DRAINAGE STUDY

Proposed Culvert Replacement South Street over Miscoe Brook Drainage Study

Introduction

This drainage study was performed to study the stormwater runoff conditions for the South Street culvert over Miscoe Brook replacement project in Franklin, MA. The Town of Franklin is proposing a culvert replacement project at the South Street over Miscoe Brook culvert. The proposed culvert provides a span of greater than 10' for a public way and therefore will be under the jurisdiction of MassDOT. The proposed culvert replacement consists of the removal of a degraded, undersized culvert with a Massachusetts Stream Crossing compliant three-sided box culvert. Generally, the proposed roadway features and dimensions will closely match existing conditions. The project is subject to the Massachusetts Department of Environmental Protection Wetlands Protection Act. This analysis has been performed to conclude that the proposed conditions for the project will not have any adverse effects on stormwater conditions.

Stormwater Pre and Post Conditions

The project intends to maintain existing drainage patterns including flow paths, watershed size, peak flows, and discharges for the area of work (approximately 100' on either side of the culvert). The existing roadway utilizes country drainage and has no structural stormwater BMPs in the vicinity of the culvert and Miscoe Brook. There are no proposed changes to ground cover, increase in impervious area, or additional stormwater management BMPs proposed. The project qualifies as a redevelopment project and as a limited project as described in 310 CMR 10.05(6)(k)7, and therefore the project is required to meet certain Stormwater Standards to the maximum extent practicable. The proposed 16' wide by 3' high box culvert opening is a little over 5 times the area of the existing culvert opening. This will provide for an increased hydraulic capacity as well as increased flood storage volume, and help to maintain normal stream flow velocities at the culvert.

Stormwater Standards

Standard 1: No New Untreated Discharges

No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

The intention of this project is to maintain existing drainage patterns. No new stormwater BMPs or discharges are proposed. As designed the project will meet Standard 1 and not discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

Standard 2: Peak Rate Attenuation

Stormwater management systems shall be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates.

As a limited roadway/ redevelopment project, this project must meet this standard to the maximum extent practicable. The intention of this project is to maintain existing drainage patterns, including ground cover, drainage flow paths, conveyances, and therefore peak flows. The project does not propose any increases in impervious surface. As designed the project will not increase pre-development peak discharge rates and meets Standard 2.

Standard 3: Recharge

Loss of annual recharge to groundwater shall be eliminated or minimized through the use of environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance.

As a limited roadway/ redevelopment project, this project must meet this standard to the maximum extent practicable. The intention of this project is to maintain existing drainage patterns, including ground coverage. The project does not include any proposed increase in impervious surfaces or any other change in ground cover, and therefore does not require any proposed groundwater recharge. As designed the project will meet Standard 3 and not cause an increase in loss of annual recharge to groundwater.

Standard 4: Water Quality

Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).

As a limited roadway/redevelopment project, this project must meet this standard to the maximum extent practicable. The intention of this project is to maintain existing drainage patterns, including ground coverage. The project does not include any proposed increase in impervious surfaces, and therefore does not

require any additional water quality treatment BMPs. As designed the project will meet Standard 4 and not cause an impairment of water quality to waters of the Commonwealth.

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

For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.

As a limited roadway/redevelopment project, this project must meet this standard to the maximum extent practicable, however the proposed project area is not considered a land use with higher potential pollutant load since the land use is not changing, therefore, Standard 5 does not apply to this project.

Standard 6: Critical Areas

Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply and stormwater discharges near or to any other critical area require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook.

As a limited roadway/redevelopment project, this project must meet this standard to the maximum extent practicable, however the project area does not discharge to any Critical Areas and therefore Standard 6 does not apply to this project.

Standard 7: Redevelopment and Other Projects Subject to the Standards Only to the Maximum Extent Practicable

A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

This project is considered a redevelopment project as it is the repair of a public roadway and culvert, and as such is required to meet Standards 2, 3, 4, 5, and 6 only to the maximum extent practicable. The intention of this project is to maintain existing drainage patterns, including ground cover, drainage flow paths, conveyances, discharge peak flow rates, groundwater recharge, and water quality. As designed the project will exceed the requirements of Standard 7 by meeting all other Standards to the full extent.

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

A plan to control construction-related impacts, including erosion, sedimentation, and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

This project in whole will disturb less than one acre of land, and therefore the project will not require coverage under the EPA NPDES Construction General Permit.

The project has been designed to include erosion and sedimentation controls to prevent impacts to down gradient resource areas. Perimeter sediment control barriers will be installed in construction areas upgradient of adjacent resources areas.

See attached Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan.

Standard 9: Operation and Maintenance Plan

A Long -Term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function as designed.

The completed stormwater management system will be maintained by the Town of Franklin Department of Public Works. See attached Operation and Maintenance Plan.

Standard 10: Prohibition of Illicit Discharges

All illicit discharges to the stormwater management system are prohibited.

Only stormwater is proposed to be conveyed through the stormwater management system. No illicit materials will be permitted. The Town DPW is responsible for the maintenance of the stormwater system. See attached Illicit Discharge Compliance Statement.

Conclusion

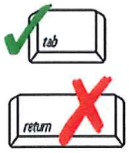
TEC believes the culvert replacement project meets all of the Standards of the MassDEP Stormwater Regulations by matching pre-development conditions after the proposed work has been completed.

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.

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

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.

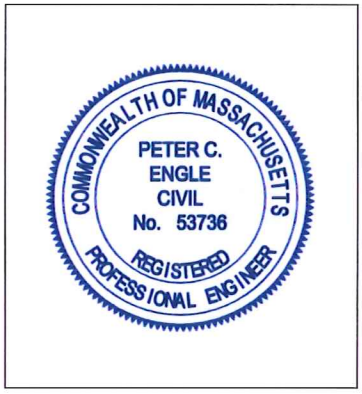
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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



2.7.24

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): Replacement of existing non stream crossing standards compliant culvert with stream crossing standards compliant structure.

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 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 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 for 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.

Illicit Discharge Compliance Statement

Name of Owner: Town of Franklin

Name of Facility: South Street Culvert over Miscoe Brook

Location: Franklin, MA

The Construction Plans and Drainage Report for the South Street Culvert over Miscoe Brook Replacement Project, meet the requirements of Standard 10 of the Massachusetts Stormwater Handbook. The Construction Plans have been prepared by qualified personnel at the direction of **Town of Franklin.**

The Construction Plans identify the location of temporary erosion and sediment control measures and control of water. If required, any dewatering water will be routed to a stilling basin or dewatering bag prior to discharge to a resource area. All aspects of construction period BMPs will be inspected for damage, wear and malfunction, and appropriate steps will be taken to repair or replace construction period BMPs at the site in accordance with the Stormwater Management Standards.

The Construction Plans identify the location of permanent stormwater BMPs and stabilization measures. The Long-Term Operation and Maintenance Plan for the storm water BMPs will be implemented. All aspects of storm water BMPs will be inspected for damage, wear and malfunction, and appropriate steps will be taken to repair or replace the system or portions of the system so that the storm water at the site may be managed in accordance with the Stormwater Management Standards.

There is no record or knowledge of existing illicit discharges to the on-site stormwater management system and there will be no future illicit discharges to the system.

Any future property owners/ operators will be notified of their continuing legal responsibility to operate and maintain the stormwater management system per the Long-Term Operation and Maintenance Plan.

Signature:_____
(To be signed prior to occupancy)

Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan

TEC Project File No. T1406

Proposed Culvert Replacement

South Street Over Miscoe Brook

Prepared for: **Town of Franklin – Dept. of Public Works**
257 Fisher Street
Franklin, MA 02038

Prepared by: **TEC, Inc.**
311 Main Street, Suite 201
Worcester, MA 01608

December 20, 2023

CONSTRUCTION PERIOD POLLUTION PREVENTION AND EROSION AND SEDIMENTATION CONTROL PLAN

Name of Applicant: Town of Franklin
Name of Facility: South Street Culvert over Miscoe Brook
Location: Franklin, MA

Good Housekeeping BMPs

Goals

Minimize the potential for contaminants to enter or runoff from the site during construction activities. Fuel and other equipment related fluids must be properly stored. The Contractor shall establish secure storage areas that collect any spillage to meet requirements of the Fire Department regarding the storage of flammable materials. The Contractor shall complete and submit the plans to the Engineer.

General Requirements

The following presents a proactive approach to all of the best management practices, erosion and sedimentation controls, mitigation measures, and monitoring activities for this Project.

Perimeter Sediment Barrier

A sediment barrier requires a great deal of maintenance. Silt fences should be inspected immediately after each rainfall and at least daily during prolonged rainfall. Remove accumulated sediment when it reaches one half the height of the sediment fence. Remove sediment deposits promptly to provide adequate storage volume for the next rain and to reduce pressure on fence. Take care to avoid undermining fence during cleanout. Sagging, frayed, torn, or otherwise damaged fabric should be repaired or replaced. Repair end runs and undercutting. Inspect reinforcement and staking materials for structural integrity and replace when necessary. Inspect wattles/tubes/socks/bales before a forecasted storm event, immediately after each runoff producing rainfall and at least daily during prolonged rainfall. Ensure there are not gaps or evidence of undermining. Close attention should be paid to the repair of damage, undercutting, and flow around. Necessary repairs or replacement should be accomplished promptly. Replace rotted or sediment covered barriers as necessary. Sediment deposits should be checked after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier. Sediment deposits remaining after the barrier has been removed should be graded to conform to the existing topography and properly stabilized/vegetated.

Temporary Seeding and Slope Stabilization

Seeding shall be used to temporarily stabilize areas that will not be brought to final grade for a period of more than 30 working days and to stabilize disturbed areas before final grading or in a season not suitable for permanent seeding. Stabilization of open soil surfaces will be implemented within 14 days after grading or construction activities have temporarily or permanently ceased unless there is sufficient snow cover to prohibit implementation.

Vegetative slope stabilization will be used to minimize erosion on slopes of 3:1 or steeper. Annual grasses, such as annual rye, will be used to ensure rapid germination and production of root mass. Permanent stabilization will be completed with the planting of perennial grasses or legumes unless otherwise stated on construction documents. Establishment of temporary and permanent vegetative cover may be established by hydro-seeding or sodding. A suitable topsoil, good seedbed preparation, and adequate lime, fertilizer, and water will be provided for effective establishment of

these vegetative stabilization methods. Root systems restrain the soils so that they are less apt to be dislodged and carried offsite by stormwater runoff or wind.

Temporary seeding also reduces the problems associated with mud and dust from bare soil surfaces during construction. Mulch will also be used after permanent seeding to protect soil from the impact of falling rain and to increase the capacity of the soil to absorb water.

General Maintenance

Refer to the Inspection and Maintenance Checklist (at the end of this section) identifying inspection and maintenance measures for each specific BMP.

The contractor or subcontractor will be responsible for implementing each control shown on the Plan. In accordance with EPA regulations, the contractor must sign a copy of a certification to verify that a plan has been prepared and that permit regulations are understood.

The onsite contractor will inspect all sediment and erosion control structures weekly and after each rainfall event meeting the minimum requirements as defined in the Plan.

Records of the inspections will be prepared and maintained onsite by the contractor as required by the Plan, as well as federal, state, and local authorities.

- Silt shall be removed from behind barriers if greater than 6-inches deep or as needed.
- Damaged or deteriorated items will be repaired immediately after identification.
- The underside of wattles/tubes/socks/bales should be kept in close contact with the earth and reset as necessary.
- Sediment that is collected in structures shall be disposed of properly and covered if stored onsite.
- At a minimum establish good housekeeping BMPs for:
    - Material handling and waste management
    - Staging areas
    - Designate washout areas
    - Equipment vehicle fueling and maintenance
    - Spill prevention and control

Erosion control structures shall remain in place until all disturbed earth has been securely stabilized. After removal of structures, disturbed areas shall be regraded and stabilized as necessary.

Spill Prevention and Control

The Contractor will actively maintain and manage the site activities with the procedures outlined in this Plan. In the event of a petroleum or other deleterious substance spill, action will be taken by the Contractor to contain and remove the spill. The Contractor will comply with the relevant section(s) of the Oil Pollution Prevention Act, 40 CFR 112.7.

Responsibility

All project personnel share the responsibility for the initial control and reporting of the oil and other substance spill, especially the personnel that first discover the spill. The Site Safety and Health Officer (SSHO) will be responsible for determining the necessary safety equipment and for establishing safety practices to be followed by the Contractor during the clean-up operations. All personnel will be trained in the use of and location of this equipment, prior to the commencement of the construction.

The Contractor's goal is to provide effective, efficient, and coordinated action to minimize or mitigate damages to the environment and public health and welfare from oil or other substance discharges, conforming to applicable federal, state, and local regulations, as well as other provisions and restrictions. In the event of spills or releases that may occur during the Project, a representative on-site qualified by OSHA training requirements (29 CFR 1910.120) for a Level 3 Hazmat Technician will be provided and will have the responsibility and authority for supervising the cleanup. If the representative determines that the cleanup operations are beyond the capacity of the Contractor, assistance shall be requested from its Subcontractor.

In the event of an emergency spill, the Contractor will be responsible for retaining the environmental Subcontractor. The selected environmental subcontractor will develop a Hazardous Materials Health and Safety Plan, which will be referenced when a spill or release is discovered, and the control of the spill or release is beyond the scope of the Spill Prevention Control and Countermeasure plan. The Contractor's Project Manager is responsible for giving the SSHO directions for initiating the Hazardous Materials Health and Safety Plan.

Alert and reporting procedures will become effective immediately upon observance and indication of a spill or discharge of oil or other substances on the project.

Reportable observations are:

1. Leaks or spills
2. Soils which are discolored or have an odor
3. Discharge of oil or other similar substances from drainpipes.

The Engineer will be informed immediately of all substantial spills, releases, or other substance discharges. All telephone numbers for the Emergency Response agencies will be posted on site. The Contractor or its Subcontractors will implement control and countermeasures immediately.

Fuel and Oil Delivery Trucks

The equipment superintendent or their designee will monitor all truck unloading procedures to verify all hoses are tight and do not leak, and if necessary, will tighten, adjust, or replace them to prevent a release of any kind. In the event of a major spill, alert and initial report procedures will be implemented, and an emergency response contractor will be called in to perform the cleanup.

Equipment

Motorized equipment that requires fuel and oil to operate will be inspected prior to the start of each work shift by the operator (in the field) to ensure there is no leakage of oil, fuel, or other material. Trucks will be inspected prior to use for potential leaks or drips. If a leak is found, repairs will be made immediately, and spillage will be cleaned up manually using sorbent material. Vehicles that are found to be leaking will be immediately taken out of service until repairs can be made.

Drum Storage

Drum storage, if any, will be located in a secure area within the Project limits away from environmental areas of concern. Petroleum liquids and other substances stored in drums will be kept in a drum container that consists of a drum rack and drip containment pan that is capable of containing 110% of the stored volume should the drum rupture.

Lubrication / Oil Maintenance

Replacement lubrication will be directly deposited from the lubrication truck to the equipment lubrication reservoir. No other container system will be used to transport oil to the equipment. Mobile equipment will be serviced off site or in the lay-down area. Equipment that cannot be moved will be serviced in the field. The Contractor will place a containment pan or absorbent below the service area prior to initiating service activities in the field. Waste disposal will be completed by the Contractor or by a waste disposal firm. Miscellaneous lubricants for operating equipment will be limited to daily quantities.

Spent Oil

Oil that has already been used on the job will be disposed of via a certified waste disposal firm. Spent oil will be stored in a labeled (hazardous waste signs) and vented fuel storage cell located at the staging area awaiting disposal by a certified waste disposal firm (i.e. Enpro, Inc.). The staging area will be located within the boundary of the project but outside of resource area buffer zones and inspected daily for leaks or spills. The storage cell will be contained to hold 110% of the largest container or 10% of the total volume in storage, whichever is greater.

Special Oil Spill Equipment

Sorbent Pads

Sorbent pads will be available to absorb oil and petroleum compounds. If necessary, the pads will be used to absorb oil spills or leaks by placing them on the oil and giving them adequate time to absorb it. The sorbent pads will be stored in equipment box located in the maintenance area. The pads shall float and be water repellent, so they can absorb oil on water. Saturated/contaminated pads will be placed in an appropriate container and stored within the maintenance area. A certified waste disposal firm will dispose of the approved containers.

Sorbent Compound

The compound will be used for contaminants spilled on decks or hard surfaces. In most cases, it can be applied directly to spills, but if the spill is large, it can be used to form a dike around the spill to prevent further migration.

Construction Period BMP Inspection & Maintenance Report

General Information			
Project Name			
MassDEP File Number:			
Date of Inspection		**Start/End Time**	
Inspector's Name(s) & Contact Information			

Type of Inspection:
❑ Regular ❑ Pre-storm event ❑ During storm event ❑ Post-storm event

Weather Information

Has there been a storm event since the last inspection? ❑Yes ❑No
If yes, provide:
Storm Start Date & Time: Storm Duration (hrs): Approximate Amount of Precipitation (in):

Weather at time of this inspection?
❑ Clear ❑Cloudy ❑ Rain ❑ Sleet ❑ Fog ❑ Snowing ❑ High Winds
❑ Other: Temperature:

Have any discharges occurred since the last inspection? ❑Yes ❑No
If yes, describe:

Are there any discharges at the time of inspection? ❑Yes ❑No
If yes, describe:

	Site – Specific BMPs	BMP Installed?	BMP Maintenance Required?	Corrective Action Needed and Notes
1	Sediment Control Barrier BMPs	❑Yes ❑No	❑Yes ❑No	
2	Catch Basin Inlet Protection BMPs	❑Yes ❑No	❑Yes ❑No	
3	Soil Stabilization BMPs	❑Yes ❑No	❑Yes ❑No	
4	Dewatering BMPs	❑Yes ❑No	❑Yes ❑No	

CERTIFICATION STATEMENT

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Print name and title: _____

Signature: _____ **Date:** _____

Overall Site Issues

	BMP/activity	Implemented?	Maintenance Required?	Corrective Action Needed and Notes
1	**Slopes** and disturbed areas not actively being worked properly stabilized?	❑Yes ❑No	❑Yes ❑No	
2	**Natural Resource** areas (e.g., streams, wetlands, mature trees, etc.) protected with barriers or similar BMPs?	❑Yes ❑No	❑Yes ❑No	
3	**Perimeter Controls** and sediment barriers adequately installed (keyed into substrate) and maintained?	❑Yes ❑No	❑Yes ❑No	
4	**Discharge Points** and receiving waters free of any sediment deposits?	❑Yes ❑No	❑Yes ❑No	
5	**Storm Drain Inlets** properly protected?	❑Yes ❑No	❑Yes ❑No	
6	**Construction exit** preventing sediment from being tracked into the street?	❑Yes ❑No	❑Yes ❑No	
7	**Trash / Litter** from work areas collected and placed in covered dumpsters?	❑Yes ❑No	❑Yes ❑No	
8	**Washout Facilities** (e.g., paint, stucco, concrete) available, clearly marked, and maintained?	❑Yes ❑No	❑Yes ❑No	
9	**Vehicle and Equipment Fueling,** cleaning, and maintenance areas free of spills, leaks, or any other deleterious material?	❑Yes ❑No	❑Yes ❑No	
10	**Materials** that are potential stormwater contaminants stored inside or under cover?	❑Yes ❑No	❑Yes ❑No	
11	**Non-stormwater discharges** (wash water, dewatering) properly controlled?	❑Yes ❑No	❑Yes ❑No	

Stormwater Management Operations and Maintenance Plan

TEC Project File No. T1406

Proposed Culvert Replacement

South Street Over Miscoe Brook

Prepared for: **Town of Franklin – Dept. of Public Works**
257 Fisher Street
Franklin, MA 02038

Prepared by: **TEC, Inc.**
311 Main Street, Suite 201
Worcester, MA 01608

December 20, 2023

Stormwater Management Operation and Maintenance Plan

Name of Applicant: **Town of Franklin**
Name of Facility: **South Street Culvert over Miscoe Brook**
Location: **Franklin, MA**

A detailed, written log of all scheduled preventative and corrective maintenance performed for the stormwater management measures must be kept by the Applicant, including a record of all inspections and copies of maintenance-related work orders. Attachment 1, "Inspection and Maintenance Check List" shall be maintained as a record of regularly scheduled inspection and maintenance items as outlined below for every year. Maintenance required and actions taken shall be recorded in Attachment 2, "Inspection and Maintenance Log". The funding, operation, and maintenance of all stormwater management Best Management Practices (BMPs) shall be provided by the DPW of Town of Franklin or their appointee.

