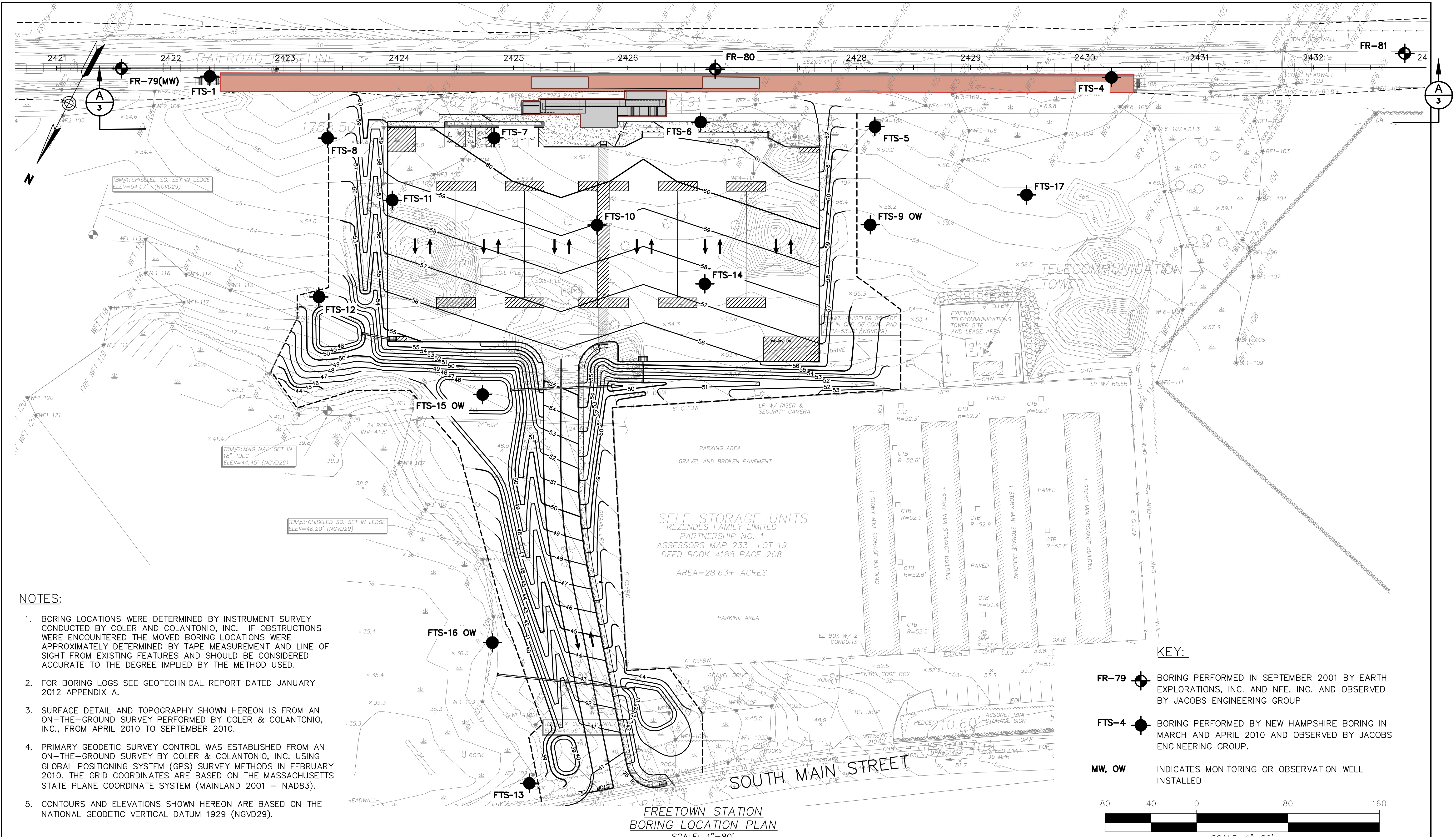
FIGURES



FREETOWN STATION
PROJECT LOCUS PLAN
NOT TO SCALE

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

FREETOWN STATION
FREETOWN, MASSACHUSETTS
FIGURE 1



FREETOWN STATION
BORING LOCATION PLAN
SCALE: 1"=80'

NOTES:

1. BORING LOCATIONS WERE DETERMINED BY INSTRUMENT SURVEY CONDUCTED BY COLER AND COLANTONIO, INC. IF OBSTRUCTIONS WERE ENCOUNTERED THE MOVED BORING LOCATIONS WERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENT AND LINE OF SIGHT FROM EXISTING FEATURES AND SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.
2. FOR BORING LOGS SEE GEOTECHNICAL REPORT DATED JANUARY 2012 APPENDIX A.
3. SURFACE DETAIL AND TOPOGRAPHY SHOWN HEREON IS FROM AN ON-THE-GROUND SURVEY PERFORMED BY COLER & COLANTONIO, INC., FROM APRIL 2010 TO SEPTEMBER 2010.
4. PRIMARY GEODETIC SURVEY CONTROL WAS ESTABLISHED FROM AN ON-THE-GROUND SURVEY BY COLER & COLANTONIO, INC. USING GLOBAL POSITIONING SYSTEM (GPS) SURVEY METHODS IN FEBRUARY 2010. THE GRID COORDINATES ARE BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (MAINLAND 2001 – NAD83).
5. CONTOURS AND ELEVATIONS SHOWN HEREON ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29).

KEY:

FR-79 ⌖	BORING PERFORMED IN SEPTEMBER 2001 BY EARTH EXPLORATIONS, INC. AND NFE, INC. AND OBSERVED BY JACOBS ENGINEERING GROUP
FTS-4 ●	BORING PERFORMED BY NEW HAMPSHIRE BORING IN MARCH AND APRIL 2010 AND OBSERVED BY JACOBS ENGINEERING GROUP.
MW, OW	INDICATES MONITORING OR OBSERVATION WELL INSTALLED