Maintenance routine and schedule: Routine inspections will be conducted on a monthly basis and thorough investigations will be conducted twice a year. Tasks that are common to all systems include regular removal of accumulated sediments, floatables and debris. Inspections will occur after every major storm event for the first six (6) months after construction. Inspections will be conducted by a person trained in stormwater management systems and experienced in drainage design.

The owner agrees to comply with a minimum maintenance schedule as follows:

1. Grass Landscaping / Vegetative Stabilization

The grass landscaping will be inspected after every major storm event for the two (2) months after seeding to ensure functionality. Thereafter, inspections should take place every six (6) months in the spring and fall and after severe storm events. Grass showing signs of wear and erosion will be re-loamed/re-seeded as necessary to prevent further erosion from taking place.

2. Street Sweeping

Street sweeping schedules: The Town will be responsible for semi-annual street sweeping with sweepings concentrated in the Spring and Fall, consistent with current DPW schedules.

3. Rip Rap/ Stone Stabilization:

Inspect stone after heavy rains for erosion and for stone displacement. Rock may need to be added if sediment builds up in the pore spaces. Make repairs immediately using appropriate stone sizes. If erosion is occurring the stones are too small or not graded well. If the movement of stone is occurring riprap stones may be too small or not graded well, or the appropriate filter fabric may not be installed under riprap. If erosion occurs around the stone, the foundation may not be excavated wide or deep enough. If erosion of the foundation is occurring, the appropriate filter fabric may be damaged or not installed under

the stone and should be installed or repaired. Headwalls should be inspected for cracking, displacement, and erosion around wingwalls. Any signs of erosion should be repaired immediately with appropriate erosion controls blankets or rip rap stone.

The Long-Term Pollution Prevention Plan

The Town of Harvard agrees to comply with the following Long-Term Pollution Prevention Plan to ensure long-term stormwater quality discharge from the site:

- Good housekeeping practices: The project will be maintained by the Town DPW.
- Provisions for storing materials and waste products inside or under cover: No materials or waste products are expected to be stored at the site following construction.
- Vehicle washing controls: No vehicle washing is expected at the site following construction.
- Requirements for routine inspections and maintenance of stormwater BMPs: The Town DPW will provide long-term maintenance of the stormwater system.
- Spill prevention and response plans: There are no proposed uses at the site that would provide an opportunity for a spill of oil or hazardous materials, other than a sudden, catastrophic, vehicle failure. If a vehicle release is the result of an accident, the police and fire department will respond and address any release.
- Provisions for maintenance of lawns, gardens, and other landscaped areas: The Town DPW will provide long-term maintenance for the landscaped areas.
- Requirements for storage and use of fertilizers, herbicides, and pesticides: No storage or use of fertilizers, herbicides, or pesticides are expected at the site following construction.
- Provisions for operation and management of septic systems: The project does not involve any proposed septic systems.
- Provisions for solid waste management: The Town is responsible for roadway litter clean up.
- Snow disposal and plowing plans relative to Wetland Resource Areas: The Town is responsible for snow plowing and disposal. Road snow shall not be stored in wetland resource areas along the roadway.
- Provisions for prevention of illicit discharges to the stormwater management system: Only stormwater is proposed to be conveyed through the stormwater management system. No illicit materials will be permitted. The Town DPW is responsible for the maintenance of the stormwater system. An illicit discharge compliance statement is available.

- 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: Not applicable, the project is not for a LUHPPL.

- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan: The DPW personnel are trained as part of their current work practices.

- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan:

  Town of Franklin Department of Public Works
  DPW Administration Building
  257 Fisher Street
  Franklin, MA 02038
  (508) 553-5500
  (508) 520-4910
  dpw@franklinma.gov

Long-Term Operation and Maintenance
INSPECTION AND MAINTENANCE SCHEDULE

South Street Culvert over Miscoe Brook
Franklin, MA

Best Management Practice (BMP)	Inspection Frequency	Maintenance Frequency
Landscaping and Vegetative Stabilization	After heavy rains and Bi-Annual (Early Spring & Late Fall)	As Needed
Rip Rap/ Stone Stabilization and Headwalls	After heavy rains and Bi-Annually Min (Early Spring & Late Fall)	As Needed
Roadway Sweeping	Bi-Annual (Early Spring & Late Fall)	Bi-Annual (2-Times / Year) (Apr/May and Oct/Nov.)

* Actual time of inspecting and maintaining items may vary. The chart shall be used to indicate the frequency of events.
** This chart shall be used in conjunction with the "Stormwater Management Operations and Maintenance Plan".

Name of Applicant: Town of Franklin

Name of Facility: South Street Culvert over Miscoe Brook

Location: Franklin, MA

Inspection and Maintenance Log

Inspection No.	Date	Inspections Performed	Maintenance Actions Taken
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			

Additional Sheets shall be added as needed.

SUPPORTING MAPS AND DATA

USGS science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map US Topo

FRANKLIN QUADRANGLE
MASSACHUSETTS - RHODE ISLAND
7.5-MINUTE SERIES

Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 19T
This map is not a legal document. Boundaries may be
generalized for this map scale. Private lands within government
reservations may not be shown. Obtain permission before
entering private lands.

Imagery ..... NAIP, July 2016 - September 2016
Roads ..... U.S. Census Bureau, 2015 - 2018
Names ..... GNIS, 1974 - 2018
Hydrography ..... National Hydrography Dataset, 2004 - 2015
Contours ..... National Elevation Dataset, 2012
Boundaries ..... Multiple sources; see metadata file 2016 - 2017
Wetlands ..... FWS National Wetlands Inventory 1992 - 2010

UTM GRID AND 2018 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard.

ADJOINING QUADRANGLES
1 Milford
2 Hollston
3 Medfield
4 Blackstone
5 Wrentham
6 Georgeville
7 Pawtucket
8 Attleboro

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

FRANKLIN, MA, RI
2021

NSN 7643013246254
NGA MEP NO. USGS24K1625X

TEC
The Engineering Corp

311 Main Street, Suite 201
Worcester, MA 01608
774.701.0550

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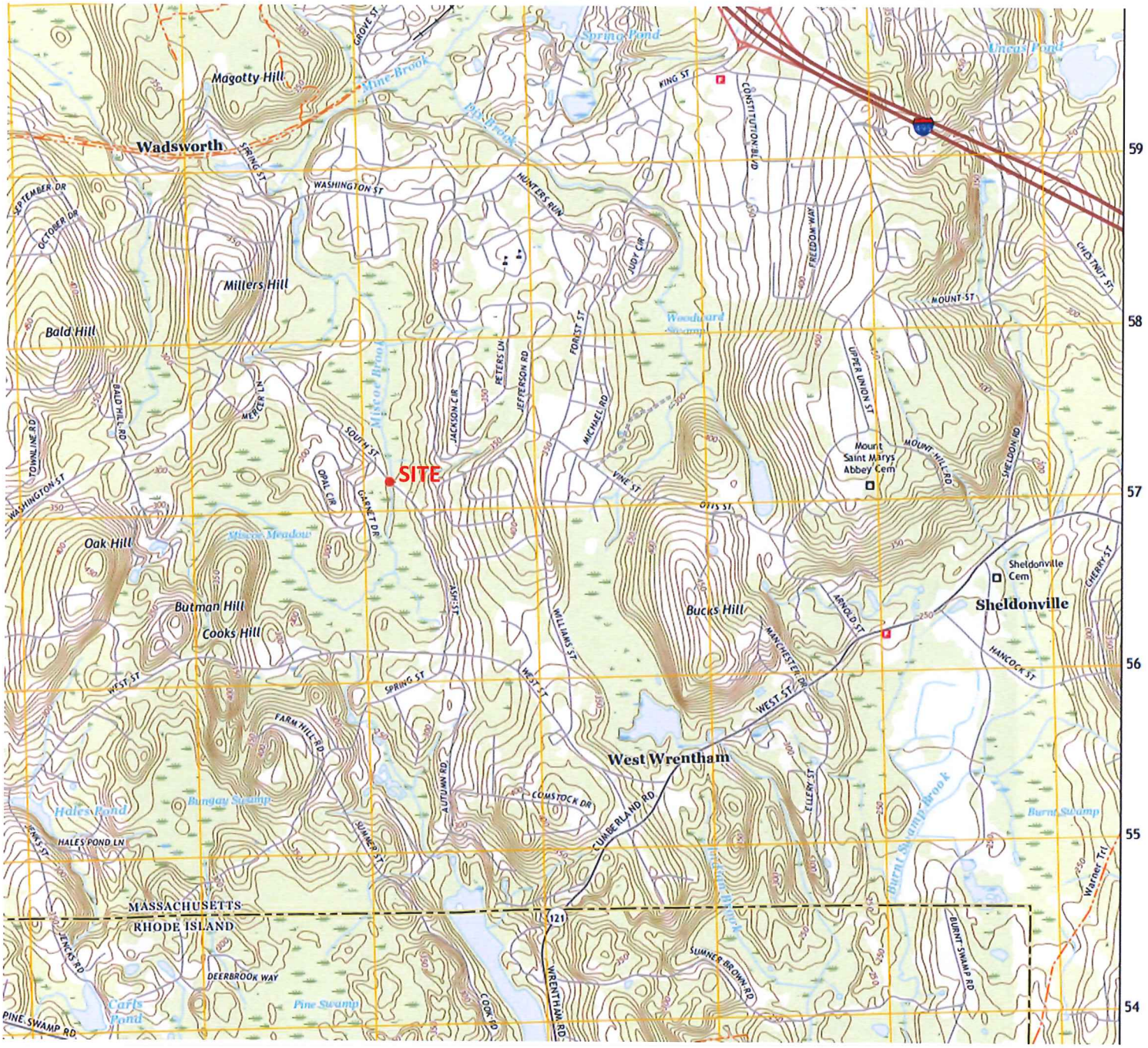

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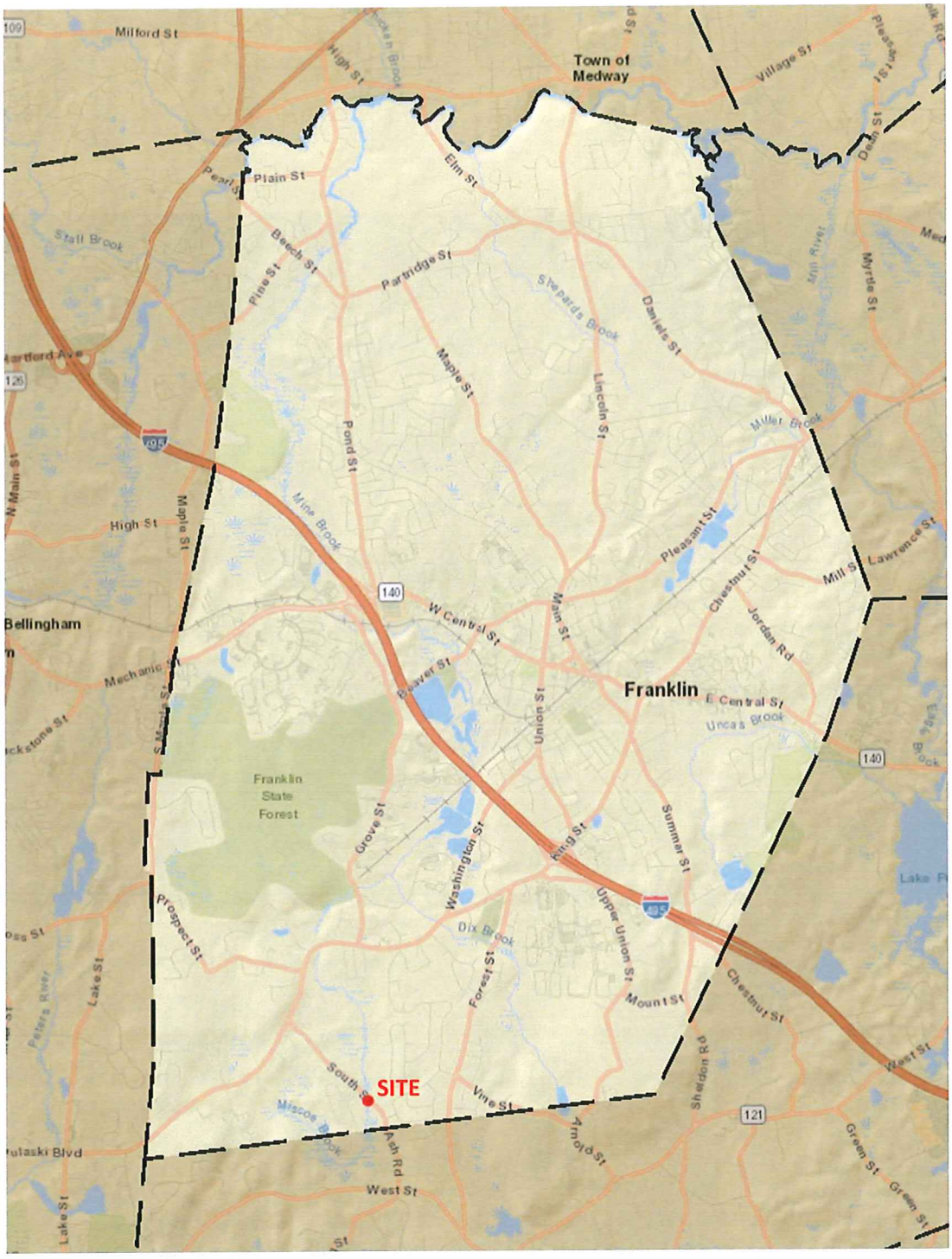
Assessors Map



National Flood Hazard Layer FIRMette

FEMA

71°25'55"W 42°2'42"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

71°25'18"W 42°2'15"N

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) Zone A, V, A99
- With BFE or Depth Zone AE, AO, AH, VE, AR
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
- Future Conditions 1% Annual Chance Flood Hazard Zone X
- Area with Reduced Flood Risk due to Levee. See Notes. Zone X
- Area with Flood Risk due to Levee Zone D

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard Zone X
- Effective LOMRs
- Area of Undetermined Flood Hazard Zone D

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 10/18/2023 at 9:56 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

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NHESP Map

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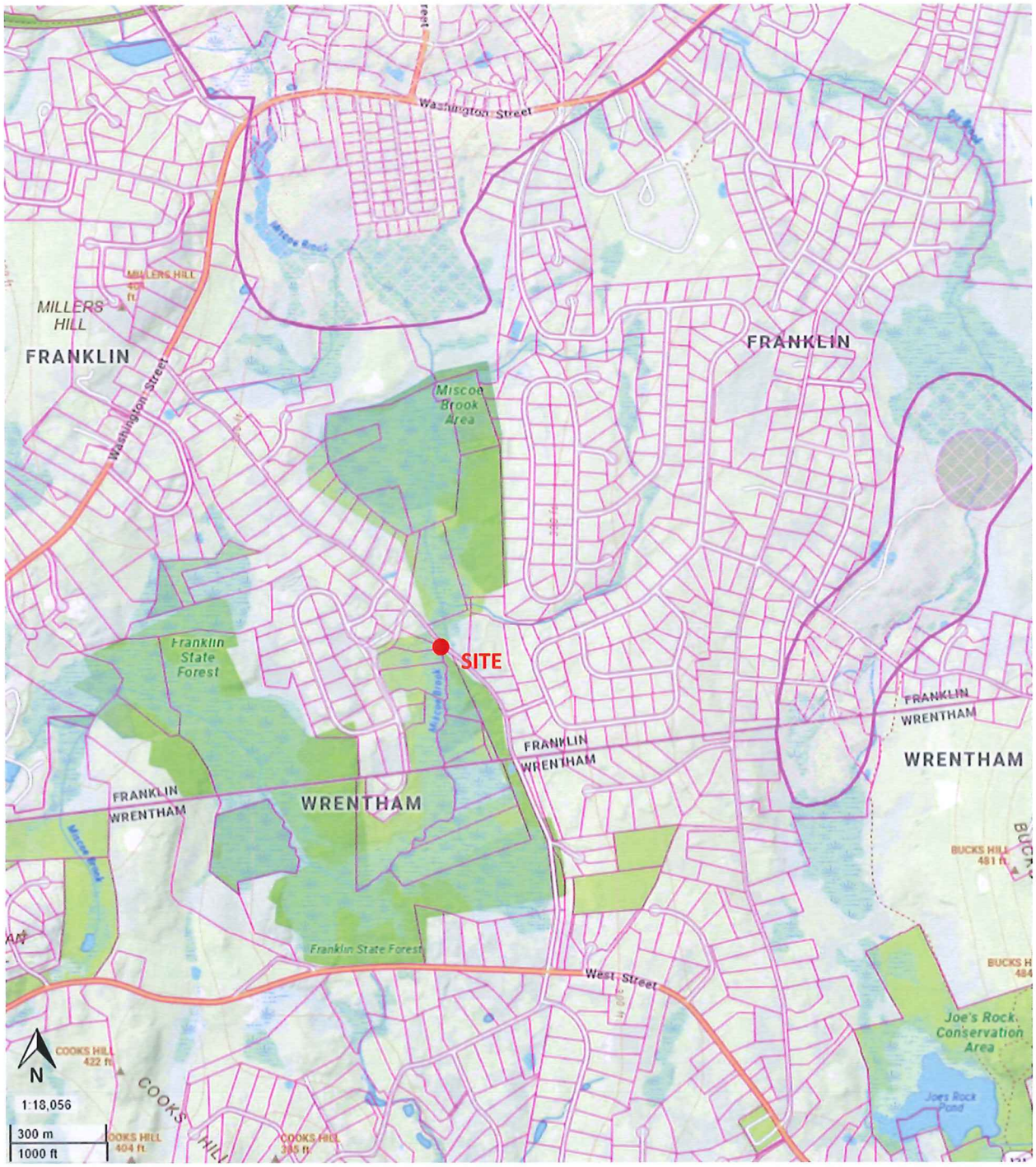
Critical Area/ Wellhead Protection Map



WETLAND RESOURCE DELINEATION REPORT

Client: TEC, David Nader, PE
Hancock Project #: 26500
Address: 96 South Street, Franklin MA
Date: September 28th, 2022

Bordering Vegetated Wetland (BVW) and MAHW associated with a mapped USGS perennial stream (Miscoe Brook) were field delineated by a Wetland Professional in Training Scientist (WPIT®) on September 28th, 2022, in accordance with MassDEP wetland delineation standards.

Bordering Vegetated Wetlands (BVW)

In accordance with the MA WPA implementing regulations set forth under 310 CMR 10.55 and the utilization of the methodology described within (1) "BVW: Bordering Vegetated Wetlands Delineation Criteria and Methodology," issued March 1, 1995; and (2) "Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act: A handbook," produced by the Massachusetts Department of Environmental Protection, date March 1995., Hancock Associates staff delineated the following Bordering Vegetated Wetlands (BVW), which are defined under 310 CMR 10.55(2)(a) as, "freshwater wetlands which border on creeks, rivers, streams, ponds, and lakes. The types of freshwater wetlands are wet meadows, marshes, swamps, and bogs. Bordering Vegetated Wetlands are areas where the soils are saturated and/or inundated such that they support a predominance of wetland indicator plants." The limit of BVW is further defined as *"the line within which 50% or more of the vegetational community consists of wetland indicator plants and saturated or inundated conditions exist. Wetland indicator plants shall include but not necessarily be limited to those plant species identified in the Act. Wetland indicator plants are also those classified in the indicator categories of Facultative, Facultative+, Facultative Wetland-, Facultative Wetland, Facultative Wetland+, or Obligate Wetland in the National List of Plant Species That Occur in Wetlands: Massachusetts (Fish & Wildlife Services, U.S. Department of the Interior, 1988) or Plants Exhibiting Physiological or Morphological Adaptations to Life in the Saturated or Inundated Conditions".*

BVW was delineated to the extent that it would broadcast associated buffer zone toward the limits of proposed work on the roadway. The delineation was based on observations of where vegetative species composition transitions from dominance of wetland indicator species to dominance of upland indicator species. Other notable characteristics were the presence of a perennial stream that had flow downslope to the BVW complex and mucky, saturated soils.

BVW was delineated with two (2) flag series, identified as Series A and Series B as follows:

A-series Wetland

The A series wetland is a BVW located on the western side of Miscoe Brook, which broadcasts associated buffer zones and setback zones in accordance with the Franklin Wetlands Bylaw/Ordinance. The limit of BVW associated with the A-series wetland was demarcated with a two-flag series labeled A (100 through 103E) and A (200 through 204E). A data plot was taken at WFA103 and WFA100 and provided herein within Attachment A.

B-series Wetland

The B series wetland is a BVW located on the eastern side of Miscoe Brook, which broadcasts associated buffer zones and setback zones in accordance with the Franklin Wetlands Bylaw/Ordinance. The limit of BVW associated with the B-series wetland was demarcated with a two-flag series labeled B (100 through 104E) and B (200 through 202E). A data plot was taken at WFB100 and WFB101 and provided herein within Attachment A.

Miscoe Brook - Riverfront (310 CMR 10.58)

In accordance with the MA WPA implementing regulations set forth under 310 CMR 10.58 Hancock Associates wetland staff delineated the following Riverfront which is defined under 310 CMR 10.58(2)(a) as *"Riverfront Area is the area of land between a river's mean annual high-water line and a parallel line measured horizontally. The riverfront area may include or overlap other resource areas or their buffer zones. The riverfront area does not have a buffer zone."*

The Riverfront Area is the area of land between a river's mean annual high-water (MAHW) line measured horizontally outward from the river and a parallel line located 200 feet away in Franklin, Massachusetts.

MAHW was delineated to the extent that it would broadcast associated 200-foot riverfront area toward the limits of proposed work on the property. The delineation was based on observations of hydrology and where vegetative species composition transitions from dominance of wetland indicator species to dominance of upland indicator species.

Riverfront was delineated with four (4) flag series, identified as, MAHW 100-series, 200-series, 300-series, and 400-series as follows:

MAHW 100-series

The 100-series, runs northeast of south street and is bound by South Street to the south and BVW to the north. This delineation is associated with the existing USGS mapped perennial stream (Miscoe Brook), which broadcasts associated buffer zones and setback zones in accordance with the MA WPA, Riverfront Area (10.58), and Franklin Bylaw/Ordinance. The limit of MAHW associated with the existing perennial stream was demarcated with a 100-series of four (4) flags labeled MAHW (100 through 102E).

MAHW 200-series

The 200-series runs parallel to the 100-series just west and is bound by the Commonwealth of Massachusetts land (Map 341, Lot 3) to the east and South Street to the south The limit of MAHW associated with the perennial stream was demarcated with a 200-series of five (5) wetland flags labeled MAHW (200 through 204E), where the terminal flag turns a bit northwest.

MAHW 300-series

The 300-series, runs southwest and is bound by South Street to the south and 2/6 Ruby way to the northwest. This delineation is associated with the existing USGS mapped perennial stream (Miscoe Brook), which broadcasts associated buffer zones and setback zones in accordance with the MA WPA, Riverfront Area (10.58), and Franklin Bylaw/Ordinance. The limit of MAHW associated with the existing perennial stream was demarcated with a 300-series of three (3) flags labeled MAHW (300 through 302E).

MAHW 400-series

The 400-series, runs southeast of south street and is bound by land owned by the Commonwealth of Massachusetts associated with (Map 341 Lot 3) and the MAHW 300-series to the north. This delineation is associated with the existing USGS mapped perennial stream (Miscoe Brook), which broadcasts associated buffer zones and setback zones in accordance with the MA WPA, Riverfront Area (10.58), and Franklin Bylaw/Ordinance. The limit of MAHW associated with the existing perennial stream was demarcated with a 400-series of four (4) flags labeled MAHW (400 through 403E).

Bank full Width

The edge of the bankfull channel typically corresponds to the start of the floodplain. A floodplain receives floodwaters in most years but is vegetated by perennial plants and trees. This vegetation often reflects repeated flow-related disturbance and may not support mature trees. Field determination of the bankfull channel edge of streams rely on where the substrate is dominated by boulders or bedrock or where the channel is tightly confined, a distinct floodplain may not exist. In these situations, you will have to rely on secondary indicators, such as vegetation or other evidence of flood flows to determine the bankfull width. These indicators may include:

- A change in vegetation from bare surfaces or annual water-tolerant species to perennial upland or water-tolerant shrubs and trees.
- Bare areas associated with scour around woody debris or other obstructions.
- The top of point bars; or
- The lowest elevation at which fine organic debris is caught on brush or trees

After field evaluations and desktop analysis was conducted, it was determined that the existing perennial steam at both the inlet and outlet did not give a proper centerline to take bank full width stage evaluation from. There was no single distinct point when we were demarcating the channels on one either side of the banks that would have been viable to pull from.

As requested, two (2) set of USACOE data forms have been provided and attached to this report.

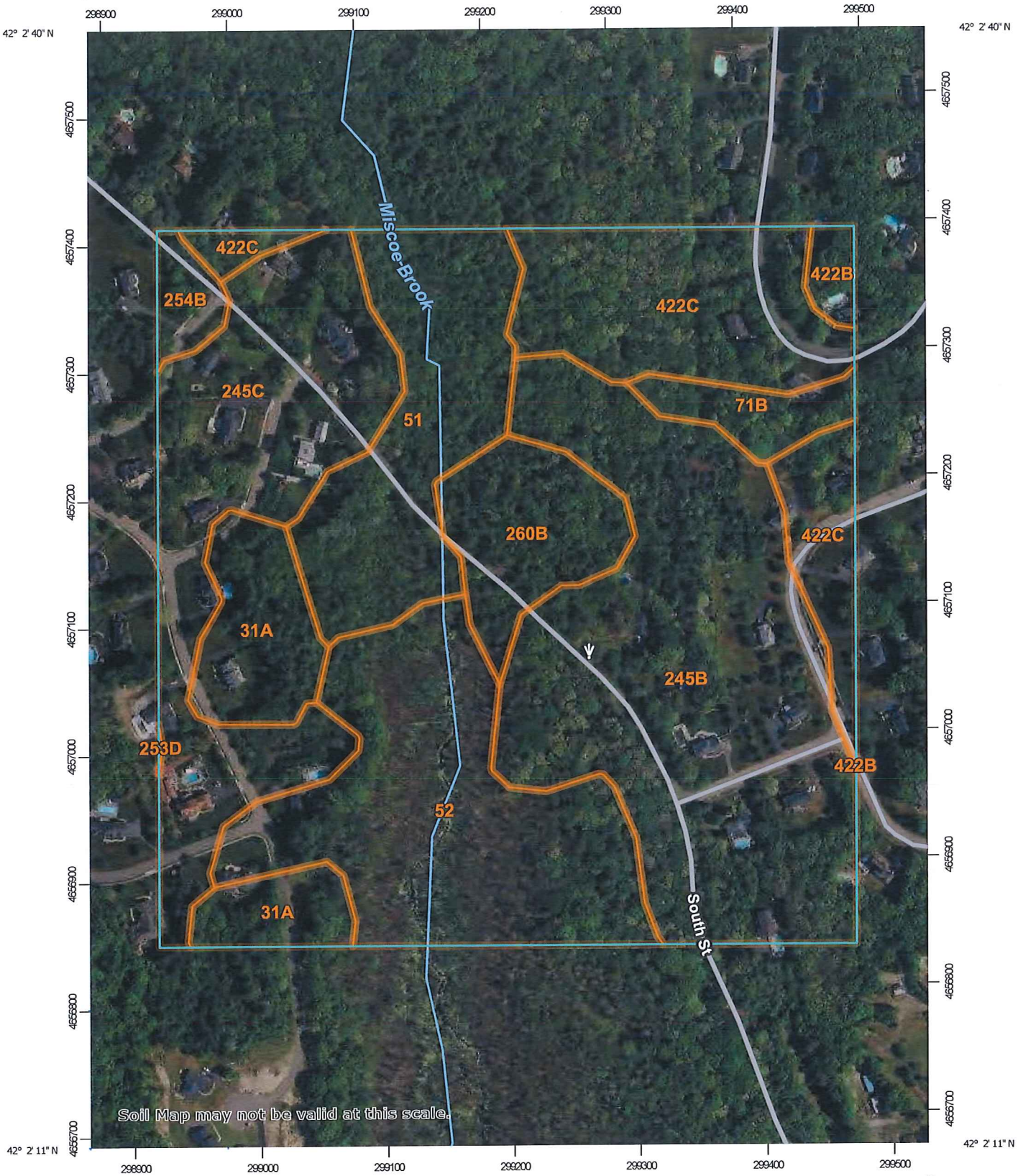
If you have any questions regarding the delineation, please contact me at dmorse@hancockassociates.com or 978-777-3050 ext. 413.

Devon Morse, WPIT
Project Manager/Wetland Scientist
Hancock Associates

Attachments:

A – USACOE Data Forms

Soil Map—Norfolk and Suffolk Counties, Massachusetts
(South Street, Franklin MA)



Map Scale: 1:4,270 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 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 map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 18, Sep 9, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
31A	Walpole sandy loam, 0 to 3 percent slopes	5.0	6.5%
51	Swansea muck, 0 to 1 percent slopes	8.3	10.7%
52	Freetown muck, 0 to 1 percent slopes	12.8	16.6%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	1.7	2.2%
245B	Hinckley loamy sand, 3 to 8 percent slopes	20.8	27.0%
245C	Hinckley loamy sand, 8 to 15 percent slopes	12.5	16.2%
253D	Hinckley loamy sand, 15 to 35 percent slopes	0.0	0.0%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	1.0	1.3%
260B	Sudbury fine sandy loam, 2 to 8 percent slopes	4.1	5.4%
422B	Canton fine sandy loam, 0 to 8 percent slopes, extremely stony	0.7	0.9%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	10.1	13.2%
Totals for Area of Interest		**76.9**	**100.0%**

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: South Street - Miscoe Brook Cuvert Replacement City/County: FRanklin/Norfolk County Sampling Date: 09/28/2022

Applicant/Owner: The Engineering Group (TEC) State: MA Sampling Point: WFA103

Investigator(s): D.Morse, WPIT Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Bogs, swamps Local relief (concave, convex, none): Concave Slope (%): 0-1

Subregion (LRR or MLRA): _____ Lat: 42.04774 Long: -71.426479 Datum: NAD83

Soil Map Unit Name: Swansea muck, 0-1 percent slopes NWI classification: PFO1E

Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No ✓ (If no, explain in Remarks.)

Are Vegetation ✓, Soil ✓, or Hydrology ✓ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:
Level 2 Drought Status decared - referenced from Mass.gov/info-details/drought-status
Disturbed urban roadway

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15) **(LRR U)**
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No ✓	Depth (inches): _____
Water Table Present?	Yes _____	No ✓	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No ✓	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Upland data plot, no wetland hydrology present

VEGETATION (Five Strata) – Use scientific names of plants.

Sampling Point: WFA103

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. eastern white pine (Pinus strobus)	10.0	Yes	FACU
2. northern red oak (Quercus rubra)	10.0	Yes	FACU
3. american elm (Ulmus americana)	3.0	No	FACW
4.			
5.			
6.			
	23	= Total Cover	

50% of total cover: 11 20% of total cover: 5

Sapling Stratum (Plot size: 5' radius)			
1.			
2.			
3.			
4.			
5.			
6.			
	0	= Total Cover	

50% of total cover: _____ 20% of total cover: _____

Shrub Stratum (Plot size: 5' radius)			
1. smooth arrowwood (Viburnum dentatum)	10.0	Yes	FAC
2. black chokeberry (Aronia melanocarpa)	5.0	Yes	FAC
3.			
4.			
5.			
6.			
	15	= Total Cover	

50% of total cover: 7 20% of total cover: 3

Herb Stratum (Plot size: 5' radius)			
1. deer tongue panic grass (Dichanthelium clandestinum)	5.0	No	FACW
2. common plantain (Plantago major)	20.0	Yes	FACU
3. garlic mustard (Alliaria petiolata)	20.0	Yes	FAC
4. common ragweed (Ambrosia artemisiifolia)	20.0	Yes	FACU
5. wrinkle leaf goldenrod (Solidago rugosa)	10.0	No	FAC
6.			
7.			
8.			
9.			
10.			
11.			
	75	= Total Cover	

50% of total cover: 38 20% of total cover: 15

Woody Vine Stratum (Plot size: 30' radius)			
1. virginia creeper (Parthenocissus quinquefolia)	20.0	Yes	FACU
2.			
3.			
4.			
5.			
	20	= Total Cover	

50% of total cover: 10 20% of total cover: 4

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 37% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	2	x 2 =	4
FAC species	3	x 3 =	9
FACU species	5	x 4 =	20
UPL species		x 5 =	
Column Totals:	10 (A)		33 (B)

Prevalence Index = B/A = 3.3

Hydrophytic Vegetation Indicators:

- [x] 1 - Rapid Test for Hydrophytic Vegetation
- [x] 2 - Dominance Test is >50%
- [x] 3 - Prevalence Index is ≤3.0[1]
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes [ ] No [x]

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: WFA103

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-3"								organic layer
3-12"	7.5YR 2.5/3							
12-20"	7.5YR 3/4							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Organic Bodies (A6) **(LRR P, T, U)**
- ___ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ___ Muck Presence (A8) **(LRR U)**
- ___ 1 cm Muck (A9) **(LRR P, T)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Coast Prairie Redox (A16) **(MLRA 150A)**
- ___ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) **(LRR P, S, T, U)**
- ___ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ___ Thin Dark Surface (S9) **(LRR S, T, U)**
- ___ Loamy Mucky Mineral (F1) **(LRR O)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) **(LRR U)**
- ___ Depleted Ochric (F11) **(MLRA 151)**
- ___ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ___ Umbric Surface (F13) **(LRR P, T, U)**
- ___ Delta Ochric (F17) **(MLRA 151)**
- ___ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR O)**
- ___ 2 cm Muck (A10) **(LRR S)**
- ___ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ___ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ☐ **No** ☑

Remarks: Urban roadway with pavement and fill

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: South Street - Miscoe Brook Culvert Replacement City/County: Franklin / Norfolk County Sampling Date: 09/28/2022

Applicant/Owner: The Engineering Group (TEC) State: MA Sampling Point: WFA204

Investigator(s): D. Morse, WPIT Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Bogs, swamps Local relief (concave, convex, none): Concave Slope (%): 0-1

Subregion (LRR or MLRA): _____ Lat: 42.04774 Long: -71.426479 Datum: NAD83

Soil Map Unit Name: Swansea muck, 0 to 1 percent slopes NWI classification: PFO1E

Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No ✓ (If no, explain in Remarks.)

Are Vegetation ✓, Soil ✓, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes ✓	No _____	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks: (Explain alternative procedures here or in a separate report.)

Level 2 Drought Status declared - referenced from Mass.gov/info-details/drought-status

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ✓ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ✓ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15)
- ___ Hydrogen Sulfide Odor (C1)
- ✓ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ✓ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes _____	No ✓	Depth (inches): _____
Water Table Present?	Yes ✓	No _____	Depth (inches): 16"
Saturation Present? (includes capillary fringe)	Yes _____	No ✓	Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: WFA204

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. American elm (Ulmus americana)	35.0	Y	FACW
2. Red maple (Acer rubrum)	25.0	Y	FAC
3. Eastern white pine (Pinus strobus)	3.0	N	FACU
4.			
5.			
6.			
7.			
	63.0	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5' radius)			
1. Northern spicebush (Lindera benzoin)	5.0	Y	FACW
2. Smooth arrowwood (Viburnum dentatum)	5.0	Y	FAC
3.			
4.			
5.			
6.			
7.			
	10.0	= Total Cover	
Herb Stratum (Plot size: 5' radius)			
1. Broadleaved cat-tail (Typha latifolia)	80.0	Y	OBL
2. Sensitive fern (Onoclea sensibilis)	30.0	Y	FACW
3. Common reed (Phragmites australis)	20.0	N	FACW
4. Spotted joe-pye weed (Eutrockium maculatum)	10.0	N	OBL
5. Beaked sedge (Carex rostrata)	40.0	Y	OBL
6. Cinnamon fern (Osmundastrum cinnamomeum)	10.0	N	FACW
7. Deer-tongue rosette-panicgrass (Dichanthelium clandestinum)	3.0	N	FACW
8.			
9.			
10.			
11.			
12.			
	193.0	= Total Cover	
Woody Vine Stratum (Plot size: 30' radius)			
1.			
2.			
3.			
4.			
		= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 7 (A)

Total Number of Dominant Species Across All Strata: 7 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	130	x 1 =	130
FACW species	103	x 2 =	206
FAC species	30	x 3 =	90
FACU species	3	x 4 =	12
UPL species		x 5 =	
Column Totals:	266 (A)		438 (B)

Prevalence Index = B/A = 1.65

Hydrophytic Vegetation Indicators:

- ✓ 1 - Rapid Test for Hydrophytic Vegetation
- ✓ 2 - Dominance Test is >50%
- ✓ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Vegetation Strata:

Tree – Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub – Woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vines – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: WFA204

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-2"								organic layer
2-8"	10YR 2/1							
8-20"	10YR 4/2							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains.