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

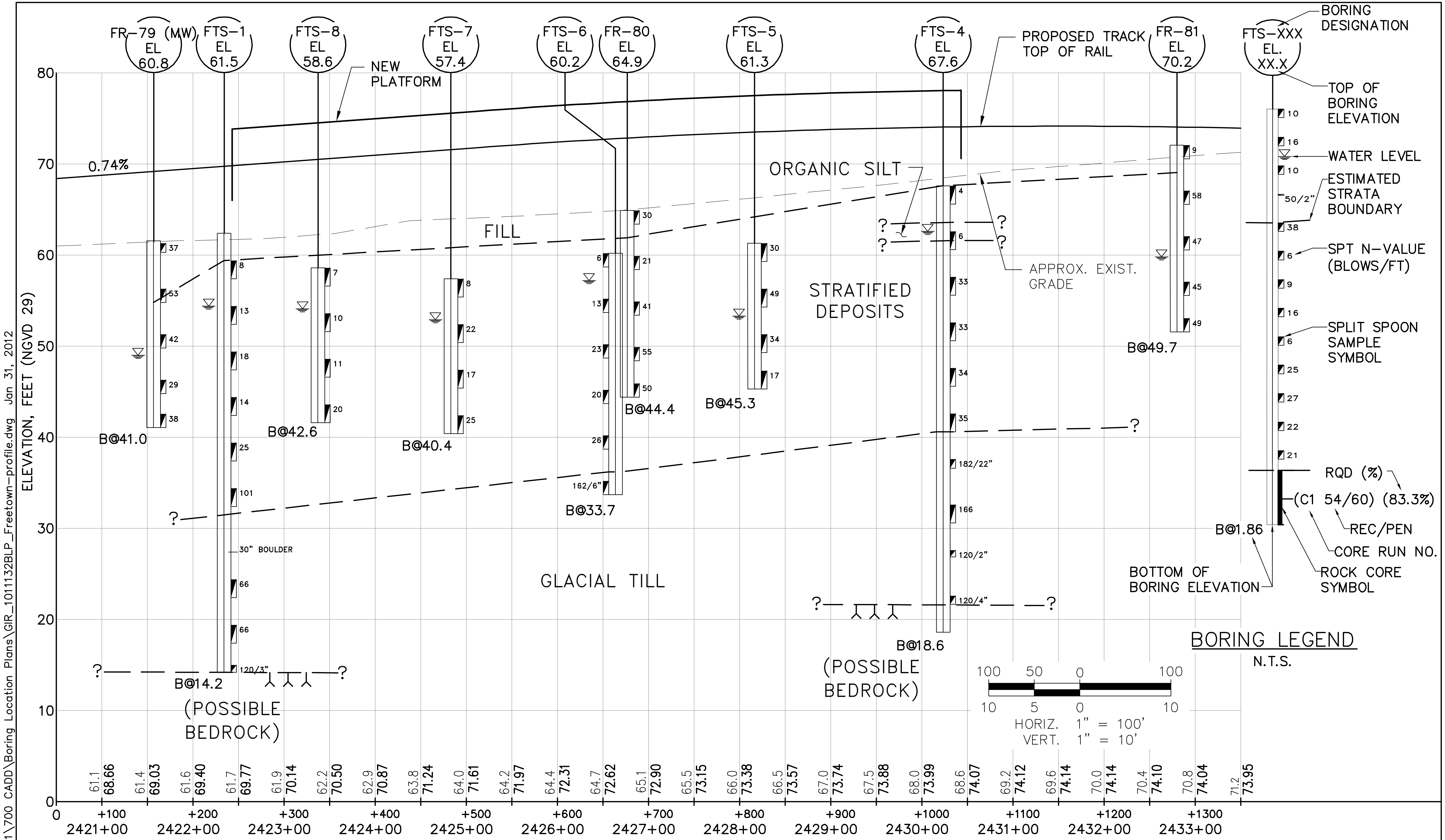
FREETOWN STATION
FREETOWN, MASSACHUSETTS
SUBSURFACE EXPLORATION PLAN

DATE: JANUARY 2012

FIGURE NO: 2

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Freetown.dwg Jan 31, 2012

F:\Proj\013471\700 CADD\Boring Location Plans\GIR_1011132BLP_Freetown-profile.dwg Jan 31, 2012



MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
SOUTH COAST RAIL
COMMUTER RAIL EXTENSION PROJECT
MBTA CONTRACT NO. X2PS68

JACOBS
343 CONGRESS STREET
BOSTON, MA 02110
(617) 242-9222

FREETOWN STATION
FREETOWN, MASSACHUSETTS
SUBSURFACE PROFILE A-A

DATE: JANUARY 2012

FIGURE NO: 3

APPENDIX A: EXPLORATION LOGS

FTS-1
FTS-4 TO FTS-17
FR-79 MW
FR-80 AND FR-81

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	FTS - 001
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	62.4
				DRILL RIG	ATV CME - 550	DATUM	NGVD 29
				SPT HAMMER	140 lb Auto	GRID N	
						COORD E	
						DATE START	4/5/10
						DATE END	4/5/10

METHOD OF DRILLING	
	Wash Boring w/Casing
48.25	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH(ft)	REMARKS
4/5/2010	8	Upon Completion (In Casing)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Top 3 ft railroad ballast.
		2 3 5 6	S1	3 - 5	8	59.4	SILT WITH SAND (ML); non-plastic silt, some fine sand, little gravel, light brown, moist.
5							
		6 7 6 6	S2	8 - 10	8	55.4	WELL GRADED SAND (SW); fine to coarse sand, trace silt, gray, wet.
10							
		4 7 11 14	S3	13 - 15	14	50.4	POORLY GRADED SAND (SP); fine sand, trace non-plastic silt, grayish-brown, wet.
15							
		6 7 7 10	S4	18 - 20	0		NO RECOVERY: push spoon, still no recovery.
20							
		5 10 15 12	S5	23 - 25	16	41.4	SILT (ML); non-plastic silt, grayish-brown, wet.
25							
		22 36 65 120/0"	S6	28 - 29.5	18		SILT WITH SAND (ML); non-plastic silt, little fine sand, gray, wet.
30							
			C1	31 - 33.5	18	31.4	CONGLOMERATE BOULDER; rounded to sub rounded clasts, gray.
						28.9	
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 001

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	FTS - 001
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 2 OF 2

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		22 31 35 32	S7	38 - 40	10		SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little mostly fine gravel, grayish-brown, wet, GLACIAL TILL.
40							
		32 31 35 36	S8	43 - 45	12		SIMILAR TO S7.
45							
		120/3"	S9	48 - 48.25	3	14.2	SIMILAR TO S7; some pieces of rock in tip of spoon, possible top of bedrock.
50							Bottom of Hole at 48.25'.
55							Boring offset from stake ~18 ft SW along existing track.
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◤ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

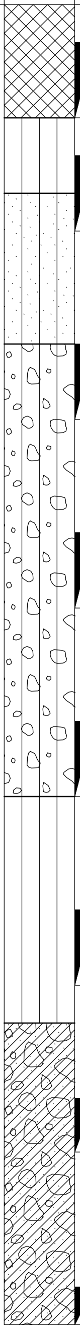
BORING NO. FTS - 001

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 004
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 2

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	S. Bolduc	ELEVATION	67.6
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2742213.6
49	Terminated	4/5/2010	5	Upon Completion (In Casing)			COORD E	766673.1
							DATE START	4/5/10
							DATE END	4/5/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
							Top 1 ft railroad ballast.
		2 1 3 1	S1	1 - 3	7		POORLY GRADED SAND (SP); mostly fine sand, trace non-plastic silt, dark brown, moist.
						64.6	
		3 2 4 4	S2	4 - 6	12		(4 - 5') SILT (ML); slightly plastic silt, trace organics, dark brown, wet.
5						62.6	(5 - 6') SILT WITH SAND (ML); non-plastic silt, little fine to coarse sand, gray, wet.
						58.6	
10		14 16 17 19	S3	9 - 11	14		SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little fine gravel, trace coarse gravel up to 1", gray, wet.
15		15 17 16 19	S4	14 - 16	8		SIMILAR TO S3.
20		16 17 17 24	S5	19 - 21	6		SILT WITH GRAVEL (ML); non-plastic silt, little fine gravel, trace fine to coarse sand, grayish-brown, wet.
						46.6	
25		17 19 16 21	S6	24 - 26	16		SILT (ML); non-plastic silt, grayish brown, wet.
						40.6	
30		66 82 100/5"	S7	29 - 30.42	12		SANDY SILT (ML); non-plastic silt, some fine to coarse sand, trace fine gravel, graish brown, wet, GLACIAL TILL.
35		71	S8	34 - 36	17		SIMILAR TO S7.

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 004

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO. FTS - 004
	LOCATION	Freetown, MA	
	OWNER	Mass.Bay Transportation Authority	SHEET 2 OF 2
	JOB NUMBER	E2347101	

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		74 92 106					
		120/2"	S9	39 - 39.16	0		NO RECOVERY
40							
		98 120/4"	S10	44 - 44.83	6		SANDY SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse sand, little mostly fine gravel, grayish-brown, wet, GLACIAL TILL.
45							
						20.6	Top of apparent Bedrock, roller bit to 49 ft.
						18.6	
50							Bottom of Hole at 49'.
55							
60							
65							
70							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 004

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 005
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	61.3
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER: 140 lb Safety	GRID COORD N	2742348.2
16	Terminated	3/31/2010	8	Upon Completion (Augers pulled)		E	766836.2
						DATE START	3/31/10
						DATE END	3/31/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 3 1 2	S1	0 - 2	24		SILT (ML); non-plastic silt, brown, wet, topsoil.
5		15 21 28 29	S2	4 - 6	16	57.3	SILT WITH SAND (ML); non-plastic silt, little fine to coarse sand, trace fine gravel, gray, moist,.
10		9 21 13 20	S3	9 - 11	19	53.3	SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse gravel up to 1.5", little fine to coarse sand, grayish-brown, wet.
15		7 5 12 19	S4	14 - 16	8		SILT WITH GRAVEL (ML); non-plastic silt, little fine gravel, trace sand, grayish-brown, wet.
						45.3	Bottom of Hole at 16'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 005

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	FTS - 006
	LOCATION	Freetown, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	T. Pentacost	ELEVATION	60.2
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2742415.9
26.5	Terminated	3/31/2010	3	Upon Completion (Augers pulled)			COORD E	766973
							DATE START	3/31/10
							DATE END	3/31/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		1 3 3 3	S1	0 - 2	9		SILT (ML); non-plastic silt, trace sand, brown, wet.
						56.2	
5		3 7 10 13	S2	5 - 7	16		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, some fine to coarse gravel up to 1", trace silt, brown, wet.
						51.2	
10		11 14 9 13	S3	10 - 12	10		SILTY SAND (SM); fine to medium sand, some non-plastic silt, trace fine gravel, brown, wet.
15		9 10 10 12	S4	15 - 17	14		SIMILAR TO S3.
						41.2	
20		24 14 12 25	S5	20 - 22	8		SILTY SAND WITH GRAVEL (SM); mostly fine sand, some non-plastic silt, little fine to coarse gravel up to 1.5", grayish brown, wet.
							Cobbles / boulders encountered.
						36.2	
25		35 52 110/6"	S6	25 - 26.5	18		SILT WITH SAND (ML); non-plastic silt, little mostly fine sand, trace fine gravel, grayish brown, wet.
						33.7	
							Bottom of Hole at 26.5'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◢ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO.	FTS - 006

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	FTS - 007
	LOCATION	Freetown, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	T. Pentacost	ELEVATION	57.4
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID COORD N	2742512.4
17	Terminated	4/1/2010	4.5	Upon Completion (Augers pulled)			E	767126.5
							DATE START	4/1/10
							DATE END	4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 3 5 6	S1	0 - 2	15		POORLY GRADED SAND (SP); fine sand, brown, moist.
						53.4	
5		8 10 12 9	S2	5 - 7	18		SILT (ML); non-plastic silt, gray, wet.
10		4 8 9 10	S3	10 - 12	12		SILT (ML); non-plastic silt, gray, wet.
15		12 11 14 23	S4	15 - 17	18		SILT (ML); non-plastic silt, gray, wet.
						40.4	
							Bottom of Hole at 17'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 007

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	FTS - 008
	LOCATION	Freetown, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	T. Pentacost	ELEVATION	58.6
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM	NGVD 29
	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID N	2742580.5
17	Terminated	4/1/2010	4.5	Upon Completion (Augers pulled)			COORD E	767255.5
							DATE START	4/1/10
							DATE END	4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0		3 3 4 5	S1	0 - 2	19		POORLY GRADED SAND (SP); mostly fine sand, trace silt, brown, moist.
5		4 4 6 8	S2	5 - 7	10	53.6	POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, trace non-plastic silt, gray, wet.
10		8 5 6 5	S3	10 - 12	14		SIMILAR TO S2.
						45.6	
15		5 9 11 13	S4	15 - 17	16	42.6	SILT (ML); non-plastic silt, gray, wet.
							Bottom of Hole at 17'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 008

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	FTS - 009 OW
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight
				DRILL RIG	ATV D-50
				SPT HAMMER	140 lb Safety

ELEVATION		57.6	
DATUM		NGVD 29	
GRID COORD	N	2742426.1	
	E	766799.8	
DATE START		3/31/10	
DATE END		3/31/10	

METHOD OF DRILLING

	Hollow Stem Auger
17	Wash Boring w/Casing
25.42	Terminated

GROUNDWATER READINGS

DATE/TIME	DEPTH(ft)	REMARKS
3/31/2010	2	Upon Completion (In Augers)
7/7/2010	6	Monitoring Well Reading
9/13/2011	5	Monitoring Well Reading

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 4 6 21	S1	0 - 2	8		SILT (ML); non-plastic silt, trace fine sand, light brown, moist.
						54.6	
		9 27 25 19	S2	4 - 6	20		(4 - 5') SANDY SILT (ML); non-plastic silt, some fine sand, light brown, wet.
5						52.6	(5 - 6') GRAVELY SILT (ML); non-plastic silt, some fine to coarse gravel up to 1", trace sand, gray, wet.
						50.6	
10		15 17 18 22	S3	9 - 11	13		SILT WITH SAND (ML); non-plastic silt, little fine to coarse sand, grayish brown, wet.
15		3 6 7 8	S4	14 - 16	12		SANDY SILT (ML); non-plastic silt, some mostly fine sand, trace fine gravel, grayish brown, wet.
						40.6	
		43 120/6"	S5	18 - 19	12		SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse gravel up to 1", trace sand, grayish brown, wet.
20							
						36.6	
		100/4"	S6	23 - 23.33	0		NO RECOVERY
25		100/5"	S7	25 - 25.42	3	32.2	POORLY GRADED GRAVEL WITH SAND (GP); mostly fine gravel, some fine to coarse sand, gray, wet.
							Bottom of Hole at 25.42'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◩ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 009 OW

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 010
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	T. Pentacost	ELEVATION	56.9
				DRILL RIG	ATV D-50	DATUM	NGVD 29
				SPT HAMMER	140 lb Safety	GRID N	2742537.7
						COORD E	767011.2
						DATE START	4/1/10
						DATE END	4/1/10

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
	Hollow Stem Auger			
17	Terminated	4/1/2010	10	Upon Completion (Augers pulled)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0	▨	2 4 4 3	S1	0 - 2	8		SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some non-plastic silt, little fine gravel, grayish brown, moist, FILL.
4						52.9	
5		11 10 12 12	S2	5 - 7	11		SANDY SILT (ML); non-plastic silt, some fine to coarse sand, grayish brown, moist.
8						48.9	
10		14 12 17 18	S3	10 - 12	16		SILT (ML); non-plastic silt, gray, wet.
15		10 13 13 15	S4	15 - 17	15		SIMILAR TO S3.
17						39.9	
							Bottom of Hole at 17'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 010

LOG OF TEST BORING

PROJECT	South Coast Rail	BORING NO.	FTS - 011
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	56.0
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER 140 lb Safety	GRID N	2742602.2
15	Terminated	4/1/2010	2	Upon Completion (Augers pulled)		COORD E	767180
						DATE START	4/1/10
						DATE END	4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 2 3 6	S1	0 - 2	13		SANDY SILT (ML); non-plastic silt, some fine sand, brown, moist.
		10 11 15 10	S2	3 - 5	15		SILT (ML); non-plastic silt, trace fine sand, gray, wet.
5							
		9 15 18 21	S3	8 - 10	24	48.0	SILT (ML); non-plastic silt, gray, wet.
10							
		7 12 12 15	S4	13 - 15	24		SIMILAR TO S3.
15						41.0	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- Auger Sample (AS)
- Rock Core (RC) and RQD (%) REC (%)
- Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- Undisturbed (U)-Shelby Tube, (P)-Piston
- Jar Sample (JS)
- Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 011

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	FTS - 012	
	LOCATION	Freetown, MA			
	OWNER	Mass.Bay Transportation Authority			
	JOB NUMBER	E2347101		SHEET 1 OF 1	

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	T. Pentacost	ELEVATION	50.2
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29
	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER 140 lb Safety	GRID N	2742706.9
17	Terminated	4/1/2010	8	Upon Completion (Augers pulled)		COORD E	767197.3
						DATE START	4/1/10
						DATE END	4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 4 3 5	S1	0 - 2	7		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, some non-plastic silt, brown, moist.
5		14 14 11 10	S2	5 - 7	10		POORLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, some non-plastic silt, trace fine gravel, grayish brown, wet.
						41.2	
10		9 8 9 9	S3	10 - 12	4		SILT (ML); non-plastic silt, brown, wet, cobble in tip of spoon.
15		8 8 9 10	S4	15 - 17	10		SILT (ML); non-plastic silt, gray, wet.
						33.2	
							Bottom of Hole at 17'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 012

LOG OF TEST BORING

JACOBS	PROJECT	South Coast Rail	BORING NO.	FTS - 013
	LOCATION	Freetown, MA		
	OWNER	Mass.Bay Transportation Authority		
	JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring		DRILLER	C. Knight	ELEVATION		38.6
METHOD OF DRILLING		GROUNDWATER READINGS			DRILL RIG	ATV D-50	DATUM		NGVD 29
	Wash Boring w/Casing	DATE/TIME	DEPTH(ft)	REMARKS	SPT HAMMER	140 lb Safety	GRID	N	2742997.3
15	Terminated	4/1/2010	3	Upon Completion (Augers pulled)			COORD	E	766836
							DATE START		4/1/10
							DATE END		4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		2 2 1 2	S1	0 - 2	4		TOPSOIL; organic material, brown, moist.
						36.6	
		10 13 14 16	S2	3 - 5	20		SILT (ML); non-plastic silt, grayish brown, wet.
5							
		10 11 11 10	S3	8 - 10	24		SIMILAR TO S2.
10							
						26.6	
		16 15 16 18	S4	13 - 15	10		SILTY SAND WITH GRAVEL (SM); fine to coarse sand, some non-plastic silt, little fine gravel, gray, wet.
15						23.6	
							Bottom of Hole at 15'.
20							
25							
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO.	FTS - 013

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 014
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight
				DRILL RIG	ATV D-50
				SPT HAMMER	140 lb Safety