[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) **(LRR R, MLRA 149B)**
- ___ Polyvalue Below Surface (S8) **(LRR R, MLRA 149B)**
- ___ Thin Dark Surface (S9) **(LRR R, MLRA 149B)**
- ___ Loamy Mucky Mineral (F1) **(LRR K, L)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(LRR K, L, MLRA 149B)**
- ___ Coast Prairie Redox (A16) **(LRR K, L, R)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR K, L, R)**
- ___ Dark Surface (S7) **(LRR K, L)**
- ___ Polyvalue Below Surface (S8) **(LRR K, L)**
- ___ Thin Dark Surface (S9) **(LRR K, L)**
- ___ Iron-Manganese Masses (F12) **(LRR K, L, R)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 149B)**
- ___ Mesic Spodic (TA6) **(MLRA 144A, 145, 149B)**
- ___ Red Parent Material (F21)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ✓ No _____

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: South Street - Miscoe Brook Cuvert Replacement City/County: FRanklin/Norfolk County Sampling Date: 09/28/2022

Applicant/Owner: The Engineering Group (TEC) State: MA Sampling Point: WFB101

Investigator(s): D.Morse, WPIT Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Bogs, swamps Local relief (concave, convex, none): Concave Slope (%): 0-1

Subregion (LRR or MLRA): _____ Lat: 42.04774 Long: -71.426479 Datum: NAD83

Soil Map Unit Name: Swansea muck, 0-1 percent slopes NWI classification: PFO1E

Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No ✓ (If no, explain in Remarks.)

Are Vegetation _____, Soil ✓, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No ✓	**Is the Sampled Area within a Wetland?** Yes _____ No ✓
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes _____	No ✓	

Remarks:
Level 2 Drought Status decared - referenced from Mass.gov/info-details/drought-status
Upland plot along urban roadway

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15) **(LRR U)**
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No ✓	Depth (inches): _____
Water Table Present?	Yes _____	No ✓	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No ✓	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Five Strata) – Use scientific names of plants.

Sampling Point: WFB101

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. eastern white pine (Pinus strobus)	10.0	Yes	FACU
2. northern red oak	40.0	Yes	FAC
3.			
4.			
5.			
6.			
	50	= Total Cover	

50% of total cover: 25 20% of total cover: 10

Sapling Stratum (Plot size: 5' radius)			
1.			
2.			
3.			
4.			
5.			
6.			
	0	= Total Cover	

50% of total cover: _____ 20% of total cover: _____

Shrub Stratum (Plot size: 5' radius)			
1. witch hazel	15.0	Yes	FACW
2. coastal sweet pepperbush (Clethra alnifolia)	15.0	Yes	FAC
3.			
4.			
5.			
6.			
	30	= Total Cover	

50% of total cover: 15 20% of total cover: 6

Herb Stratum (Plot size: 5' radius)			
1. deer tongue panic grass (Dichanthelium clandestinum)	10.0	No	FACW
2. common ragweed (Ambrosia artemisiifolia)	20.0	Yes	FACU
3. common plantain (Plantago major)	20.0	Yes	FACU
4. wrinkle leaf goldenrod (Solidago rugosa)	5.0	No	FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	55	= Total Cover	

50% of total cover: 27 20% of total cover: 11

Woody Vine Stratum (Plot size: 30' radius)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

50% of total cover: _____ 20% of total cover: _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 30% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	2	x 2 =	4
FAC species	2	x 3 =	6
FACU species	4	x 4 =	16
UPL species		x 5 =	
Column Totals:	8 (A)		26 (B)

Prevalence Index = B/A = 3.25

Hydrophytic Vegetation Indicators:

- [x] 1 - Rapid Test for Hydrophytic Vegetation
- [x] 2 - Dominance Test is >50%
- [x] 3 - Prevalence Index is ≤3.0[1]
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes [ ] No [x]

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: WFB101

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-2"								organic layer
2-4"	2.5Y 6/3						FLS	
4-12"	2.5Y 5/3							refusal at 12"

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Organic Bodies (A6) **(LRR P, T, U)**
- ___ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ___ Muck Presence (A8) **(LRR U)**
- ___ 1 cm Muck (A9) **(LRR P, T)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Coast Prairie Redox (A16) **(MLRA 150A)**
- ___ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) **(LRR P, S, T, U)**
- ___ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ___ Thin Dark Surface (S9) **(LRR S, T, U)**
- ___ Loamy Mucky Mineral (F1) **(LRR O)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) **(LRR U)**
- ___ Depleted Ochric (F11) **(MLRA 151)**
- ___ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ___ Umbric Surface (F13) **(LRR P, T, U)**
- ___ Delta Ochric (F17) **(MLRA 151)**
- ___ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR O)**
- ___ 2 cm Muck (A10) **(LRR S)**
- ___ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ___ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ☐ **No** ☑

Remarks: Refusal at 12"
Urban roadway with pavement and fill

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: South Street - Miscoe Brook Cuvert Replacement City/County: FRanklin/Norfolk County Sampling Date: 09/28/2022

Applicant/Owner: The Engineering Group (TEC) State: MA Sampling Point: WFB100

Investigator(s): D.Morse, WPIT Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Bogs, swamps Local relief (concave, convex, none): Concave Slope (%): 0-1

Subregion (LRR or MLRA): _____ Lat: 42.04774 Long: -71.426479 Datum: NAD83

Soil Map Unit Name: Swansea muck, 0-1 percent slopes NWI classification: PFO1E

Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No ✓ (If no, explain in Remarks.)

Are Vegetation _____, Soil ✓, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes ✓ No _____	
Wetland Hydrology Present?	Yes ✓ No _____	

Remarks:
Level 2 Drought Status decared - referenced from Mass.gov/info-details/drought-status

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ✓ Saturation (A3)
- ✓ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ Marl Deposits (B15) **(LRR U)**
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ✓ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ✓ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present? Yes _____ No ✓ Depth (inches): _____

Water Table Present? Yes _____ No ✓ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ✓ No _____ Depth (inches): 0"

Wetland Hydrology Present? Yes ✓ No _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
Bank of Miscoe River

VEGETATION (Five Strata) – Use scientific names of plants.

Sampling Point: WFB100

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. eastern white pine (Pinus strobus)	10.0	Yes	FACU
2. red maple (Acer rubrum)	10.0	Yes	FAC
3. american elm (Ulmus americana)	20.0	Yes	FACW
4. swamp white oak (Quercus bicolor)	10.0	Yes	FACW
5.			
6.			
	50	= Total Cover	
50% of total cover: 25	20% of total cover: 10		

Sapling Stratum (Plot size: 5' radius)			
1.			
2.			
3.			
4.			
5.			
6.			
	0	= Total Cover	
50% of total cover:	20% of total cover:		

Shrub Stratum (Plot size: 5' radius)			
1. highbush blueberry (Vaccinium corymbosum)	15.0	Yes	FACW
2. coastal sweet pepperbush (Clethra alnifolia)	30.0	Yes	FAC
3.			
4.			
5.			
6.			
	45	= Total Cover	
50% of total cover: 22	20% of total cover: 9		

Herb Stratum (Plot size: 5' radius)			
1. deer tongue panic grass (Dichanthelium clandestinum)	10.0	No	FACW
2. tall meadow rue (Thalictrum pubescens)	20.0	Yes	FACW
3. cinnamon fern (Osmundastrum cinnamomeum)	20.0	Yes	FACW
4. wrinkle leaf goldenrod (Solidago rugosa)	20.0	Yes	FAC
5. smallspike false nettle (Boehmeria cylindrica)	15.0	Yes	OBL
6.			
7.			
8.			
9.			
10.			
11.			
	85	= Total Cover	
50% of total cover: 42	20% of total cover: 17		

Woody Vine Stratum (Plot size: 30' radius)			
1. poison ivy (Toxicodendron radicans)	5.0	Yes	FAC
2. river grape (Vitis riparia)	15.0	Yes	FAC
3.			
4.			
5.			
	20	= Total Cover	
50% of total cover: 10	20% of total cover: 4		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 11 (A)

Total Number of Dominant Species Across All Strata: 12 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 92% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	1	x 1 =	1
FACW species	5	x 2 =	10
FAC species	5	x 3 =	15
FACU species	1	x 4 =	4
UPL species		x 5 =	
Column Totals:	12 (A)		30 (B)

Prevalence Index = B/A = 2.5

Hydrophytic Vegetation Indicators:

- [x] 1 - Rapid Test for Hydrophytic Vegetation
- [x] 2 - Dominance Test is >50%
- [x] 3 - Prevalence Index is ≤3.0[1]
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes [x] No [ ]

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: WFB100

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains.

[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ Organic Bodies (A6) **(LRR P, T, U)**
- ___ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ___ Muck Presence (A8) **(LRR U)**
- ___ 1 cm Muck (A9) **(LRR P, T)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Coast Prairie Redox (A16) **(MLRA 150A)**
- ___ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7) **(LRR P, S, T, U)**
- ___ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ___ Thin Dark Surface (S9) **(LRR S, T, U)**
- ___ Loamy Mucky Mineral (F1) **(LRR O)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Marl (F10) **(LRR U)**
- ___ Depleted Ochric (F11) **(MLRA 151)**
- ___ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ___ Umbric Surface (F13) **(LRR P, T, U)**
- ___ Delta Ochric (F17) **(MLRA 151)**
- ___ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR O)**
- ___ 2 cm Muck (A10) **(LRR S)**
- ___ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ___ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ___ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

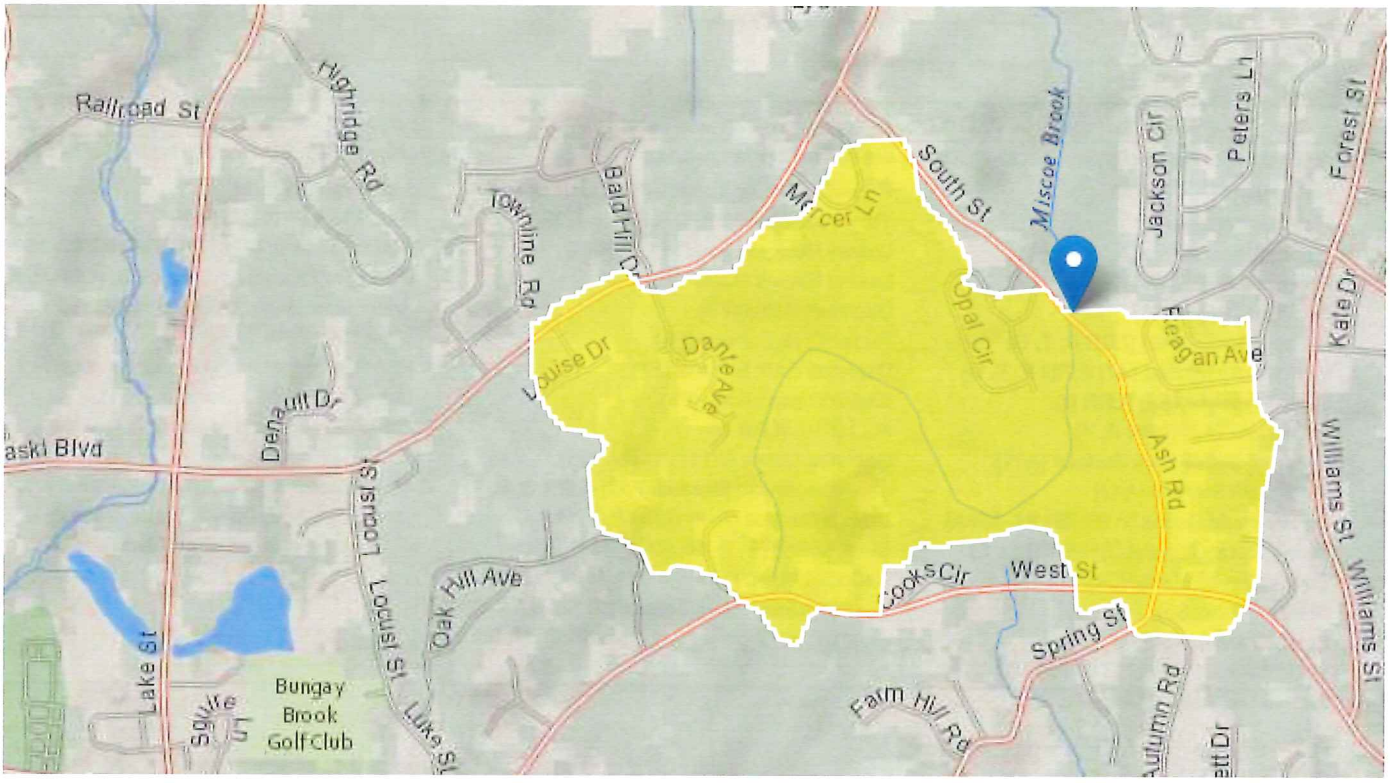
Depth (inches): _____

Hydric Soil Present? **Yes** ☑ **No** ☐

Remarks: Mucky peat soils along river bank (Miscoe River)

Miscoe Brook at South Street StreamStats Report

Region ID: MA
Workspace ID: MA20231221173644939000
Clicked Point (Latitude, Longitude): 42.04104, -71.42656
Time: 2023-12-21 12:37:05 -0500



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	7.064	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	2.345	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.31	square mile per mile
DRNAREA	Area that drains to a point on a stream	1.17	square miles
ELEV	Mean Basin Elevation	307	feet
FOREST	Percentage of area covered by forest	89.59	percent

Parameter Code	Parameter Description	Value	Unit
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	20.32	percent
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	66.93	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.16	512
ELEV	Mean Basin Elevation	307	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	20.32	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	32.3	ft^3/s	16.5	63.4	42.3
20-percent AEP flood	54.3	ft^3/s	27.3	108	43.4
10-percent AEP flood	72	ft^3/s	35.3	147	44.7
4-percent AEP flood	97.6	ft^3/s	46.3	206	47.1
2-percent AEP flood	119	ft^3/s	54.6	259	49.4
1-percent AEP flood	142	ft^3/s	63.2	319	51.8
0.5-percent AEP flood	166	ft^3/s	71.7	384	54.1
0.2-percent AEP flood	201	ft^3/s	82.8	488	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics

Low-Flow Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	2.345	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Low-Flow Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.121	ft^3/s
7 Day 10 Year Low Flow	0.052	ft^3/s

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	2.345	percent	0.32	24.6

Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
50 Percent Duration	1.12	ft^3/s
60 Percent Duration	0.806	ft^3/s
70 Percent Duration	0.522	ft^3/s
75 Percent Duration	0.41	ft^3/s
80 Percent Duration	0.38	ft^3/s
85 Percent Duration	0.276	ft^3/s
90 Percent Duration	0.227	ft^3/s
95 Percent Duration	0.124	ft^3/s
98 Percent Duration	0.0786	ft^3/s
99 Percent Duration	0.0555	ft^3/s

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	2.345	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.31	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
August 50 Percent Duration	0.296	ft^3/s

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	7.064	percent	2.2	23.9

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Bankfull Width	16	ft	21.3
Bankfull Depth	0.993	ft	19.8
Bankfull Area	15.7	ft^2	29
Bankfull Streamflow	41.5	ft^3/s	55

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	16.2	ft
Bieger_D_channel_depth	1.17	ft
Bieger_D_channel_cross_sectional_area	19.3	ft^2

Bankfull Statistics Disclaimers [New England P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	26.4	ft
Bieger_P_channel_depth	1.42	ft
Bieger_P_channel_cross_sectional_area	37.5	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	13.1	ft
Bieger_USA_channel_depth	1.25	ft
Bieger_USA_channel_cross_sectional_area	18.6	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Bankfull Width	16	ft	21.3
Bankfull Depth	0.993	ft	19.8
Bankfull Area	15.7	ft^2	29
Bankfull Streamflow	41.5	ft^3/s	55
Bieger_D_channel_width	16.2	ft	
Bieger_D_channel_depth	1.17	ft	
Bieger_D_channel_cross_sectional_area	19.3	ft^2	
Bieger_P_channel_width	26.4	ft	
Bieger_P_channel_depth	1.42	ft	
Bieger_P_channel_cross_sectional_area	37.5	ft^2	
Bieger_USA_channel_width	13.1	ft	
Bieger_USA_channel_depth	1.25	ft	
Bieger_USA_channel_cross_sectional_area	18.6	ft^2	

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_cam

Probability Statistics

Probability Statistics Parameters [Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	66.93	percent	0	100
FOREST	Percent Forest	89.59	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Flow Report [Perennial Flow Probability]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PC
Probability Stream Flowing Perennially	0.835	dim	71

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.17	square miles	0.1	3000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 2]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	6260	ft^3/s

Maximum Probable Flood Statistics Citations

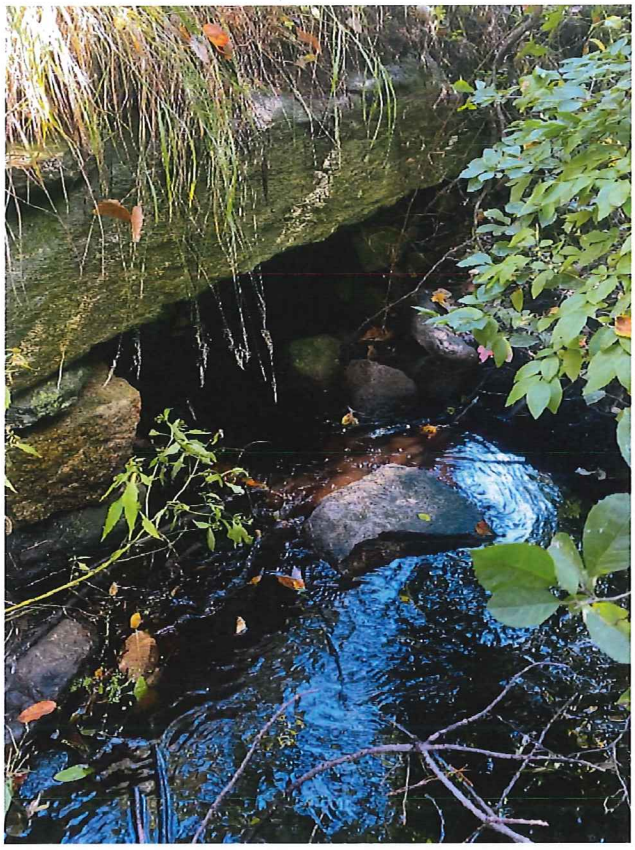
Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

Application Version: 4.19.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.3.2

H&H ANALYSIS

HYDRAULIC STUDY REPORT

South Street over Miscoe Brook
Town of Franklin, Norfolk County, Massachusetts
Bridge No. Unclassified Municipal
PROJECT No. 22-0177



December, 2022

Prepared for:

TEC - The Engineering Corp
282 Merrimack Street, 2d Floor
Lawrence, MA 01843
978.794.1792

Table of Contents

List of Tables

List of Figures

1.0 Executive Summary

The purpose of this technical report is to present the results of a study conducted at the culvert conveying Miscoe Brook under South Street in Franklin, MA in order to evaluate the hydraulic performance of the existing culvert and to develop an alternative design. This report was prepared in a manner consistent with the Massachusetts Department of Transportation (MassDOT) guidelines for preparation of hydraulic studies at bridge sites modified to account for the preliminary nature of the design.

The scope of this investigation consisted of a review of pertinent hydrologic analysis data for the Miscoe Brook at the Project site and a detailed hydraulic analysis. Data collected, hydraulic model input/output and scour calculations are presented in the appendices of this report. A narrative discussion of the problem statement, engineering methods, and the conclusions of the hydraulic study follows.

2.0 Project Description

The culvert is located on South Street about 0.8 miles south of the intersection of Washington Street in the town of Franklin, Norfolk County, Massachusetts **(Figure 2-1).**

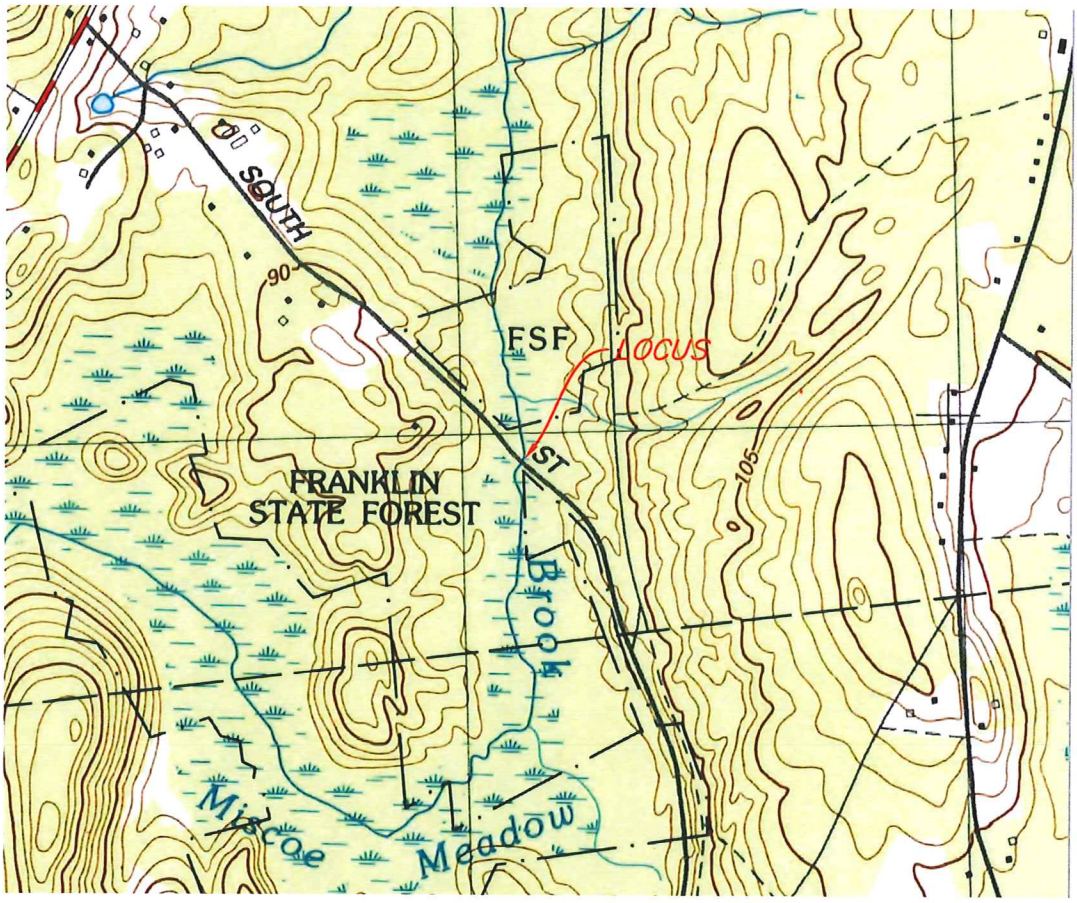


Figure 2-1: Culvert Location

2.1 Existing Structure

The subject culvert is located on South Street in the Town of Franklin, Norfolk County, Massachusetts located largely within the South Street layout about 0.8 miles south of the intersection with Washington Street. The Massachusetts State Plane Coordinates (NAD83-feet) for the center of the culvert are N 2,839,920/E 676,116 **(Appendix 7.1.1)**. The culvert does not have a MassDOT designation and the date of construction is unknown. The culvert consists of 2' high x 4.5' wide open bottom box culvert that is about 36'long. The outlet has a 42" RCP pipe inserted into the structure for an unknown distance, which we assume was to reinforce a failing structure. There are stone headwalls on both ends.

The roadway is a two-lane Urban Local roadway approximately 22' wide with no curbing or sidewalks in the area of the culvert. There is approximately 3.5' of cover over the existing culvert at the crown of the roadway. The runoff from the roadway sheet flows off the pavement on the sides of the road where it then flows into the brook.

.

Figure 2-2: Existing Culvert

2.1.1 Crossed Waterway at the Culvert Location

The Miscoe Brook flows from its source in the Miscoe Meadow about 1.3 miles west of the point where it flows under South Street. The river continues to flow north toward Mine Brook. The upstream drainage area is about 1.14 square miles **Figure 2-3**. According to the USGS map, the stream is perennial (**Appendix 7.1.1**).

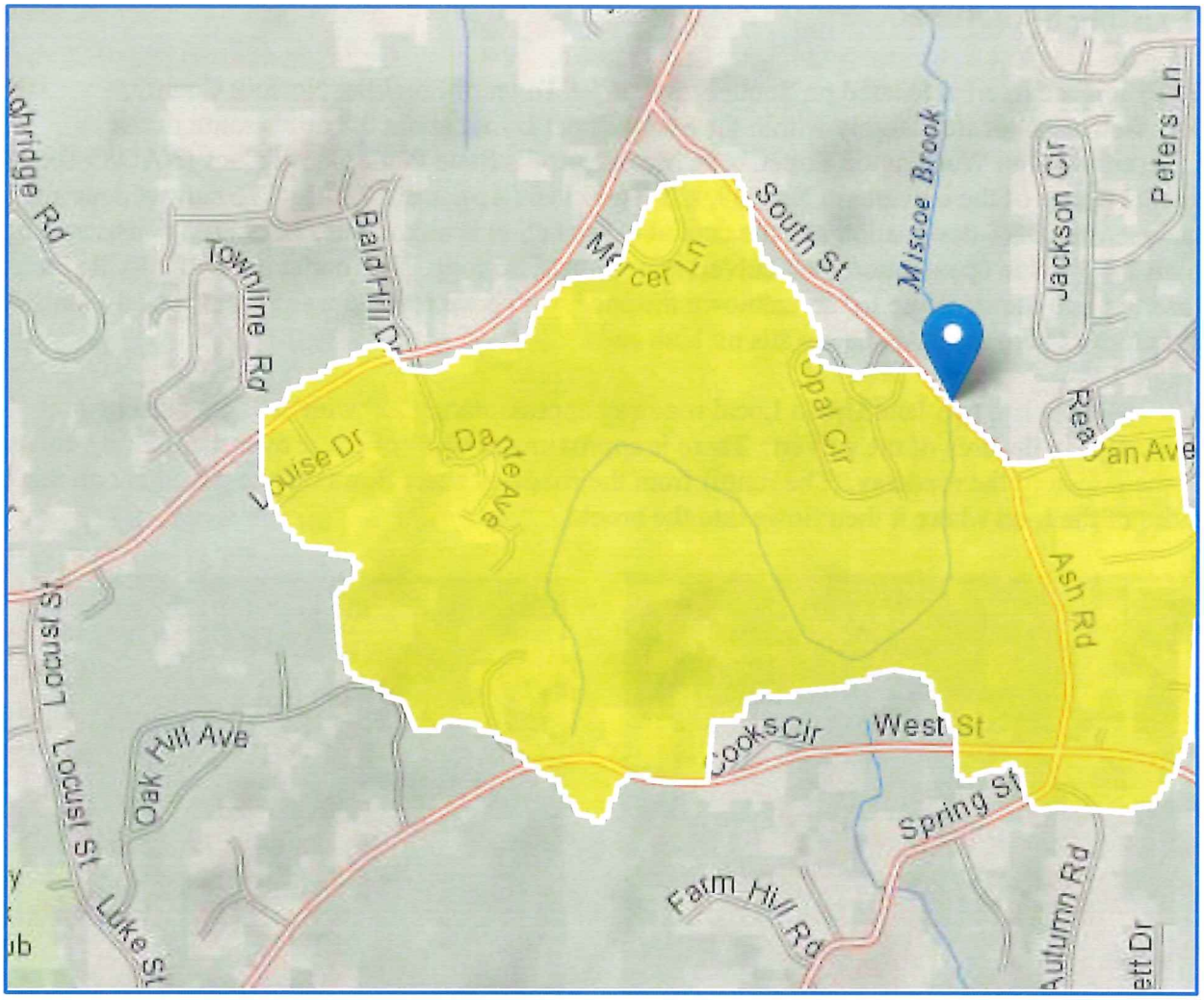


Figure 2-3: Drainage Area at Bridge Crossing

2.1.2 Highway Conveyed

South Street is classified as an Urban Local road which conveys approximately 1,154 vehicle trips per day. It is two-lane and approximately 22' wide with no curbing in the area of the culvert.

2.1.3 Land Use in the Vicinity of the Bridge

Land use near the bridge is a mix of private, state and town-owned forest and single-family residential homes. (**Figure 2-4**).

Figure 2-4: Land Use at the Bridge Location

2.1.4 Special Site Considerations

The existing culvert is located within the National Flood Insurance Program (NFIP) Special Flood Hazard Area (SFHA) Zone A as shown on the 2012 Flood Insurance Rate Map (FIRM) Panel No. 25021C0316E (**Appendix 7.1.2 and Figure 2-5**).

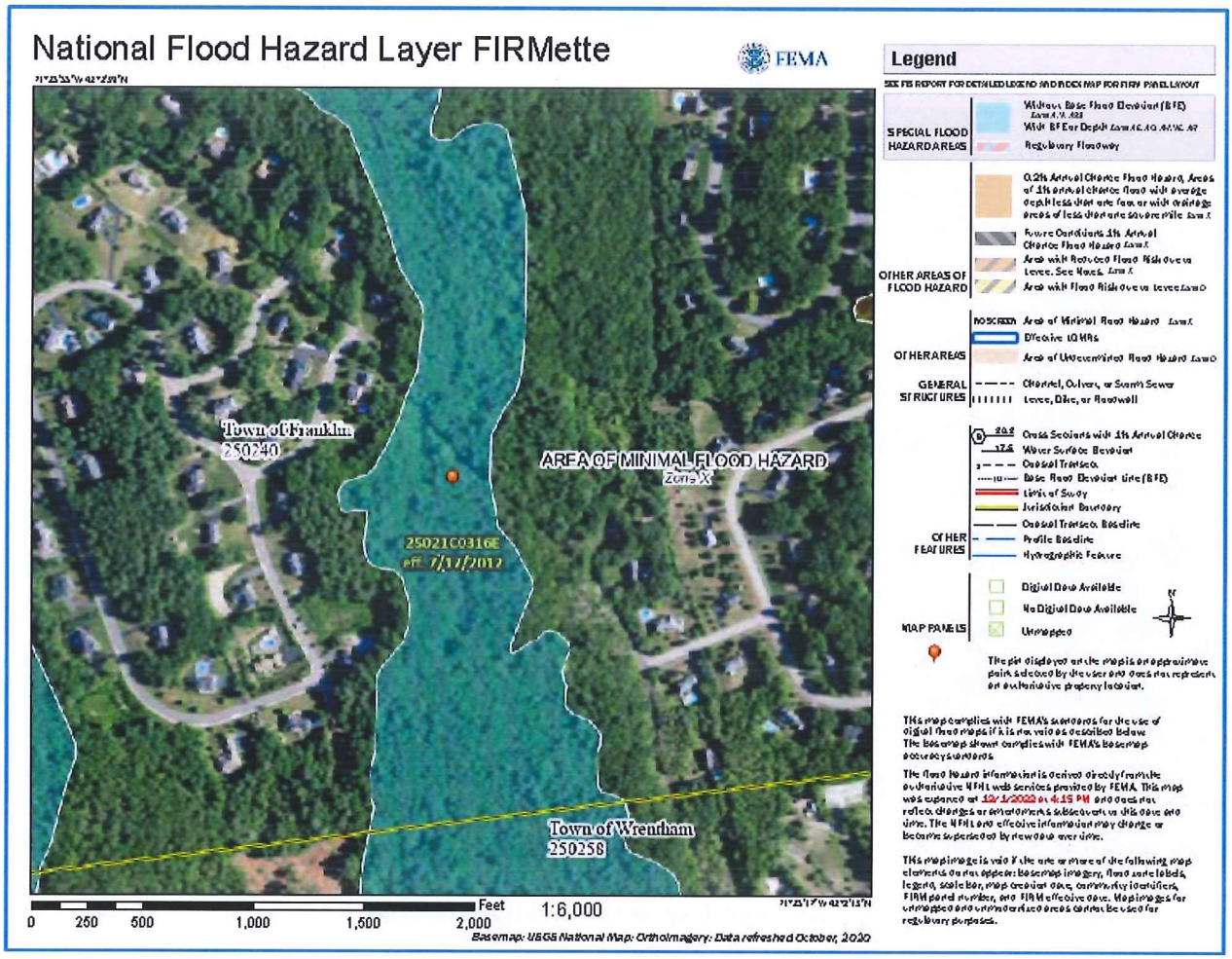


Figure 2-5: Flood Insurance Rate Map

2.2 Proposed Action

The project objective is to upgrade the existing culvert to the maximum feasible extent to comply with the MassDOT LRFD Bridge Manual (**Reference 2**) and with the Massachusetts Stream Crossing Standard (**Reference 6**). The proposed action is the construction of a culvert with 0 degree headwalls and wing walls in the same general location and alignment with the existing culvert. **Figures 2-6 to 2-7** show the proposed cross sections of the alternatives.

- Alternative 1 – 3'H x 16'W Open Bottom Precast Concrete Culvert
- Alternative 2 – 3'H x 8'W Open Bottom Precast Concrete Culvert

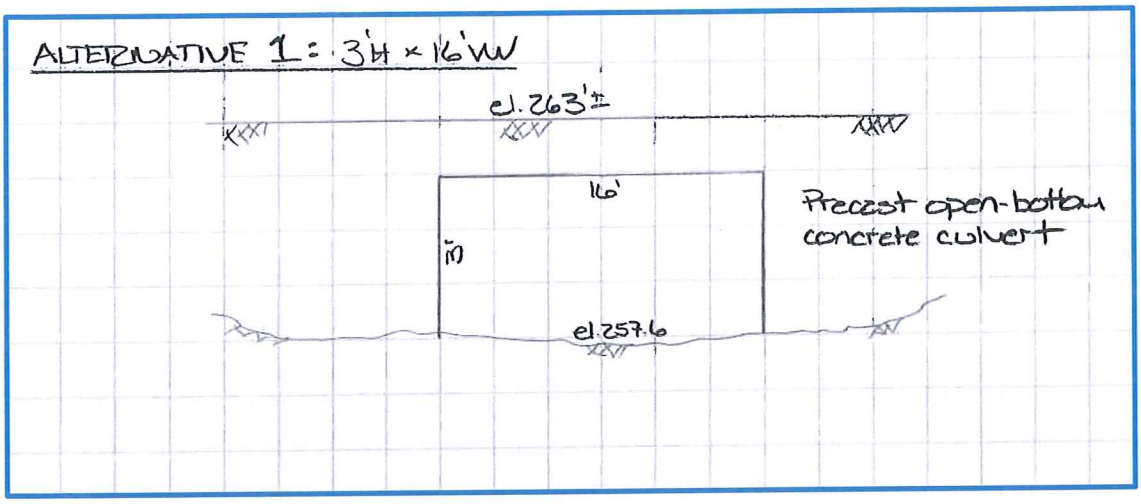


Figure 2-6: Alternative 1: 3'H x 16'W

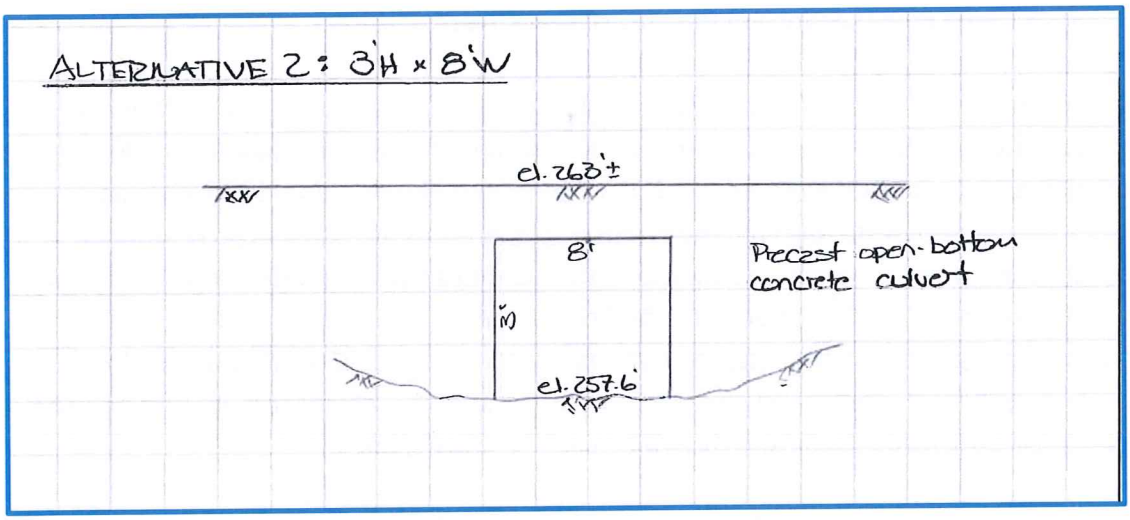


Figure 2-7: Alternative 2: 3'H x 8'W

3.0 Data Collection

The following references and reports on the study area were available and were used as guidance during the hydrologic and hydraulic model development and analysis:

- Norfolk County Flood Insurance Rate Map (FIRM) No. 25021C0316E, July 17, 2012 **(Reference 1)**
- USGS Gauging Station 01103220 Miscoe Brook Franklin, MA data **(Appendix 7.2.2)**
- Scour Sediment Sampling Results (**Appendix 7.4.2**)
- Base plans prepared by Hancock Associates, September 8, 2022

4.0 Engineering Methods

Hydrologic and hydraulic analyses were conducted to estimate the peak design discharges and water surface elevations respectively at the culvert location. The following sections briefly describe the methodology.