METHOD OF DRILLING		GROUNDWATER READINGS		
		DATE/TIME	DEPTH(ft)	REMARKS
	Wash Boring w/Casing			
25	Terminated	4/1/2010	6	Upon Completion (In Casing)

ELEVATION		55.6
DATUM		NGVD 29
GRID COORD	N	2742539.3
	E	766903.9
DATE START		4/1/10
DATE END		4/1/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		3 2 2 8	S1	0 - 2	10		SILT WITH SAND (ML); non-plastic silt, little fine sand, brown, moist.
5		9 13 16 18	S2	3 - 5	12	52.6	POORLY GRADED SAND (SP); mostly medium sand, trace silt, brown, moist.
10		22 16 25 28	S3	8 - 10	4	48.6	WELL GRADED SAND WITH SILT (SW-SM); fine to coarse sand, some non-plastic silt, trace gravel, gray, wet.
15		6 8 13 18	S4	13 - 15	10		SIMILAR TO S3.
20		10 23 24 10	S5	18 - 20	11		SIMILAR TO S3.
25		20 16 6 11	S6	23 - 25	1	33.6	POORLY GRADED SAND WITH SILT (SP-SM); mostly coarse sand, little non-plastic silt, grayish brown, wet.
30						30.6	Bottom of Hole at 25'.
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- ▤ Auger Sample (AS)
- ▮ Rock Core (RC) and RQD (%) REC (%)
- ◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)
- ▯ Undisturbed (U)-Shelby Tube, (P)-Piston
- ⧗ Jar Sample (JS)
- ☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO.	FTS - 014

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 015 OW
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	46.7
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

METHOD OF DRILLING		DATE/TIME	DEPTH(ft)	REMARKS			
	Wash Boring w/Casing				SPT HAMMER: 140 lb Safety	GRID N	2742715.6
25	Terminated	4/2/2010	5	Monitoring Well Reading		COORD E	767030.8
		7/7/2010	8	Monitoring Well Reading		DATE START	4/2/10
						DATE END	4/2/10

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
		7 12 4 10	S1	0 - 2	18		SILT (ML); non-plastic silt, trace fine gravel, brown, moist.
						43.7	
		12 14 16 15	S2	3 - 5	7		WELL GRADED SAND WITH GRAVEL (SW); fine to coarse sand, little fine gravel, trace silt, brown, moist.
5							
		10 11 12 10	S3	8 - 10	4		SIMILAR TO S2.
10							
						34.7	
		6 7 8 7	S4	13 - 15	12		SILT (ML); non-plastic silt, trace fine sand, grayish brown, wet.
15							
		7 7 6 6	S5	18 - 20	15		SILT (ML); non-plastic silt, gray, wet.
20							
		5 8 9 11	S6	23 - 25	16		SIMILAR TO S5.
25						21.7	
							Bottom of Hole at 25'.
30							
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

Auger Sample (AS)	Rock Core (RC) and RQD (%) REC (%)	Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	Undisturbed (U)-Shelby Tube, (P)-Piston	Jar Sample (JS)	Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 015 OW

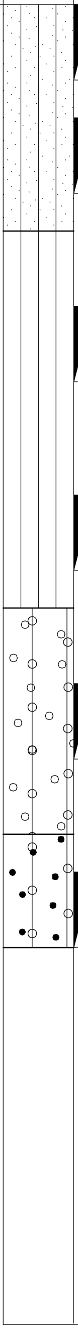
LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 016 OW
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	C. Knight	ELEVATION	37.6
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29

	METHOD OF DRILLING	DATE/TIME	DEPTH(ft)	REMARKS			
	Wash Boring w/Casing				SPT HAMMER: 140 lb Safety	GRID N	2742903.5
25	Terminated	4/2/2010	1	Monitoring Well Reading		COORD E	766922
		7/7/2010	1.4	Monitoring Well Reading		DATE START	4/2/10
						DATE END	4/2/10



DEPTH (ft)	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
	2 4 2 5	S1	0 - 2	12		SANDY SILT (ML); non-plastic silt, some fine sand, light brown, moist.
5	11 15 14 11	S2	3 - 5	16		SANDY SILT (ML); non-plastic silt, some fine sand, light brown, wet.
					31.6	
10	5 8 9 7	S3	8 - 10	14		SILT (ML); slightly plastic silt, gray, wet, PP = 1 TSF. Pocket Penetrometer = 1 tsf.
15	6 8 12 9	S4	13 - 15	15		SIMILAR TO S3, PP = 0.75 TSF. Pocket Penetrometer = 0.75 tsf.
					21.6	Boring collapses with sand at 16 ft.
20	11 10 16 18	S5	18 - 20	5		WELL GRADED SAND WITH SILT (SW-SM); fine to coarse sand, little non-plastic silt, trace fine gravel, grayish brown, wet.
					15.6	
25	94 78 76 58	S6	23 - 25	3		NARROWLY GRADED SAND WITH SILT (SP-SM); mostly fine sand, little non-plastic silt, gray, wet.
					12.6	Bottom of Hole at 25'.
30						
35						

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

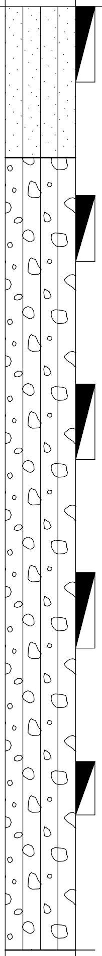
BORING NO. FTS - 016 OW

LOG OF TEST BORING

JACOBS

PROJECT	South Coast Rail	BORING NO.	FTS - 017
LOCATION	Freetown, MA		
OWNER	Mass.Bay Transportation Authority		
JOB NUMBER	E2347101		SHEET 1 OF 1

INSPECTOR	T. Telesco	CONTRACTOR	NH Boring	DRILLER	T. Pentacost	ELEVATION	60.7
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	ATV D-50	DATUM	NGVD 29
	Hollow Stem Auger	DATE/TIME	DEPTH(ft)	REMARKS			
				SPT HAMMER	140 lb Safety	GRID COORD N	2742339.1
25	Terminated	3/31/2010	10	Upon Completion (In Augers)		GRID COORD E	766691
						DATE START	3/31/10
						DATE END	3/31/10



DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	SAMPLE NO.	DEPTH (ft)	REC. (in)/(%)	ELEV.	FIELD CLASSIFICATION AND REMARKS
0		3 6 14 27	S1	0 - 2	15		(0 - .5') TOPSOIL; roots, brown, moist. (.5 - 2') SILT WITH SAND (ML); non-plastic silt, little fine sand, gray, moist.
						56.7	
5		30 22 52 100/3"	S2	5 - 6.75	12		SILT WITH GRAVEL (ML); non-plastic silt, some fine to coarse gravel up to 1", little fine to coarse sand, gray, moist, cobble encountered.
10		22 12 10 10	S3	10 - 12	9		SIMILAR TO S2.
15		31 46 100/2"	S4	15 - 17	6		SILT WITH GRAVEL (ML); non-plastic silt, some fine gravel up to 1.5", trace sand, grayish brown, wet.
20		13 46 100/5"	S5	20 - 21.42	17		SIMILAR TO S4.
25		100/0"	S6	25 - 25	0	35.7	NO RECOVERY; boulder encountered. Bottom of Hole at 25'.
30							Cobbles and boulders encountered from 6 to 25 ft.
35							

Page 1: 0-35 feet. Each subsequent page displays 40 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

▤ Auger Sample (AS)	▮ Rock Core (RC) and RQD (%) REC (%)	◣ Split-Spoon Sample (SS) and Blow Counts per 6" REC (in)	▯ Undisturbed (U)-Shelby Tube, (P)-Piston	⧗ Jar Sample (JS)	☒ Bag Sample (B)

REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FTS - 017

LOG OF TEST BORING/MONITORING WELL

JACOBS

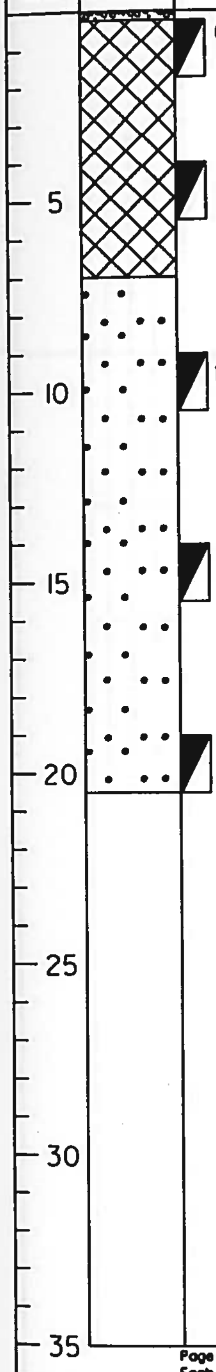
PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	FR-79 MW
LOCATION	Fall River Line - Freetown		
OWNER	Mass. Bay Transportation Authority		
JOB NUMBER	013471		SHEET 1 OF 1

INSPECTOR	C.Nagata	CONTRACTOR	Earth Exploration, Inc	DRILLER	J.Galvin
				DRILL RIG	B-57 ATV
				SPT HAMMER	140 lb Safety

ELEVATION	61.5
DATUM	FT MSL
GRID COORD N	2742611
GRID COORD E	767443
DATE START	9/07/01
DATE END	9/07/01

METHOD OF DRILLING	
0.0	Wash Boring w/Casing
9.0	Wash Boring-Open Hole
19.0	Split Spoon Sample
20.5	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH (ft)	REMARKS
9/07/01 1030	12.5	Upon completion (in casing)
5/21/02 1335	12.4	Monitoring well reading



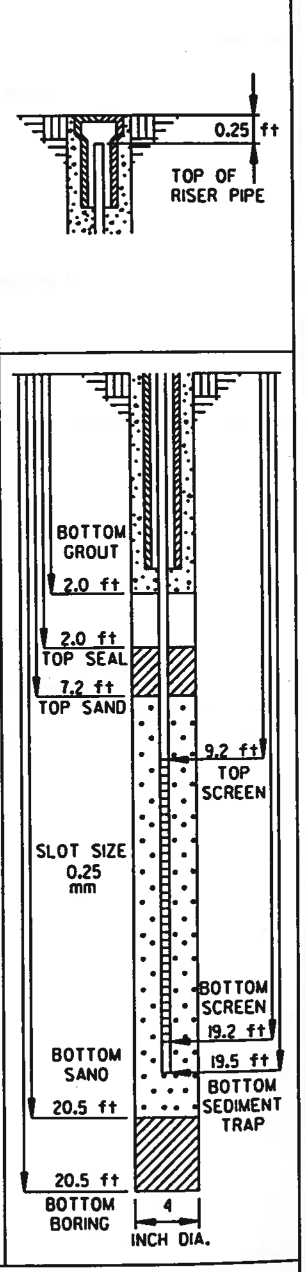
SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
6 14 23	7	SS-1	61.20	3" of ballast Well graded sand (SW) - mostly fine to medium sand with slag, trace fine to coarse subangular gravel, dark brown/black, dry (FILL) (Possibly used as subballast)
7 18 35	14	SS-2		Well graded sand (SW) - mostly fine to medium sand, trace silt, brown, wet (FILL)
			54.50	
12 20 22	14	SS-3		Poorly graded sand (SP) - mostly fine sand, light brown, wet
8 14 15	10	SS-4		Poorly graded sand (SP) - mostly fine sand, light brown, wet
19 16 22	9	SS-5		Poorly graded sand (SP) - mostly fine sand, light brown, wet
			41.00	Boring Terminated at 20.5 ft.

Remarks:
Boring located at centerline of existing tracks.
Test boring performed by GeoLogic, Inc.
Monitoring well installed (2" Dia. PVC pipe)

WELL LOG (N. T. S.)

WELL COVER INFORMATION

☐ STANDPIPE ☒ ROADBOX



Page 1: 0-35 ft., Page 2: 35-80 ft., Each subsequent page displays 45 ft.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)

90 ROCK CORE (RC) AND RQD (%) REC (%)

4 5 6 SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)

UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON

☒ JAR (JS)

☒ BAG (B)

• REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FR-79 MW

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail	BORING NO.	FR-80
LOCATION	Fall River Line - Freetown		
CLIENT	Mass. Bay Transportation Authority		
JOB NUMBER	013471	SHEET 1 OF 1	

INSPECTOR	C.Nagata	CONTRACTOR	NFE, Inc.	DRILLER	J.Galvin	ELEVATION	64.9
METHOD OF DRILLING		GROUNDWATER READINGS		DRILL RIG	B-57 ATV	DATUM	FT MSL
0.0	Wash Boring w/Casing	DATE/TIME	DEPTH (ft)	REMARKS	SPT HAMMER: 140 lb Safety	GRID N	2742369
4.0	Wash Boring-Open Hole	9/07/01 1315	12.1	Upon completion (in casing)		COORD E	766983
19.0	Split Spoon Sample					DATE START	9/07/01
20.5	Terminated					DATE END	9/07/01

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		6 12 18	18	SS-1	61.90	Well graded sand (SW) - mostly fine to medium sand with slag, trace fine to coarse subrounded gravel, dark brown/black, dry (FILL) (Possibly used as subballast)
5		24 11 10	18	SS-2		Silty sand (SM) - mostly fine sand, little to some silt, brown, wet
10		11 18 23	18	SS-3	51.90	Silty sand (SM) - mostly fine sand, little to some silt, brown, wet
15		15 17 38	12	SS-4	48.90	Silt (ML) - homogeneous, non-plastic, light brown, wet (Gravel lodged in shoe)
20		34 31 19	6	SS-5	44.40	Silty sand (SM) - Mostly fine to coarse sand, little to some silt, trace fine to coarse subangular gravel, beige, wet Boring Terminated at 20.5 ft.
25						Remarks: Boring located at centerline of existing tracks. Test boring performed by GeoLogic, Inc.
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet.
Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

AUGER (AS)	90 ROCK CORE (RC) AND ROD (%) REC (%)	4 5 6 SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)	UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON	☒ JAR (JS)	☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FR-80

LOG OF TEST BORING

JACOBS

PROJECT	New Bedford/Fall River Commuter Rail		BORING NO.	FR-81	
LOCATION	Fall River Line - Freetown				
CLIENT	Mass. Bay Transportation Authority				
JOB NUMBER	013471			SHEET 1 OF 1	
INSPECTOR	C.Nagato				
CONTRACTOR	NFE, Inc.	DRILLER	J.Galvin	ELEVATION	70.2
		DRILL RIG	B-57 ATV	DATUM	FT MSL
		SPT HAMMER	140 lb Safety	GRID COORD N	2742075
				GRID COORD E	766456
				DATE START	9/07/01
				DATE END	9/10/01

METHOD OF DRILLING	
0.0	Wash Boring w/Casing
19.0	Split Spoon Sample
20.5	Terminated

GROUNDWATER READINGS		
DATE/TIME	DEPTH (ft)	REMARKS
9/10/01 0705	10.4	Upon completion (in casing)
9/10/01 0720	7.9	Upon completion (Casing pulled)

DEPTH (ft)	STRATA SYMBOL	SAMPLE DATA	REC. (in)/(%)	SAMPLE NO.	ELEV.	FIELD CLASSIFICATION AND REMARKS
		4 5 4	18	SS-1		Clay (CL) - homogeneous, medium plasticity, trace roots, brown, dry (FILL)
					67.20	
5		21 32 26	10	SS-2		Poorly graded sand with silt (SP-SM) - mostly fine sand, trace to little silt, trace fine to coarse gravel, light brown, wet
					62.20	
10		54 33 14	6	SS-3		Well graded sand (SW) - mostly fine to medium sand, brown, wet
15		38 25 20	5	SS-4		Well graded sand with gravel (SW) - mostly fine to coarse sand, some fine to coarse subangular gravel, trace silt, light brown, wet
20		43 28 21	5	SS-5		Well graded sand with gravel (SW) - mostly fine to coarse sand, some fine to coarse subangular gravel, trace silt, light brown, wet
					49.70	Boring Terminated at 20.5 ft.
25						Remarks: Boring offset 12 ft east of centerline of tracks. Test boring performed by GeoLogic, Inc.
30						
35						

Page 1: 0-35 feet, Page 2: 35-80 feet. Each subsequent page displays 45 feet.

SAMPLES CLASSIFIED IN ACCORDANCE WITH ASTM D-2488 UNLESS OTHERWISE NOTED.