4.1 Hydrologic Analysis

The objective of the hydrologic analysis was to establish the 10% (10-yr), 4% (25-yr), 2% (50-yr) and 1% (100-yr) annual probability event peak discharges for Miscoe Brook at the Project site and to establish boundary conditions required for the hydraulic and scour analysis. The design flood frequency for an *Urban Local* bridge is 10% (**Reference 2**). The stream's drainage area at the Project location was delineated using the USGS StreamStats Website (**Reference 8**); See **Section 2.1.1** and **Figure 2-3** for delineated area at the bridge.

There is no available data at the FEMA Engineering Library to determine the base flood elevations or surveyed cross sections in the area of the culvert.

USGS Gauge No. 01103220 **(Reference 3)** is located at the culvert location. The drainage area at this gauging station is 1.15 square miles. Nine years of peak flow data from 2001 to 2009 is available at the gauge **(Appendix 7.2.2)**. This data will be used to determine the design flows for the bridge site through the use of a standard Log Pearson Type III annual flood frequency analysis of the gauge data using the PeakFQ software **(Reference 7).** Given the short period of record of the gauge data, the PeakFQ peak flows for the various return frequencies will not generate a high degree of accuracy for hydrologic conditions for the site and will not be used for the proposed condition hydraulic and scour analyses, but will be used as a check on the Streamstats data, which will be used for the design.

The Streamstats peak flows used in the design and the PeakFQ flows at the culvert site are detailed in **Table 4-1** and the hydrologic computations are in **Appendix 7.2.4**.

Table 4-1: Peak Flood Discharges

Annual Probability Flood Event	Streamstats Peak Flow (cfs)	PeakFQ Flow @ Site USGS Stream Gauge 01103220 (cfs)
10% (10-year)	69.8	39.0
4% (25-year)	94.6	56.2
2% (50-year)	115.0	72.2
1% (100-year)	137.0	91.4

4.2 Hydraulic Analyses

The hydraulic analysis was conducted using the US Army Corps of Engineer (USACOE), Hydrologic Engineering Center, HEC-RAS version 6.2 River Analysis System (**Reference 9**). HEC-RAS is capable of calculating steady flow water surface profile computations, one- and two-dimensional unsteady flow simulation, movable boundary sediment transport computations and water quality analysis. For the purposes of this analysis, we will be using the one-dimensional, steady flow water surface profile module to calculate the water surface profiles for the existing condition and then develop a proposed upgraded design for the project site. Water surface profiles for 10%, 4%, 2% and 1% annual chance peak discharge events were developed in a manner consistent with the applicable NFIP base floodplain development performance standards. The datum used in all hydraulic models is NAVD 1988.

4.2.1 No-Rise and Existing Conditions Analyses

Because the existing structure spans does not span an effective NFIP regulatory floodway it is not necessary to develop a no-rise base flood elevation profile hydraulic analysis as outlined in the MassDOT LRFD Bridge Manual, Part 1, January 2020 Revision, paragraph 1.3.5 (**Reference 3**). However, a notional no-rise base flood analysis using the same general criteria will be conducted and the goal is to demonstrate that there will not be an increase in the base flood elevation in the area of the culvert.

4.2.2 Duplicative Effective Analysis

A duplicative effective analysis was conducted that involved creating an existing conditions profile using the Streamstats derived 1% annual chance peak event (Table 4-1). The reach domain was run between HEC-RAS cross section 0, which is about 216' downstream of the site, to cross section HEC-RAS cross section 506, which is about 250' upstream of the site. Additional surveyed cross section data was input between the limits in order to accurately represent the channel geometry **Figure 4-1**. The Streamstats base flow listed in **Table 4-1** was used and a normal depth slope of 0.0023 was used as the upstream reach boundary condition. A summary of the duplicative effective analysis is presented in **Table 4-2**

Table 4-2: Comparison of Existing and Proposed BFE's for 1% Probability Design Flow

HEC-RAS Cross Section	Description of Cross Section	Existing Water Surface Elevation (ft,NAVD)	Alternative 1 Proposed Water Surface Elevation (ft,NAVD)	Alternative 1 Project Impact (ft)	Alernative 2 Proposed Water Surface Elevation (ft,NAVD)	Alternative 2 Project Impact (ft)
0	Survey	258.7	258.7	0.0	258.7	0.0
216	Survey	260.3	259.2	-1.1	259.2	-1.1
Bridge						
256	Survey	263.0	259.9	-3.1	261.2	-1.8
376	Survey	263.0	260.3	-2.7	261.4	-1.6
506	Survey	263.0	260.8	-2.3	261.5	-1.6

The duplicative model was used run using HEC-RAS in a subcritical flow mode under the following two scenarios: (1) Using the Streamstats base flow and normal depth for boundary conditions for the

no-rise analysis and; (2) Using the Streamstats derived flows and normal depth for boundary conditions for the Project design.

Figure 4-1: HEC-RAS Cross Section Layout Plan

4.2.3 Proposed Condition Analysis

The proposed action is to replace the existing culvert and the alternatives described in **Section 2.2** were evaluated. The proposed condition models were developed after updating the existing culvert geometry with the proposed culvert geometry. All other model parameters remain the same as in the existing condition model. The proposed condition analysis was performed:

(1) To compare the effective existing condition model with the proposed model results using the Streamstats 1% probability event base flow for the no-rise analysis; and
(2) To evaluate the Project impact using the Streamstats flow data for the design hydrology.

Proposed Condition No-Rise Analysis

For the no-rise analysis, the proposed model was analyzed with the Streamstats 1% frequency event base flow listed in **Table 4-1** and a normal depth slope = 0.0023 as the upstream boundary condition using one dimensional steady state HEC-RAS modeling. The model was run in a subcritical flow regime. **Table 4-2** shows the results of the no-rise analysis at each of the HEC-RAS cross sections.

Proposed Condition Design Flood Analysis

As stated, all design flood simulations performed in HEC-RAS modeling were run in a subcritical flow mode and employed the Streamstats discharges listed in **Table 4-1.** The upstream and downstream boundary conditions were assumed to be normal depth. **Table 4-3** summarizes the hydraulic performance at the upstream cross section (HEC-RAS Cross Section 256) of the culvert for the existing condition and the proposed alternatives for the 1% frequency event. The water surface elevations for both alternatives are less than then existing conditions, and the average velocity decreases for all conditions.

Table 4-3: Summary of Hydraulic Performance Upstream of Culvert

Annual Probability Flood Event	Peak Flow (cfs)	Existing		Alternative 1		Alternative 2	
		WSEL (ft, NAVD)	Average Velocity (ft/sec)	WSEL (ft, NAVD)	Average Velocity (ft/sec)	WSEL (ft, NAVD)	Average Velocity (ft/sec)
10% (10-year)	69.8	262.2	7.8	259.1	3.2	259.9	4.7
4% (25-year)	94.6	263.0	8.6	259.4	3.8	260.4	5.4
2% (50-year)	115	263.0	8.2	259.6	4.2	260.8	5.8
1% (100-year)	137	263.0	7.4	259.9	4.6	261.2	6.3

The site has a Highway Functional Classification of Urban Local and Table 1.3.4-1 of the MassDOT LRFD Manual (**Reference 2**) lists the hydraulic design flood as the 10% annual chance event which has been calculated as 69.8 cfs (**Table 4-1**). A comparison of the 1% (100-yr) design base flood elevations (BFE) between the existing and all proposed modeled cross sections is presented in **Table 4-2.**

The proposed stream WSEL will be the same, or less than, the existing WSEL at all cross sections. **Table 4-2** and **Appendix 7.3** list the results of the HEC-RAS modeling and WSEL profiles of the river.

4.2.4 Scour Safety and Stability Analysis

Scour potential at the crossing site was analyzed using the requirements set forth by MassDOT's LRFD Bridge Manual, section 1.3.3.5 (**Reference 2**) and using the guidelines by FHWA HEC-18, "*Evaluating Scour at Bridges*" (**Reference 5).** In accordance with Section 1.3.4 of LRFD Bridge Manual, for *Urban Local* Highway Functional Classification, the river's 4% (25-year) and 2% (50-year) chance flood events were used as the scour design and scour check events respectively.

The design approach was to estimate long term aggradation/degradation, flood related contraction and local abutment scour depths for the 4% and 2% chance flood events. In this study the abutment scour is calculated using MassDOT Modified Froehlich Equation for Abutment Scour and the Modified Lauren's 1960 Equation used to calculate contraction scour.

The hydraulic variables used for scour calculations were obtained from the HEC-RAS model results. The results were extracted from cross sections at the approach section and contracted section. As listed in **Section 3.0**, the soil data for scour calculations was obtained from the sampling analysis conducted as part of this project **Appendix 7.4.1**. No historical data was available to calculate scour due to long term aggradation and degradation. In both the scour design and check event analyses, it is assumed that the channel bed elevation will not degrade over the service life of the culvert. A summary of computed 4% and 2% annual chance flood scour depths is presented in **Table 4-4.** See **Appendix 7.4.2** for the detailed scour calculations.

Table 4-4: Summary of Calculated Scour

Alternative	Annual Chance Event (%)	Contraction Scour (ft)	Local Abutment Scour (ft)	Total Abutment Scour (ft)
1	4	0.3	1.6	1.9
	2	0.3	1.9	2.2
2	4	0.7	2.2	2.9
	2	0.9	2.5	3.4

4.2.5 DEP Stream Crossing Standards

The DEP Stream Crossing Standards analyze a proposed crossing on a number of criteria that fall under the rubric of General Standard or Optimum Standard. The General Standard is typically reserved for repairs or replacements to existing structures and Optimum Standard for new construction. Alternative 1 will meet all of the General and Optimum Standards and Alternative 2 will meet the same except for the Crossing Span. See **Table 4-6** for a summary of the criteria.

Table 4-5: DEP Stream Crossing Standards

Standard	General Standard	Optimum Standard	Alternative #1	Alternative #2
1. Type of Crossing	Spans strongly preferred	same	Open Bottom Box Culvert	Open Bottom Box Culvert
2. Embedment	Culverts embedded 2'	same	Embedded min 2'	Embedded min 2'
3. Crossing Span	Spans channel width min of 1.2 bankfull width	Spans min of 1.2 bankfull with sufficient headroom to provide dry passage of wildlife	1.2 bankfull width w/3'+/- headroom	0.60 bankfull width w/3'+/- headroom
4. Openness	Openness ratio of 0.82. Crossing should be wide and high relative to length.	Openness ratio of 1.64 and min height of 6'. If significant conditions reduce wildlife passage maintain min height of 8' and openness ratio of 2.64	Openness ratio of 1.33 w/3'+/- height	Openness ratio of 0.67 w/ 3'+/- height
5. Substrate	Natural bottom	same	Natural bottom	Natural bottom
6. Water Depth & Velocity	Comparable to found in natural channel	same	Water depth and velocity are comparable to natural channel	Water depth and velocity are comparable to natural channel

5.0 Conclusions & Recommendations

5.1 Conclusions

1. The Project hydraulic model predicts that the existing culvert will convey the 10% annual chance design flood event.
2. The Project hydraulic model predicts that either alternative will safely convey the 10% annual chance design flood event, but will not have 2' of freeboard.
3. Both alternatives will convey the entire storm and will not have weir flow over the roadway during the 1% chance flood event.
4. Alternative 1 will meet all the DEP Stream Crossing General Standards
5. Alternative 2 will not meet the Crossing Span or Openness standards of the DEP Stream Crossing Standards.

5.2 Recommendations

6. The information in **Table 5-1** for the recommended alternative should be presented within the Hydraulic Data Tables in the General Notes of the Construction Plan sets.
7. The grades that will exist at the headwall should be stabilized with flexible revetments consisting of MassDOT Standard Specification M2.02.0 Riprap over a composite filter medium consisting of a layer of MassDOT Standard Specification M2.01.1, crushed stone placed over an appropriate MassDOT Standard Specification M9.50.0 Geotextile Fabric membrane.
8. The calculated 4% (25-year) chance flood event total scour depth presented in **Table 5-1** for Alternative 1 should be considered for use as a bridge foundation condition in LRFD strength and service limit state foundation stability determination. Similarly, the calculated 2% (50-yr) chance flood event scour depth should be considered for use as a bridge foundation condition in the LRFD extreme event limit state foundation stability determination. The design engineer should be cognizant that the proposed culvert substructure will meet the foundation scour stability requirements set forth in MassDOT Bridge LRFD Manual (**Reference 2**), Section 3.2.10, and presented below.

   For new bridges or full bridge replacements, the substructures shall be designed to meet the requirements of Paragraphs 3.2.10.2 and 3.9.10.3 for the calculated design and check scour without using scour countermeasures.

9. The design engineer should specify that the material to be placed in the stream under the bridge meets the gradation of the existing stream bed (**Appendix 7.4.1**).

Table 5-1: Hydraulic Design Data (Existing & Proposed Conditions)

Hydraulic Design Data		
Drainage Area:	1.14 Square miles	
Design Flood Discharge:	69.8 Cubic Feet Per Second	
Design Flood Annual Chance (Return Frequency):	10% (10 Years)	
	Alternative 1	**Alternative 2**
Design Flood Velocity (feet per second-fps):	3.2 fps	6.3 fps
Design Flood Elevation (feet-NAVD 88):	259.1'	261.2'
Base (100- YEAR) Flood Data		
Base Flood Discharge:	137 Cubic Feet per Second	
Base Flood Elevation:	263.0 Feet, NAVD 88	
Design and Check Scour Data	**Alternative 1**	**Alternative 2**
Scour Design Flood Annual Chance (Return Frequency):	4% (25 Years)	
Design Flood Abutment Scour Depth:	1.6 Feet	2.2 Feet
Design Flood Contraction Scour Depth:	0.3 Feet	0.7 Feet
Scour Check Flood Annual Chance (Return Frequency):	2% (50 Years)	
Check Flood Abutment Scour Depth:	1.9 Feet	2.5 Feet
Check Flood Contraction Scour Depth:	0.3 Feet	0.9 Feet
Flood of Record		
Discharge:	Not Known	
Frequency (If Known):	Not Known	
Maximum Elevation:	Not Known	
Date:	Not Known	
History of Ice Floes:	None documented	
Evidence of Scour and Erosion:	None documented	

6.0 References

6.1 Data Sources

Reference No.	Title
1	Norfolk County Flood Insurance Rate Map (FIRM) No. 25021C0316E, July 17, 2012
2	MassDOT LRFD Bridge Manual, January 2020 Revision
3	USGS Gauge Data from Station 01103220 @ Miscoe Brook Franklin, MA
4	USGS Scientific Investigations Report 2016-5156, Magnitude of Flood Flows at Selected Annual Exceedance Probabilities for Streams in Massachusetts; Zarriello, P.J., 2017
5	US Department of Transportation Federal Highway Administration Hydraulic Engineering Circular No. 18 "Evaluating Scour at Bridges", Fifth Edition, April 2012
6	MassDOT "Design of Bridges and Culverts for Wildlife Passage at Freshwater Streams" December, 2010

6.2 Data Applications

7	Peak FQ v 7.1, Annual Flood Frequency Analysis Using USGS Bulletin 17C Guidelines
8	United States Geological Survey (USGS) National Streamflow Statistics (StreamStats), Version 4.10.11
9	US Army Corps of Engineer (USACOE), Hydrologic Engineering Center, HEC-RAS River Analysis System, Version 6.2 March, 2022

7.0 Appendix

7.1 FEMA FIS & USGS Documents

7.1.1 Extract of USGS Franklin Quadrangle
7.1.2 FEMA Firmette No. 25021C0316E, July 17, 2012

7.2 Hydrologic Analyses

7.2.1 Drainage Area Using USGS Streamstats
7.2.2 USGS Gauging Station Data for Gauge No. 01103220
7.2.3 PeakFQ Report

7.3 Hydraulic Analyses

7.3.1 Existing Conditions
7.3.2 Alternative 1 (3'x16' Open Bottom Box Culvert)
7.3.3 Alternative 2 (3'x8' Open Bottom Box Culvert)

7.4 Scour Calculations

7.4.1 Scour Sediment Sampling Results
7.4.2 Scour Calculations

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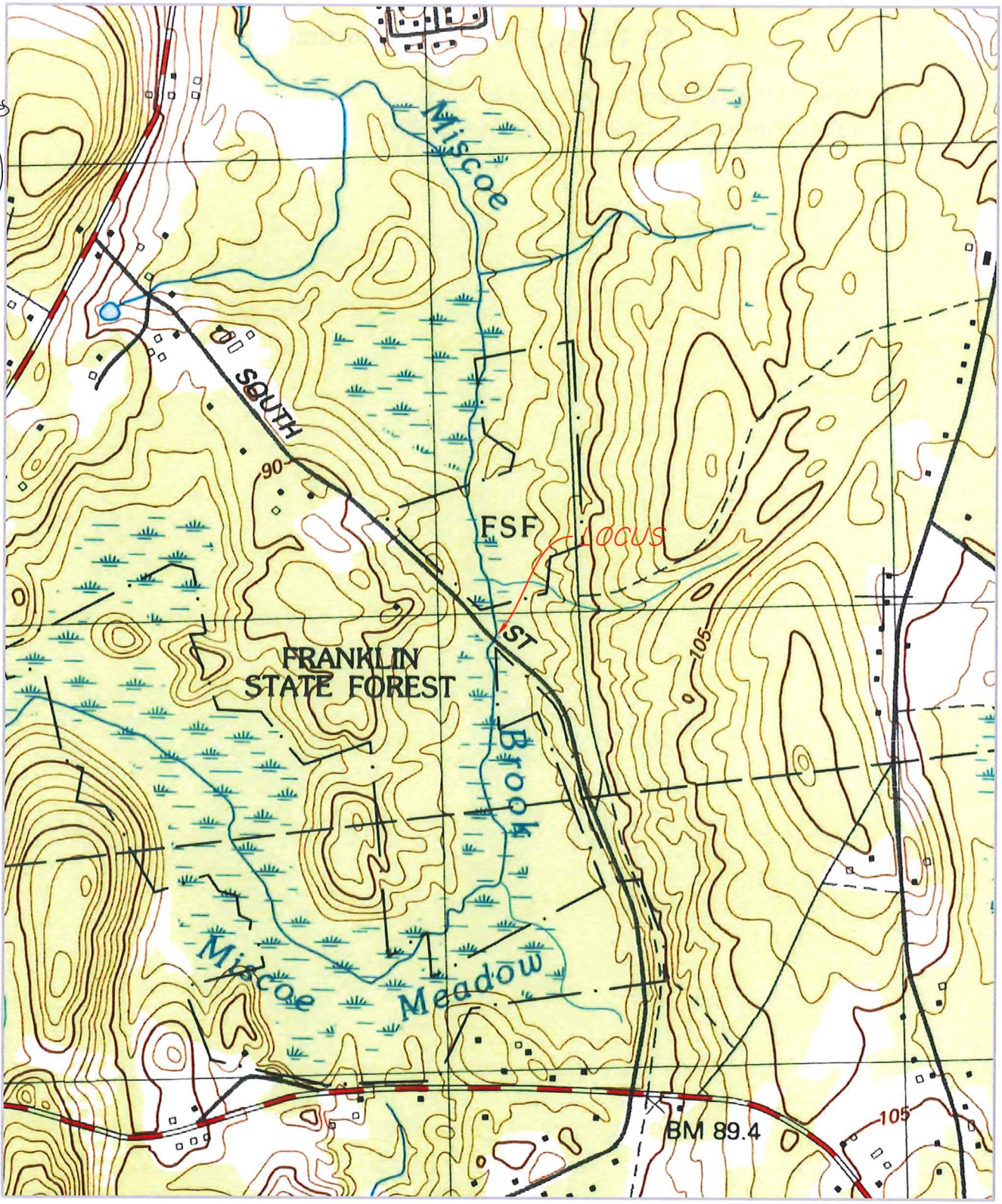


BAY COLONY GROUP, INC.
FOUR SCHOOL STREET
FOXBOROUGH, MA 02035
(508) 543-3939

USGS QUADRANGLE EXTRACT
SOUTH STREET
FRANKLIN, MA
FRANKLIN QUADRANGLE
SCALE: 1"= 1000'

National Flood Hazard Layer FIRMette

FEMA

71°25'55"W 42°2'39"N

71°25'17"W 42°2'13"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/1/2022 at 4:15 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

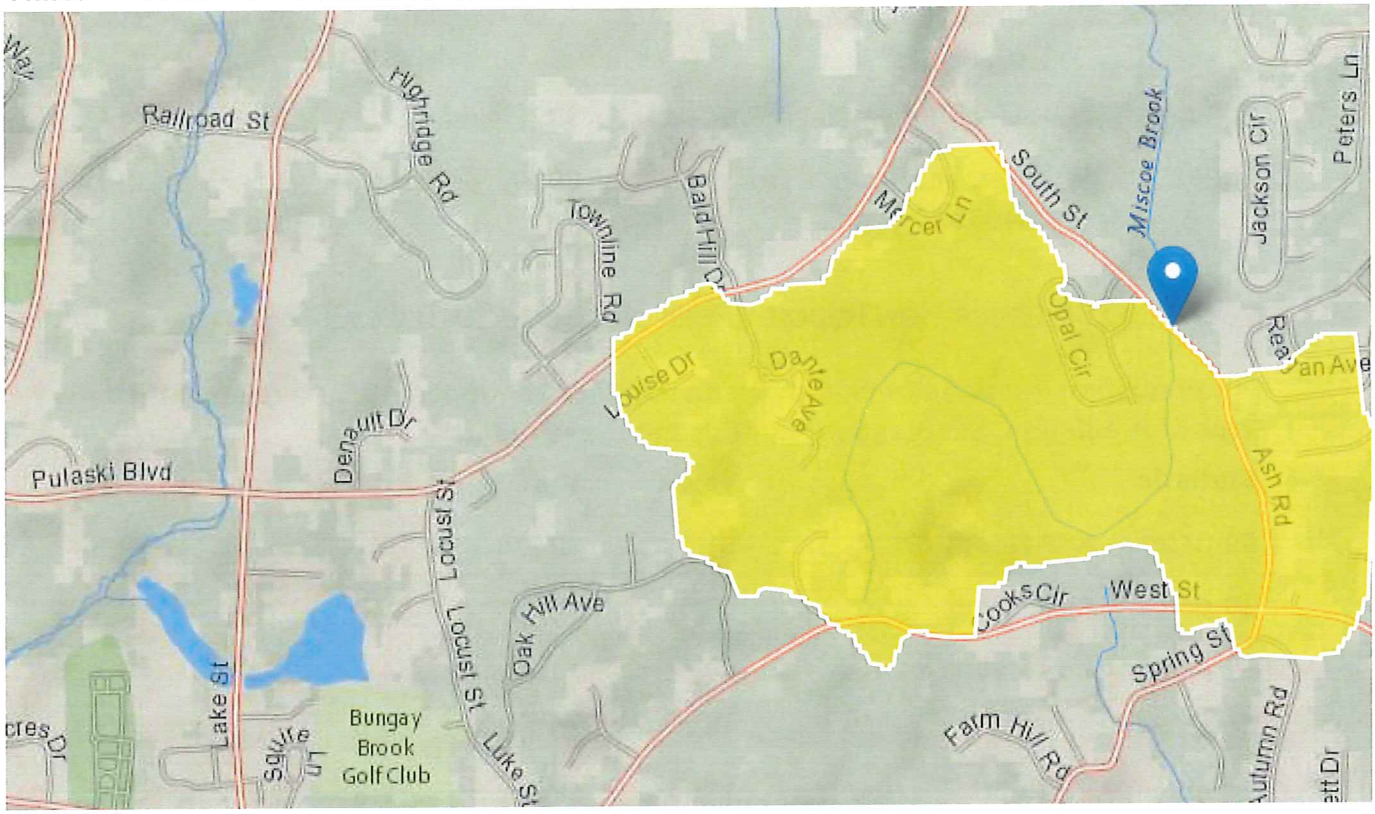
7.2 Hydrologic Analyses

7.2.1 Drainage Area Using USGS Streamstats
7.2.2 USGS Gauging Station Data for Gauge No. 01103220
7.2.3 PeakFQ Report

Appendix 7.2.1

StreamStats Report - Miscoe Brook @ South Street Franklin, MA

Region ID: MA
Workspace ID: MA20221014205057423000
Clicked Point (Latitude, Longitude): 42.04088, -71.42652
Time: 2022-10-14 16:49:43 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	7.063	percent
DRNAREA	Area that drains to a point on a stream	1.14	square miles
ELEV	Mean Basin Elevation	307	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	20.76	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.14	square miles	0.16	512
ELEV	Mean Basin Elevation	307	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	20.76	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	ASEp
50-percent AEP flood	31.3	ft^3/s	16	61.4	42.3
20-percent AEP flood	52.6	ft^3/s	26.4	105	43.4
10-percent AEP flood	69.8	ft^3/s	34.2	142	44.7
4-percent AEP flood	94.6	ft^3/s	44.8	200	47.1
2-percent AEP flood	115	ft^3/s	52.8	251	49.4
1-percent AEP flood	137	ft^3/s	60.9	308	51.8
0.5-percent AEP flood	161	ft^3/s	69.5	373	54.1
0.2-percent AEP flood	195	ft^3/s	80.3	473	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Bankfull Statistics

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.14	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	7.063	percent	2.2	23.9

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.14	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.14	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.14	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Bankfull Width	15.8	ft	21.3
Bankfull Depth	0.986	ft	19.8
Bankfull Area	15.4	ft^2	29
Bankfull Streamflow	40.7	ft^3/s	55

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	16	ft
Bieger_D_channel_depth	1.16	ft
Bieger_D_channel_cross_sectional_area	18.9	ft^2

Bankfull Statistics Disclaimers [New England P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	26.2	ft
Bieger_P_channel_depth	1.42	ft
Bieger_P_channel_cross_sectional_area	37	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	13	ft
Bieger_USA_channel_depth	1.24	ft
Bieger_USA_channel_cross_sectional_area	18.3	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Bankfull Width	15.8	ft	21.3
Bankfull Depth	0.986	ft	19.8
Bankfull Area	15.4	ft^2	29
Bankfull Streamflow	40.7	ft^3/s	55
Bieger_D_channel_width	16	ft	
Bieger_D_channel_depth	1.16	ft	
Bieger_D_channel_cross_sectional_area	18.9	ft^2	
Bieger_P_channel_width	26.2	ft	
Bieger_P_channel_depth	1.42	ft	
Bieger_P_channel_cross_sectional_area	37	ft^2	
Bieger_USA_channel_width	13	ft	
Bieger_USA_channel_depth	1.24	ft	

Statistic	Value	Unit	ASEp
Bieger_USA_channel_cross_sectional_area	18.3	ft^2	

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)
Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_

Application Version: 4.10.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

National Water Information System: Web Interface

USGS Water Resources

Data Category: Surface Water | Geographic Area: United States | GO

Click to hideNews Bulletins

- See the Water Data for the Nation Blog for the latest news and updates.

Peak Streamflow for the Nation

USGS 01103220 MISCOE BROOK NEAR FRANKLIN, MA

Available data for this site: Surface-water: Peak streamflow | GO

Norfolk County, Massachusetts
Hydrologic Unit Code 01090001
Latitude 42°02'27", Longitude 71°25'38" NAD27
Drainage area 1.15 square miles
Gage datum 260 feet above NGVD29

Output formats

Table
Graph
Tab-separated file
peakfq (watstore) format
Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2001	2001-03-22	2.65	24.0
2002	2002-05-14	1.52	4.90
2003	2003-06-23	1.99	14.0
2004	2004-04-14	2.08	15.0
2005	2005-03-29	2.31	19.0
2006	2005-10-15	3.40	48.0
2007	2006-11-24	2.03	14.0
2008	2008-02-14	2.29	19.0
2009	2008-12-12	2.50	24.0

Appendix 7.2.3

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.002.000
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

--- PROCESSING OPTIONS ---

Plot option = Graphics device
Basin char output = None
Print option = Yes
Debug print = No
Input peaks listing = Long
Input peaks format = WATSTORE peak file

Input files used:
peaks (ascii) - R:\22-0177 - South Street Franklin\PEAK.TXT
specifications - R:\22-0177 - South Street Franklin\PKFQWPSF.TMP
Output file(s):
main - R:\22-0177 - South Street Franklin\PEAK.PRT

*** User responsible for assessment and interpretation of the following analysis ***

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

Station - 01103220 MISCOE BROOK NEAR FRANKLIN, MA

TABLE 1 - INPUT DATA SUMMARY

Number of peaks in record = 9
Peaks not used in analysis = 0
Gaged peaks in analysis = 9
Historic peaks in analysis = 0
Beginning Year = 2001
Ending Year = 2009
Historical Period Length = 9
Skew option = WEIGHTED
Regional skew = 0.000
Standard error = 0.100
Mean Square error = 0.010
Gage base discharge = 0.0
User supplied high outlier threshold = --
User supplied PILF (LO) criterion = --
Plotting position parameter = 0.00
Type of analysis EMA
PILF (LO) Test Method MGBT
Perceptible Ranges:

Start Year	End Year	Lower Bound	Upper Bound	
2001	2009	0.0	INF	DEFAULT

Interval Data = None Specified

TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS

**WCF118W-SYSTEMATIC RECORD SHORTER THAN 17B SPEC. 9
**WCF233W-EXPECTED PROB OUT OF RANGE AT TAB PROB. 0.00000 0.00010
WCF002J-CALCS COMPLETED. RETURN CODE = 2
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0

MULTIPLE GRUBBS-BECK TEST RESULTS
MULTIPLE GRUBBS-BECK PILF THRESHOLD N/A
NUMBER OF PILFS IDENTIFIED 0

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
GAGED PEAKS	0.306	0.289	1.458	9

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

Station - 01103220 MISCOE BROOK NEAR FRANKLIN, MA

TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC MEAN	STANDARD DEVIATION	SKEW
EMA WITHOUT REG SKEW	1.2397	0.2648	-0.659
EMA WITH REG SKEW	1.2397	0.2648	-0.011

EMA ESTIMATE OF MSE OF SKEW WITHOUT REG SKEW 0.5727
EMA ESTIMATE OF MSE OF SKEW W/GAGED PEAKS ONLY (AT-SITE) 0.5281

TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	<- EMA ESTIMATE -> WITH REG SKEW	WITHOUT REG SKEW	<- FOR EMA ESTIMATE WITH REG SKEW -> LOG VARIANCE OF EST.	<-CONFIDENCE LIMITS-> 5.0% LOWER	95.0% UPPER
0.9950	3.6	2.5	0.0284	1.3	6.0
0.9900	4.2	3.2	0.0245	1.6	6.8
0.9500	6.4	5.8	0.0160	3.1	9.5

0.9000	7.9	7.7	0.0127	4.3	11.5
0.8000	10.4	10.7	0.0098	6.3	14.7
0.6667	13.4	14.2	0.0083	8.7	18.8
0.5000	17.4	18.6	0.0078	12.0	25.1
0.4292	19.4	20.6	0.0080	13.6	28.5
0.2000	29.0	29.3	0.0105	20.5	47.9
0.1000	37.9	35.9	0.0139	26.2	69.8
0.0400	50.4	43.5	0.0192	33.4	106.0
0.0200	60.5	48.6	0.0235	38.8	139.7
0.0100	71.4	53.2	0.0281	44.3	179.8
0.0050	83.0	57.5	0.0328	49.9	227.1
0.0020	99.6	62.6	0.0394	57.5	302.5

*Note: If Station Skew option is selected then EMA ESTIMATE WITH REG SKEW will display values for and be equal to EMA ESTIMATE WITHOUT REG SKEW.

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

Station - 01103220 MISCOE BROOK NEAR FRANKLIN, MA

TABLE 5 - INPUT DATA LISTING

WATER YEAR	PEAK VALUE	PEAKFQ CODES	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND	REMARKS
2001	24.0				
2002	4.9				
2003	14.0				
2004	15.0				
2005	19.0				
2006	48.0				
2007	14.0				
2008	19.0				
2009	24.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
O	O	Opportunistic peak
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

Station - 01103220 MISCOE BROOK NEAR FRANKLIN, MA

TABLE 6 - EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND
2006	48.0	0.0998		
2001	24.0	0.2999		
2009	24.0	0.1998		
2005	19.0	0.5000		
2008	19.0	0.3999		
2004	15.0	0.6001		
2003	14.0	0.8002		
2007	14.0	0.7001		
2002	4.9	0.9002		

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.005
Version 7.4 Annual peak flow frequency analysis Run Date / Time
5/ 4/2022 10/14/2022 16:52

Station - 01103220 MISCOE BROOK NEAR FRANKLIN, MA

TABLE 7 - EMA REPRESENTATION OF DATA

WATER YEAR	<---- USER-ENTERED ----> Q_LOWER	Q_UPPER	<-------- FINAL -------> Q_LOWER	Q_UPPER	<- PERCEPTIBLE RANGES -> LOWER	UPPER	<- PERCEPTIBLE RANGES -> LOWER	UPPER
2001	24.0	24.0	24.0	24.0	0.0	INF	0.0	INF
2002	4.9	4.9	4.9	4.9	0.0	INF	0.0	INF
2003	14.0	14.0	14.0	14.0	0.0	INF	0.0	INF
2004	15.0	15.0	15.0	15.0	0.0	INF	0.0	INF
2005	19.0	19.0	19.0	19.0	0.0	INF	0.0	INF
2006	48.0	48.0	48.0	48.0	0.0	INF	0.0	INF
2007	14.0	14.0	14.0	14.0	0.0	INF	0.0	INF
2008	19.0	19.0	19.0	19.0	0.0	INF	0.0	INF
2009	24.0	24.0	24.0	24.0	0.0	INF	0.0	INF

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 9

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01103220 USGS MISCOE BROOK NEAR FRANKLIN, M

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

7.3 Hydraulic Analyses

7.3.1 Existing Conditions
7.3.2 Alternative 1 (3'x16' Open Bottom Box Culvert)
7.3.3 Alternative 2 (3'x8' Open Bottom Box Culvert)

7.3.1 Existing Conditions

Appendix 7.3.1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South Street	506	10-yr	69.8	256.6	262.26		262.26	0.000007	0.27	678.36	329.23	0.02
South Street	506	25-yr	94.6	256.6	263.01		263.02	0.000006	0.27	941.11	369.94	0.02
South Street	506	50-yr	115	256.6	263.02		263.02	0.000009	0.33	941.96	370.07	0.03
South Street	506	100-yr	137	256.6	263.02		263.02	0.000012	0.4	943.07	370.23	0.03
South Street	376	10-yr	69.8	258.5	262.26		262.26	0.000016	0.35	612.36	329	0.04
South Street	376	25-yr	94.6	258.5	263.01		263.01	0.00001	0.33	860.25	329	0.03
South Street	376	50-yr	115	258.5	263.02		263.02	0.000015	0.4	860.86	329	0.04
South Street	376	100-yr	137	258.5	263.02		263.02	0.000021	0.47	861.64	329	0.04
South Street	256	10-yr	69.8	257.7	262.15	259.99	262.24	0.000836	2.52	27.9	378.57	0.24
South Street	256	25-yr	94.6	257.7	263.01	260.32	263.01	0.000036	0.58	627.42	418.11	0.05
South Street	256	50-yr	115	257.7	263.01	260.58	263.01	0.000054	0.7	627.43	418.12	0.06
South Street	256	100-yr	137	257.7	263.01	260.83	263.01	0.000077	0.84	627.44	418.12	0.08
South Street	234		Culvert									
South Street	216	10-yr	69.8	257.5	259.33	259.33	260.09	0.015717	7.03	10.67	8.66	0.99
South Street	216	25-yr	94.6	257.5	259.68	259.68	260.6	0.014747	7.77	13.34	9.35	0.99
South Street	216	50-yr	115	257.5	259.94	259.94	260.98	0.013983	8.26	15.49	9.88	0.99
South Street	216	100-yr	137	257.5	260.26	260.26	261.37	0.012575	8.57	18.35	115.02	0.96
South Street	0	10-yr	69.8	256.8	258.34	257.89	258.36	0.0015	1.69	113.67	178.43	0.29
South Street	0	25-yr	94.6	256.8	258.5	257.96	258.52	0.001501	1.85	141.88	185.86	0.29
South Street	0	50-yr	115	256.8	258.61	258.04	258.64	0.001501	1.96	163.36	191.33	0.3
South Street	0	100-yr	137	256.8	258.72	258.09	258.75	0.001501	2.07	185.25	196.74	0.3

Plan: Existing Conditions Miscoe Brook South Street RS: 234 Culv Group: 2'H x 4.5'W Profile: 10-yr

Q Culv Group (cfs)	69.8	Culv Full Len (ft)	35.94
# Barrels	1	Culv Vel US (ft/s)	7.76
Q Barrel (cfs)	69.8	Culv Vel DS (ft/s)	7.93
E.G. US. (ft)	262.25	Culv Inv El Up (ft)	257.66
W.S. US. (ft)	262.15	Culv Inv El Dn (ft)	257.53
E.G. DS (ft)	260.09	Culv Frctn Ls (ft)	1.32
W.S. DS (ft)	259.33	Culv Exit Loss (ft)	0.38
Delta EG (ft)	2.16	Culv Entr Loss (ft)	0.47
Delta WS (ft)	2.82	Q Weir (cfs)	
E.G. IC (ft)	262.16	Weir Sta Lft (ft)	
E.G. OC (ft)	262.25	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	259.66	Weir Max Depth (ft)	
Culv WS Outlet (ft)	259.49	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.96	Min El Weir Flow (ft)	263.01