COHESIVE SOIL		NON-COHESIVE SOIL		RELATIVE PROPORTIONS OF SOIL COMPONENTS	
BLOWS/FT	CONSISTENCY	BLOWS/FT	DENSITY		
0 - 2	VERY SOFT	0 - 4	VERY LOOSE	< 10%	TRACE
3 - 4	SOFT	5 - 10	LOOSE	15 - 25%	LITTLE
5 - 8	MEDIUM STIFF	11 - 30	MEDIUM DENSE	30 - 45%	SOME
9 - 15	STIFF	31 - 50	DENSE	50 - 100%	MOSTLY
16 - 30	VERY STIFF	51 +	VERY DENSE		
30 +	HARD				

LEGEND

- AUGER (AS)
- ROCK CORE (RC) AND ROD (%) REC (%)
- SPLIT-SPOON (SS) AND BLOW COUNTS PER 6" REC (in)
- UNDISTURBED (U)-SHELBY TUBE, (P)-PISTON
- ☒ JAR (JS)
- ☒ BAG (B)

* REFER TO THE SHEET ENTITLED "KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS" FOR ADDITIONAL SYMBOLOGY.

BORING NO. FR-81

APPENDIX B: LABORATORY DATA

GeoTesting
express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	---	Sample Type:	---	Tested By:	mmd
Sample ID:	---	Test Date:	05/03/10	Checked By:	jdt
Depth :	---	Sample Id:	---		

Moisture Content of Soil - ASTM D 2216-05

Boring ID	Sample ID	Depth	Description	Moisture Content,%
FTS-4	S-2	4-6 ft	Moist, black silt	42.4
FTS-11	S-1	0-2 ft	Moist, yellowish brown sandy silt	24
FTS-13	S-2	3-5 ft	Moist, yellowish brown silt	23.8
TS-2	S-3	9-11 ft	Moist, gray clay	32
TS-2	S-4	14-16 ft	Wet, light gray silt	37
TS-3	S-3	9-11 ft	Moist, gray clay	37.7
TS-7	S-3	8-10 ft	Wet, yellowish brown clay	36.5
TS-7	S-4	13-15 ft	Moist, gray clay	32.8
TS-11	S-2	3-5 ft	Moist, black silt with organics	26.1
TS-20	S-3	8-10 ft	Wet, gray silt	41.4

Notes: Temperature of Drying : 110° Celsius

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Jacobs Civil, Inc.				
Project:	South Coast Rail				
Location:	MA			Project No:	GTX-9764
Boring ID:	---	Sample Type:	---	Tested By:	mmd
Sample ID:	---	Test Date:	04/28/10	Checked By:	jdt
Depth :	---	Test Id:	178378		

Moisture, Ash, and Organic Matter - ASTM D 2974

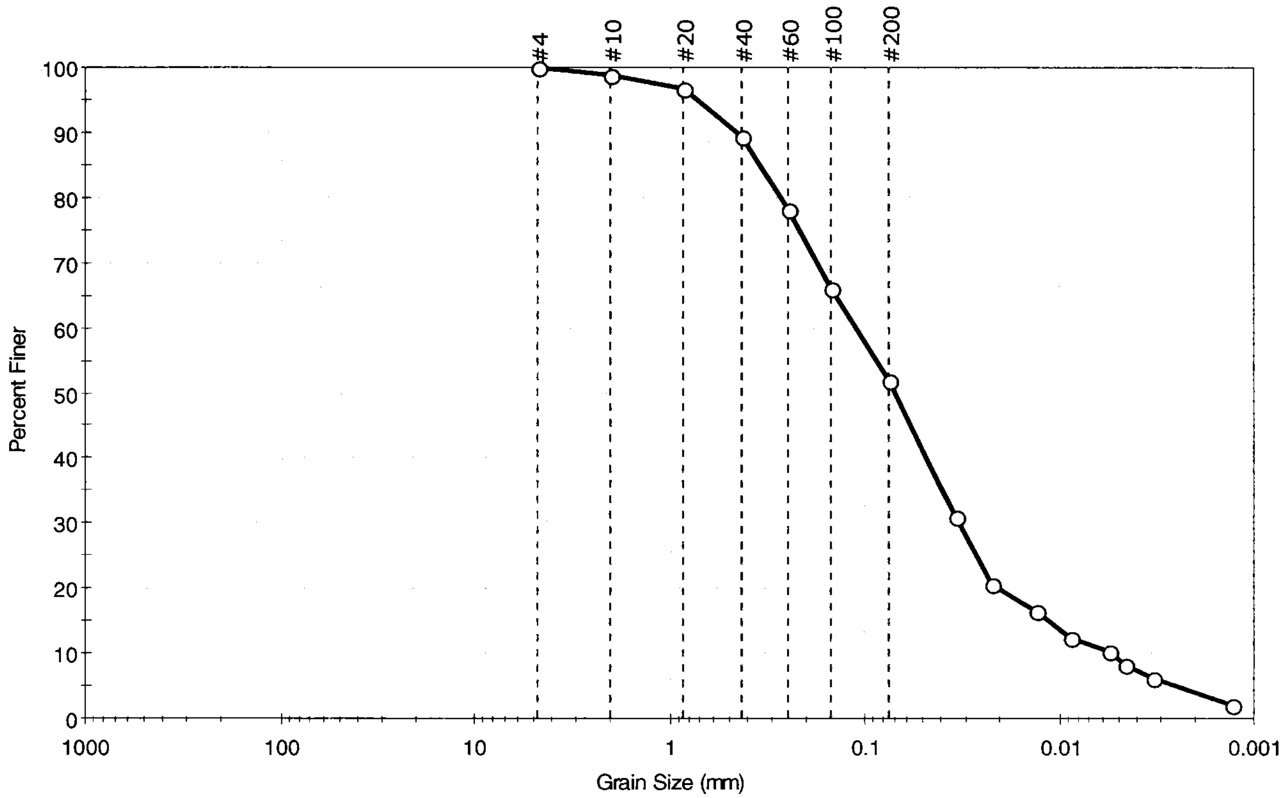
Boring ID	Sample ID	Depth	Description	Moisture Content,%	Ash Content,%	Organic Matter,%
FTS-4	S-2	4-6 ft	Moist, black silt	42	95.3	4.7
TS-11	S-2	3-5 ft	Moist, black silt with organics	26	92.2	7.8

Notes: Moisture content determined by Method A and reported as a percentage of oven-dried mass;
dried to a constant mass at temperature of 110° C
Ash content and organic matter determined by Method C; dried to constant mass at temperature 440° C

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: FTS-11
Sample Type: jar
Tested By: jbr
Sample ID: S-1
Test Date: 04/28/10
Checked By: jdt
Depth : 0-2 ft
Test Id: 178366
Test Comment: ---
Sample Description: Moist, yellowish brown sandy silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	48.1	51.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	99		
#20	0.85	97		
#40	0.42	89		
#60	0.25	78		
#100	0.15	66		
#200	0.075	52		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0340	31		
---	0.0220	21		
---	0.0131	17		
---	0.0087	12		
---	0.0056	10		
---	0.0047	8		
---	0.0033	6		
---	0.0013	2		

Coefficients

D_{85} =0.3453 mm
D_{30} =0.0326 mm
D_{60} =0.1116 mm
D_{15} =0.0112 mm
D_{50} =0.0698 mm
D_{10} =0.0054 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

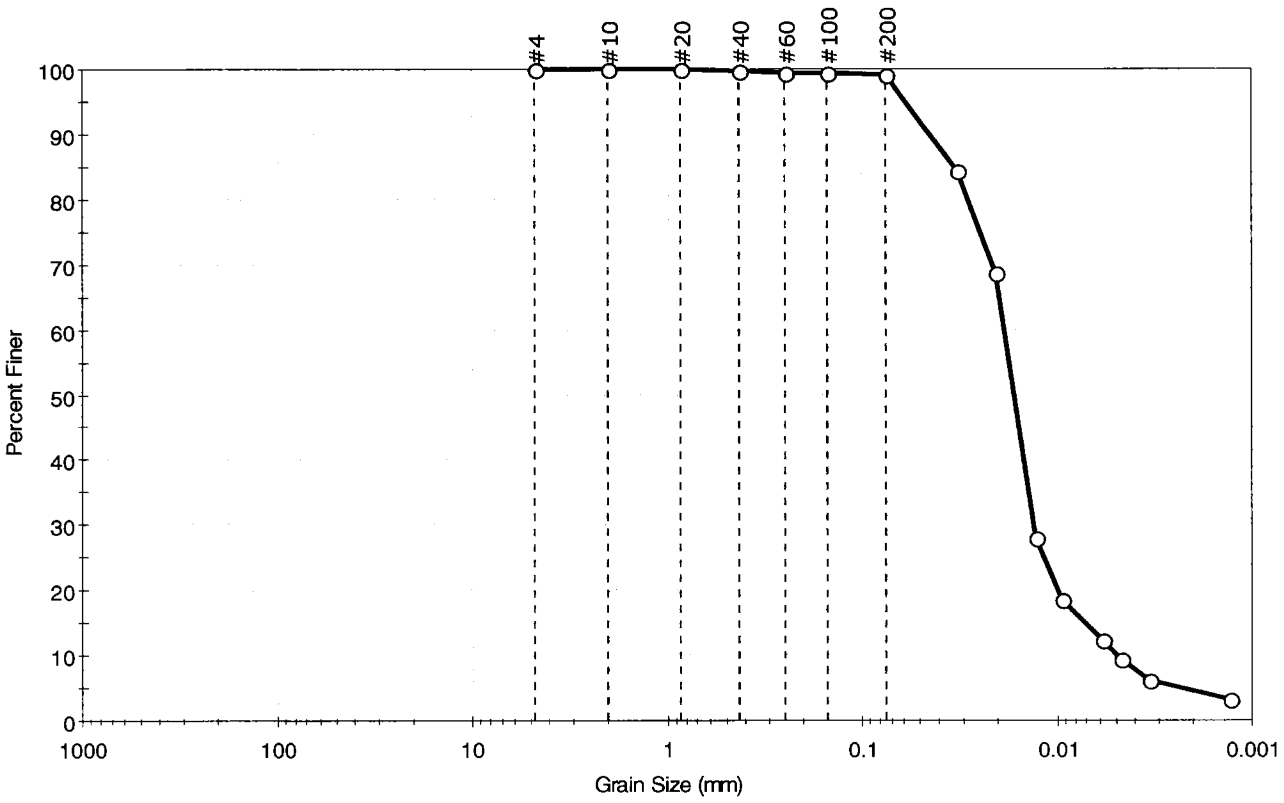
Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---

printed 5/3/2010 12:09:13 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client: Jacobs Civil, Inc.
Project: South Coast Rail
Location: MA
Project No: GTX-9764
Boring ID: FTS-13
Sample Type: jar
Tested By: jbr
Sample ID:S-2
Test Date: 04/28/10
Checked By: jdt
Depth : 3-5 ft
Test Id: 178367
Test Comment: ---
Sample Description: Moist, yellowish brown silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	1.0	99.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	99		
#100	0.15	99		
#200	0.075	99		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0325	84		
---	0.0209	69		
---	0.0130	28		
---	0.0093	19		
---	0.0058	12		
---	0.0047	9		
---	0.0034	6		
---	0.0013	3		

Coefficients

D_{85} =0.0338 mm	D_{30} =0.0133 mm
D_{60} =0.0189 mm	D_{15} =0.0071 mm
D_{50} =0.0168 mm	D_{10} =0.0049 mm
C_u =N/A	C_c =N/A

Classification

<u>ASTM</u> silt (ML)

<u>AASHTO</u> Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

printed 5/3/2010 12:11:24 PM

APPENDIX C: GEOTECHNICAL CALCULATIONS

- Allowable Bearing Capacity and Estimated Settlement
- Seismic Site Class Evaluation

JACOBS

343 Congress Street
Boston, MA 02210
617/242-9222

SHEET 1 OF 2
JOB MBTA South Coast Rail
SUBJECT Freetown Station
CALCULATED BY DH **DATE** 1/31/2012
CHECKED BY PM **DATE** 1/31/2012

PURPOSE: Evaluate bearing resistance for platform shallow foundations.

REFERENCE: AASHTO LRFD Bridge Design Specifications, 2010
AREMA Manual for Railway Engineering, 2011 Edition

ASSUMPTIONS:

- Platform footing is 4 ft wide by 10 ft long.
- Bearing surface is compacted Gravel Borrow overlying silt with sand (ML), silty sand and sand.
- Footing embedment is at least 4 feet below ground surface.
- Groundwater level is about 10 feet below bottom of foundation.
- Footing eccentricity is assumed to be zero.
- Estimated soil properties (experience, geotech literature, Table 10.4.6.2.4-1):

	γ (pcf)	ϕ
Gravel Borrow:	125	34

BEARING CAPACITY FACTORS (Table 10.6.3.1.2a-1):

	ϕ	N_c	N_q	N_γ
Gravel Borrow:	34	42.2	29.4	41.1

CALCULATE EFFECTIVE FOOTING WIDTH (B'):

$e < B/4$ (Section 10.6.3.3)

where: B = footing width (ft) = 4
e = eccentricity (ft)

Assume no footing eccentricity, thus, e = 0

B' = B-2e 4

NOMINAL BEARING RESISTANCE (q_n):

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$ (Eqn. 10.6.3.1.2a-1)

where: c = cohesion = 0
γ = total unit weight 125
D_f = depth of footing (ft) = 4 Assumed
B' = effective width of footing (ft) = 4
L = length of footing (ft) = 10
B'/L = 0.40
D_f /B' = 1.00
C_{wq} $C_{w\gamma}$ = groundwater correction factors (using B')
C_{wq} = 1.0 (Table 10.6.3.1.2a-2)
$C_{w\gamma}$ = 1.0 (Table 10.6.3.1.2a-2)

N_{cm} N_{qm} $N_{\gamma m}$ = bearing capacity factors

$N_{qm} = N_q s_q d_q i_q$ (Eqn. 10.6.3.1.2a-3)

s_q = 1.27 (Table 10.6.3.1.2a-3)

d_q = 1.20 (Table 10.6.3.1.2a-4)

i_q = 1.0 (see AASHTO p. 10-62)

N_{qm} = 44.8

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

$s_\gamma =$ 0.84 (Table 10.6.3.1.2a-3)

$i_\gamma =$ 1 (see AASHTO p. 10-62)

$N_{\gamma m} =$ 34.5

$q_n =$ 31,030 psf

ALLOWABLE BEARING RESISTANCE (q_a):

$q_a = q_n/FOS$

where: FOS = factor of safety = 2.5 for granular soil

$q_a =$ 12,412 psf

use

q_a = 12.41 ksf strength limit value

Note: Based on the anticipated light loads and potentially small footing sizes, an allowable bearing capacity of 6 ksf is recommended.

Elastic Settlement Calculations:

$$S_e = \frac{\left(q_o\,(1-v^2)\sqrt{A'}\right)}{144 E_s \beta_z}$$ eqn. 10.6.2.4.2-1

where: q_o = applied vert. stress (ksf)
v = Poisson's Ratio
E_s = Young's Modulus (ksi)
β_z = Shape/Rigidity Factor

v = Poisson's Ratio = 0.30 (Table C10.4.6.3-1)
E_s = Young's Modulus (ksi) = 6.00 (Table C10.4.6.3-1)
β_z = Shape/Rigidity Factor = 1.11 (Table 10.6.2.4.2-1)

where: B' = eff. width of footing (ft) = 4 (from bearing resistance calcs)
L = length of footing (ft): 10 (from bearing resistance calcs)
A' =(B'xL) = footing area (ft^2): 40 ft^2

Settlement (S_e) for a given q_o:

q_o = applied vertical stress (ksf) = 6.00 ksf (assumed)

Se (inches) = 0.43 inches

JACOBS™

Authored by: DH 1/29/2012
Seismic Parameters_FTS.xls

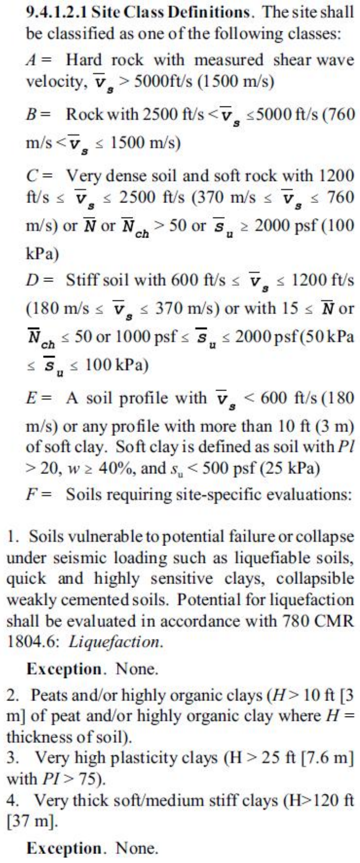
Checked by: PM 1/29/2012

Freetown Station Seismic Site Class Evaluation

Based on the platform boring with the deepest soil overburden and the lowest average blow counts (worst case)

Boring No.	Sample No.	N Value	Di	Di/N$_i$	N$_{bar}$
FTS-1	S-1	8	6	0.75	
	S-2	13	5	0.38	**33**
	S-3	18	5	0.28	
	S-4	14	5	0.36	
	S-5	25	5	0.20	
	S-6	100	5	0.05	
	S-7	66	10	0.15	
	S-8	66	7.25	0.11	
Assumed Weathered rock		66	51.75	0.78	
Total Depth =		100			
Depth to Assumed Bedrock =		48.25	Sum	3.06	

Per 9.4.1.2.1, 15 < N$_{bar}$ < 50, Site Class D



9.4.1.2.1 Site Class Definitions. The site shall be classified as one of the following classes:

A = Hard rock with measured shear wave velocity, $\overline{v}_s$ > 5000ft/s (1500 m/s)

B = Rock with 2500 ft/s < $\overline{v}_s$ ≤5000 ft/s (760 m/s < $\overline{v}_s$ ≤ 1500 m/s)

C = Very dense soil and soft rock with 1200 ft/s ≤ $\overline{v}_s$ ≤ 2500 ft/s (370 m/s ≤ $\overline{v}_s$ ≤ 760 m/s) or $\overline{N}$ or $\overline{N}_{ch}$ > 50 or $\overline{s}_u$ ≥ 2000 psf (100 kPa)

D = Stiff soil with 600 ft/s ≤ $\overline{v}_s$ ≤ 1200 ft/s (180 m/s ≤ $\overline{v}_s$ ≤ 370 m/s) or with 15 ≤ $\overline{N}$ or $\overline{N}_{ch}$ ≤ 50 or 1000 psf ≤ $\overline{s}_u$ ≤ 2000 psf (50 kPa ≤ $\overline{s}_u$ ≤ 100 kPa)

E = A soil profile with $\overline{v}_s$ < 600 ft/s (180 m/s) or any profile with more than 10 ft (3 m) of soft clay. Soft clay is defined as soil with *PI* > 20, *w* ≥ 40%, and s_u < 500 psf (25 kPa)

F = Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. Potential for liquefaction shall be evaluated in accordance with 780 CMR 1804.6: *Liquefaction*.

Exception. None.

2. Peats and/or highly organic clays (*H* > 10 ft [3 m] of peat and/or highly organic clay where *H* = thickness of soil).
3. Very high plasticity clays (H > 25 ft [7.6 m] with *PI* > 75).
4. Very thick soft/medium stiff clays (H>120 ft [37 m].

Exception. None.

Approx. Project Coordinates

Lat	41.772592
Long	-71.093589

Seismic Coefficients

S_S = 0.230 (Table 1604.10*)

S_1 = 0.060 (Table 1604.10*)

For Site Class D

F_A = 1.6 (See Table 9.4.1.2.4a*)

F_V = 2.4 (See Table 9.4.1.2.4b*)

Design Spectral Response Parameters

S_{MS} = Ss x F_A = 0.368

S_{M1} = S_1 x F_V = 0.144

S_{DS} = 2/3 x S_{MS} = 0.245

S_{D1} = 2/3 x S_{M1} = 0.096

Notes: * The Massachusetts State Building Code, 8th Edition (2010)

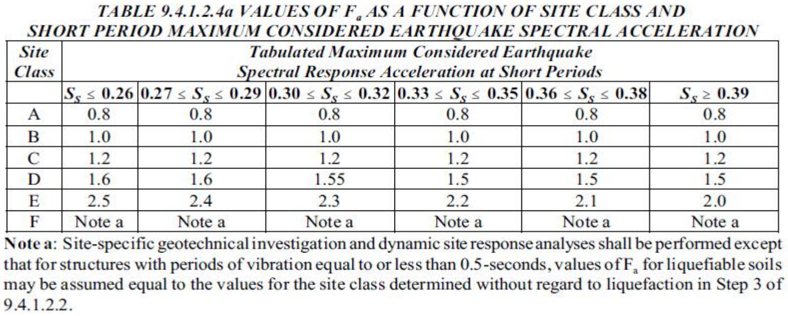


TABLE 9.4.1.2.4a VALUES OF F_a AS A FUNCTION OF SITE CLASS AND SHORT PERIOD MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL ACCELERATION

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at Short Periods*					
	$S_S \le 0.26$	$0.27 \le S_S \le 0.29$	$0.30 \le S_S \le 0.32$	$0.33 \le S_S \le 0.35$	$0.36 \le S_S \le 0.38$	$S_S \ge 0.39$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.2	1.2	1.2	1.2
D	1.6	1.6	1.55	1.5	1.5	1.5
E	2.5	2.4	2.3	2.2	2.1	2.0
F	Note a	Note a	Note a	Note a	Note a	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_a for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

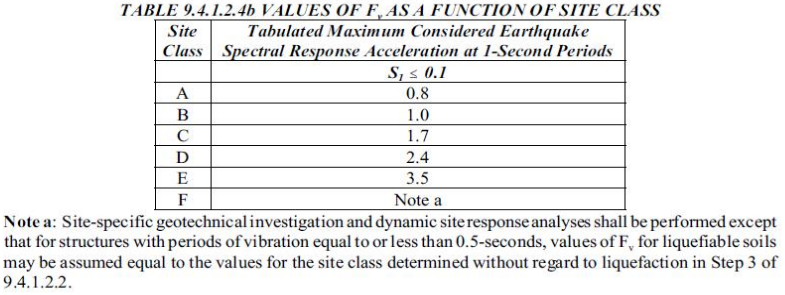


TABLE 9.4.1.2.4b VALUES OF F_v AS A FUNCTION OF SITE CLASS

Site Class	*Tabulated Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Periods*
	$S_1 \le 0.1$
A	0.8
B	1.0
C	1.7
D	2.4
E	3.5
F	Note a

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed except that for structures with periods of vibration equal to or less than 0.5-seconds, values of F_v for liquefiable soils may be assumed equal to the values for the site class determined without regard to liquefaction in Step 3 of 9.4.1.2.2.

TABLE 1604.10 GROUND SNOW LOADS; BASIC WIND SPEEDS; EARTHQUAKE DESIGN FACTORS

(For R-3 of three stories or less one- and two-family stand alone buildings, see 780 CMR 53.00 for snow and wind loads)

City/Town	Ground Snow Load $p_{g,}$ psf	Basic Wind Speed V, MPH	Earthquake Design Factors	
			Ss	S_1
Foxborough	55	100	0.25	0.064
Framingham	55	100	0.26	0.067
Franklin	55	100	0.24	0.064
Freetown	45	110	0.23	0.060
Gardner	65	100	0.26	0.070
Gay Head (a.k.a Aquinnah)	35	120	0.18	0.051
Georgetown	55	110	0.34	0.075
Gill	65	100	0.23	0.069
Gloucester	45	110	0.33	0.073
Goshen	65	100	0.22	0.067
Gosnold	35	120	0.19	0.053
Grafton	55	100	0.24	0.066
Granby	55	100	0.23	0.066
Granville	65	100	0.23	0.066
Great Barrington	65	90	0.22	0.066
Greenfield	65	100	0.23	0.069
Groton	65	100	0.30	0.073
Groveland	55	110	0.34	0.076
Hadley	55	100	0.23	0.067
Halifax	45	110	0.25	0.062
Hamilton	45	110	0.33	0.074
Hampden	55	100	0.23	0.065
Hancock	65	90	0.22	0.068
Hanover	45	110	0.26	0.064
Hanson	45	110	0.25	0.063
Hardwick	55	100	0.23	0.067
Harvard	55	100	0.28	0.070
Harwich	35	120	0.18	0.051
Hatfield	55	100	0.22	0.067
Haverhill	55	110	0.35	0.077
Hawley	65	100	0.22	0.068
Heath	65	100	0.22	0.069
Hingham	45	110	0.27	0.066
Hinsdale	65	90	0.22	0.067
Holbrook	45	105	0.26	0.065
Holden	55	100	0.25	0.068
Holland	55	100	0.23	0.064
Holliston	55	100	0.25	0.066
Holyoke	55	100	0.23	0.066
Hopedale	55	100	0.24	0.065
Hopkinton	55	100	0.25	0.066
Hubbardston	65	100	0.25	0.069
Hudson	55	100	0.26	0.068
Hull	45	110	0.28	0.067
Huntington	65	100	0.22	0.066
Ipswich	45	110	0.34	0.074
Kingston	45	110	0.24	0.061
Lakeville	45	110	0.24	0.061
Lancaster	55	100	0.27	0.070
Lanesborough	65	90	0.22	0.068