Plan: Existing Conditions Miscoe Brook South Street RS: 234 Culv Group: 2'H x 4.5'W Profile: 100-yr

Q Culv Group (cfs)	66.98	Culv Full Len (ft)	36
# Barrels	1	Culv Vel US (ft/s)	7.44
Q Barrel (cfs)	66.98	Culv Vel DS (ft/s)	7.44
E.G. US. (ft)	263.01	Culv Inv El Up (ft)	257.66
W.S. US. (ft)	263.01	Culv Inv El Dn (ft)	257.53
E.G. DS (ft)	261.37	Culv Frctn Ls (ft)	1.21
W.S. DS (ft)	260.26	Culv Exit Loss (ft)	0
Delta EG (ft)	1.64	Culv Entr Loss (ft)	0.43
Delta WS (ft)	2.75	Q Weir (cfs)	153.24
E.G. IC (ft)	263.01	Weir Sta Lft (ft)	27.72
E.G. OC (ft)	263.01	Weir Sta Rgt (ft)	266
Culvert Control	Inlet	Weir Submerg	0
Culv WS Inlet (ft)	259.66	Weir Max Depth (ft)	0.71
Culv WS Outlet (ft)	259.53	Weir Avg Depth (ft)	0.39
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	93.36
Culv Crt Depth (ft)	1.9	Min El Weir Flow (ft)	263.01

7.3.2 Alternative 1 (3'x16' Open Bottom Box Culvert)

Appendix 7.3.2

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South Street	506	10-yr	69.8	256.6	260.33		260.34	0.000188	0.91	150.56	174.98	0.11
South Street	506	25-yr	94.6	256.6	260.53		260.54	0.000235	1.06	187.29	201.48	0.13
South Street	506	50-yr	115	256.6	260.65		260.66	0.000275	1.18	212.76	217.81	0.14
South Street	506	100-yr	137	256.6	260.76		260.78	0.000318	1.3	237.62	232.63	0.15
South Street	376	10-yr	69.8	258.5	259.94	259.94	260.23	0.016242	4.47	21.27	57.29	0.9
South Street	376	25-yr	94.6	258.5	260.12	260.12	260.42	0.013667	4.63	33.99	93.03	0.85
South Street	376	50-yr	115	258.5	260.24	260.24	260.53	0.012197	4.7	47.01	123.48	0.82
South Street	376	100-yr	137	258.5	260.33	260.33	260.63	0.011707	4.85	60.09	147.9	0.81
South Street	256	10-yr	69.8	257.6	259.13	258.42	259.23	0.002347	2.5	27.92	20.51	0.37
South Street	256	25-yr	94.6	257.6	259.42	258.6	259.54	0.002319	2.81	33.63	21.35	0.38
South Street	256	50-yr	115	257.6	259.64	258.73	259.78	0.002284	3.03	37.98	21.99	0.39
South Street	256	100-yr	137	257.6	259.86	258.87	260.02	0.002238	3.23	42.45	22.64	0.39
South Street	234		Culvert									
South Street	216	10-yr	69.8	257.5	258.79	258.31	258.93	0.004145	2.97	23.46	20.31	0.48
South Street	216	25-yr	94.6	257.5	258.95	258.49	259.15	0.004953	3.54	26.69	20.85	0.54
South Street	216	50-yr	115	257.5	259.07	258.63	259.31	0.005581	3.97	28.96	21.23	0.58
South Street	216	100-yr	137	257.5	259.18	258.75	259.48	0.006242	4.41	31.1	21.58	0.62
South Street	0	10-yr	69.8	256.8	258.34	257.89	258.36	0.0015	1.69	113.67	178.43	0.29
South Street	0	25-yr	94.6	256.8	258.5	257.96	258.52	0.001501	1.85	141.88	185.86	0.29
South Street	0	50-yr	115	256.8	258.61	258.04	258.64	0.001501	1.96	163.36	191.33	0.3
South Street	0	100-yr	137	256.8	258.72	258.09	258.75	0.001501	2.07	185.25	196.74	0.3

Plan: Alternative 1 Miscoe Brook South Street RS: 234 Culv Group: 3'x16' Culve Profile: 10-yr

Q Culv Group (cfs)	69.8	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	3.2
Q Barrel (cfs)	69.8	Culv Vel DS (ft/s)	3.37
E.G. US. (ft)	259.23	Culv Inv El Up (ft)	257.6
W.S. US. (ft)	259.13	Culv Inv El Dn (ft)	257.5
E.G. DS (ft)	258.93	Culv Frctn Ls (ft)	0.15
W.S. DS (ft)	258.79	Culv Exit Loss (ft)	0.04
Delta EG (ft)	0.3	Culv Entr Loss (ft)	0.11
Delta WS (ft)	0.34	Q Weir (cfs)	
E.G. IC (ft)	259.02	Weir Sta Lft (ft)	
E.G. OC (ft)	259.23	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	258.96	Weir Max Depth (ft)	
Culv WS Outlet (ft)	258.79	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.51	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	0.84	Min El Weir Flow (ft)	263.01

Plan: Alternative 1 Miscoe Brook South Street RS: 234 Culv Group: 3'x16' Culve Profile: 100-yr

Q Culv Group (cfs)	137	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	4.55
Q Barrel (cfs)	137	Culv Vel DS (ft/s)	5.11
E.G. US. (ft)	260.03	Culv Inv El Up (ft)	257.6
W.S. US. (ft)	259.86	Culv Inv El Dn (ft)	257.5
E.G. DS (ft)	259.48	Culv Frctn Ls (ft)	0.22
W.S. DS (ft)	259.18	Culv Exit Loss (ft)	0.1
Delta EG (ft)	0.55	Culv Entr Loss (ft)	0.23
Delta WS (ft)	0.68	Q Weir (cfs)	
E.G. IC (ft)	259.84	Weir Sta Lft (ft)	
E.G. OC (ft)	260.03	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	259.48	Weir Max Depth (ft)	
Culv WS Outlet (ft)	259.18	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.28	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.32	Min El Weir Flow (ft)	263.01

7.3.3 Alternative 2 (3'x8' Open Bottom Box Culvert)

Appendix 7.3.3

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South Street	506	10-yr	69.8	256.6	260.39		260.4	0.000168	0.86	161.32	183.3	0.11
South Street	506	25-yr	94.6	256.6	260.78		260.78	0.000147	0.89	241.53	234.89	0.1
South Street	506	50-yr	115	256.6	261.11		261.11	0.000119	0.86	325.93	271.43	0.09
South Street	506	100-yr	137	256.6	261.46		261.47	0.00009	0.81	427.26	293.15	0.08
South Street	376	10-yr	69.8	258.5	260.21		260.33	0.005036	2.98	43.7	116.5	0.53
South Street	376	25-yr	94.6	258.5	260.7		260.74	0.001403	2.01	129.98	234.14	0.29
South Street	376	50-yr	115	258.5	261.06		261.08	0.000629	1.56	229.93	303.67	0.2
South Street	376	100-yr	137	258.5	261.44		261.45	0.000308	1.24	346.72	313.88	0.15
South Street	256	10-yr	69.8	257.6	259.92	258.75	260.03	0.001399	2.65	26.39	20.31	0.31
South Street	256	25-yr	94.6	257.6	260.43	258.97	260.56	0.001295	2.92	32.42	22.97	0.31
South Street	256	50-yr	115	257.6	260.81	259.14	260.96	0.001231	3.11	37	24.99	0.31
South Street	256	100-yr	137	257.6	261.2	259.32	261.36	0.001177	3.29	41.65	114.16	0.31
South Street	234		Culvert									
South Street	216	10-yr	69.8	257.5	258.85	258.63	259.19	0.009458	4.7	14.85	16.09	0.75
South Street	216	25-yr	94.6	257.5	258.97	258.86	259.49	0.012687	5.8	16.31	16.82	0.88
South Street	216	50-yr	115	257.5	259.04	259.03	259.74	0.015922	6.71	17.13	17.23	0.99
South Street	216	100-yr	137	257.5	259.2	259.2	260	0.01581	7.18	19.07	18.2	1
South Street	0	10-yr	69.8	256.8	258.34	257.89	258.36	0.0015	1.69	113.67	178.43	0.29
South Street	0	25-yr	94.6	256.8	258.5	257.96	258.52	0.001501	1.85	141.88	185.86	0.29
South Street	0	50-yr	115	256.8	258.61	258.04	258.64	0.001501	1.96	163.36	191.33	0.3
South Street	0	100-yr	137	256.8	258.72	258.09	258.75	0.001501	2.07	185.25	196.74	0.3

Plan: Alternative 2 Miscoe Brook South Street RS: 234 Culv Group: 3'x8' Culvert Profile: 10-yr

Q Culv Group (cfs)	69.8	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	4.72
Q Barrel (cfs)	69.8	Culv Vel DS (ft/s)	6.47
E.G. US. (ft)	260.04	Culv Inv El Up (ft)	257.6
W.S. US. (ft)	259.92	Culv Inv El Dn (ft)	257.5
E.G. DS (ft)	259.19	Culv Frctn Ls (ft)	0.3
W.S. DS (ft)	258.85	Culv Exit Loss (ft)	0.31
Delta EG (ft)	0.85	Culv Entr Loss (ft)	0.24
Delta WS (ft)	1.08	Q Weir (cfs)	
E.G. IC (ft)	259.86	Weir Sta Lft (ft)	
E.G. OC (ft)	260.04	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	259.45	Weir Max Depth (ft)	
Culv WS Outlet (ft)	258.85	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.36	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.33	Min El Weir Flow (ft)	263.01

Plan: Alternative 2 Miscoe Brook South Street RS: 234 Culv Group: 3'x8' Culvert Profile: 100-yr

Q Culv Group (cfs)	137	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	6.27
Q Barrel (cfs)	137	Culv Vel DS (ft/s)	8.2
E.G. US. (ft)	261.37	Culv Inv El Up (ft)	257.6
W.S. US. (ft)	261.2	Culv Inv El Dn (ft)	257.5
E.G. DS (ft)	260	Culv Frctn Ls (ft)	0.31
W.S. DS (ft)	259.2	Culv Exit Loss (ft)	0.63
Delta EG (ft)	1.37	Culv Entr Loss (ft)	0.43
Delta WS (ft)	2	Q Weir (cfs)	
E.G. IC (ft)	261.18	Weir Sta Lft (ft)	
E.G. OC (ft)	261.37	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	260.33	Weir Max Depth (ft)	
Culv WS Outlet (ft)	259.59	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	3	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.09	Min El Weir Flow (ft)	263.01

7.4 Scour Calculations

7.4.1 Scour Sediment Sampling Results
7.4.2 Scour Calculations

7.4.1 Scour Sediment Sampling Results

Professional Service Industries, Inc.
480 Neponset Street, Suite 9C
Canton, MA 02021

Phone: (781) 821-2355
Fax: (781) 821-6276

Report No: MAT:0446516-67-S1
Issue No: 1

Material Test Report

Client: BAY COLONY GROUP
4 SCHOOL ST., P.O. BOX 9136
FOXBORO, MA 02035

CC:

Project: BAY COLONY GROUP - LAB TESTING
CANTON, MA

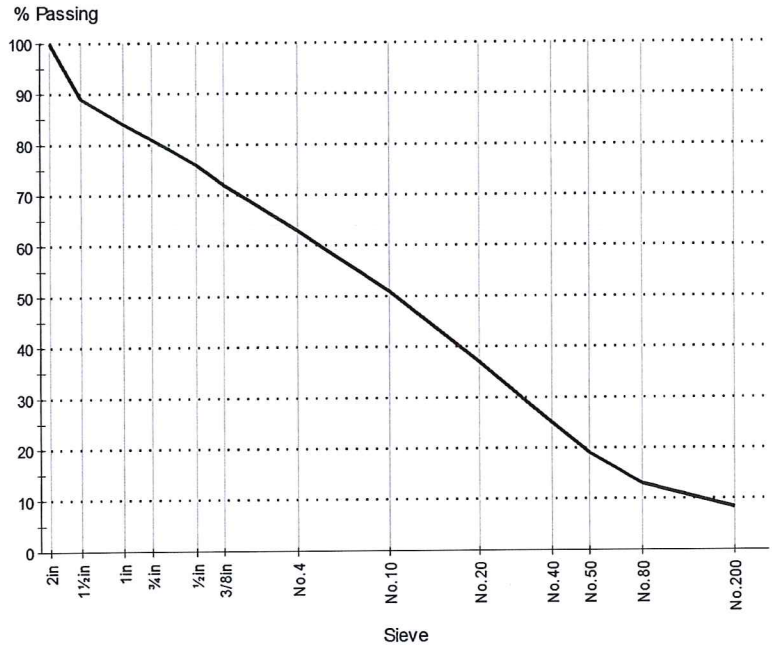
Approved Signatory: Yannick Lastennet (Department Manager)
Date of Issue: 10/20/2022

Sample Details

Sample ID:	0446516-67-S1
Client Sample ID:	
Date Sampled:	
Sampled By:	Others
Specification:	No Spec. Sieve
Supplier:	
Source:	
Material:	
Sampling Method:	
General Location:	South St. over Miscoe Brook - Franklin, MA
Location:	30' Upstream
Lift:	

Sample Description:

Particle Size Distribution



COBBLES	GRAVEL		SAND			FINES (8.4%)	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
(0.0%)	(19.5%)	(18.0%)	(11.5%)	(25.7%)	(16.9%)		

Grading: ASTM C 136, ASTM C 117

Date Tested: 10/17/2022
Tested By: Gary Brooks

Sieve Size	% Passing	Limits
2in (50.0mm)	100	
1½in (37.5mm)	89	
1in (25.0mm)	84	
¾in (19.0mm)	81	
½in (12.5mm)	76	
3/8in (9.5mm)	72	
No.4 (4.75mm)	63	
No.10 (2.0mm)	51	
No.20 (850µm)	37	
No.40 (425µm)	25	
No.50 (300µm)	19	
No.80 (180µm)	13	
No.200 (75µm)	8.4	

D85: 27.1118 **D60:** 3.8263 **D50:** 1.8814
D30: 0.5673 **D15:** 0.2134 **D10:** 0.1017
Cu: 37.62 **Cc:** 0.83

7.4.2 Scour Calculations

Appendix 7.4.2

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177

MassDOT Modified Froehlich Equation for Abutment Scour (Alternative 1)

$Y_s/Y_a=2.27\ K_1K_2\ (L'/Y_a)^{0.43}\ Fr^{0.61}$

K_1 = coefficient for abutment shape

K_2 = coefficient for angle of embankment to flow

L' = length of abutment projected normal to flow, ft

Y_a = average depth of flow in the floodplain, ft

A_e = the flow area of the approach cross section obstructed by the embankment, ft^2

Fr = Froude Number

$V_e = Q_e / A_e$, ft/sec

Q_e = the flow obstructed by the abutment and approach embankments, ft^3/sec

Y_s = scour depth, ft

Data Input

Abutment Location:

Y_a = average depth of flow in the floodplain, ft

K_1 = coefficient for abutment shape

K_2 = coefficient for angle of embankment to flow

L' = length of abutment projected normal to flow, ft

Q_e = the flow obstructed by the abutment and approach embankments, ft^3/sec

A_e = the flow area of the approach cross section obstructed by the embankment, ft^2

$V_e = Q_e / A_e$, ft/sec

Fr = Froude Number

	25-yr Frequency	
	Left	**Right**
	1.6	1.6
	0.82	0.82
	1.0	1.0
	10.0	10.0
	0.0	0.0
	0.0	0.0
	#DIV/0!	#DIV/0!
	0.100	0.100

	50-yr Frequency	
	Left	**Right**
	1.9	1.9
	0.82	0.82
	1.0	1.0
	10.0	10.0
	0.0	0.0
	0.0	0.0
	#DIV/0!	#DIV/0!
	0.110	0.110

Data Output

	Left	Right	
Ys =	1.6	1.6	**ft**

	Left	Right	
Ys =	1.9	1.9	**ft**

Bay Colony Group, Inc.
4 School Street
Foxborough, MA 02035

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177

MassDOT Modified Froehlich Equation for Abutment Scour (Alternative 2)

$Y_s/Y_a=2.27\ K_1K_2\ (L'/Y_a)^{0.43}\ Fr^{0.61}$

K_1 = coefficient for abutment shape

K_2 = coefficient for angle of embankment to flow

L' = length of abutment projected normal to flow, ft

Y_a = average depth of flow in the floodplain, ft

A_e = the flow area of the approach cross section obstructed by the embankment, ft^2

Fr = Froude Number

$V_e = Q_e / A_e$, ft/sec

Q_e = the flow obstructed by the abutment and approach embankments, ft^3/sec

Y_s = scour depth, ft

Data Input

Abutment Location:

Y_a = average depth of flow in the floodplain, ft

K_1 = coefficient for abutment shape

K_2 = coefficient for angle of embankment to flow

L' = length of abutment projected normal to flow, ft

Q_e = the flow obstructed by the abutment and approach embankments, ft^3/sec

A_e = the flow area of the approach cross section obstructed by the embankment, ft^2

$V_e = Q_e / A_e$, ft/sec

Fr = Froude Number

25-yr Frequency

Left	Right
2.7	2.7
0.82	0.82
1.0	1.0
10.0	10.0
0.0	0.0
0.0	0.0
#DIV/0!	#DIV/0!
0.100	0.100

50-yr Frequency

Left	Right
3.1	3.1
0.82	0.82
1.0	1.0
10.0	10.0
0.0	0.0
0.0	0.0
#DIV/0!	#DIV/0!
0.110	0.110

Data Output

	Left	Right	
Ys =	2.2	2.2	ft

	Left	Right	
Ys =	2.5	2.5	ft

Bay Colony Group, Inc.
4 School Street
Foxborough, MA 02035

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177
Frequency Event:	25-year (Alternative 1)

Determine Critical Velocity

$V_c = K_u y^{1/6} D^{1/3}$

V_c = Critical velocity above which bed material of D and smaller will be transported, ft/s

y = Average depth of flow upstream of the bridge, ft

D = Particle size for V_c, ft

D_{50} = Particle size in a mixture of which 50% are smaller, ft

K_u = 11.17

Data Input

y =	1.8	ft
D =	0.006173	ft
K_u =	11.17	

Velocity Upstream of Bridge = 2.8 ft/sec

Data Output

V_c = **2.3** ft/sec

Critical Velocity V_c is less than mean velocity V therefore Live Bed conditions

Modified Laursen's 1960 Equation for Contraction Scour (Live Bed Condition)

$y2/y1 = (Q2/Q1)^{6/7} (W1/W2)^{k1}$

y_1 = Average depth in the upstream main channel, ft

y_2 = Average depth in the contracted section, ft

y_o = Existing depth in the contracted section before scour, ft

Q_1 = Flow in the upstream channel transporting sediment, ft3/s

Q_2 = Flow in the contracted channel, ft3/s

W_1 = Bottom width of the upstream main channel that is transporting bed material, ft

W_2 = Bottom width of main channel in contracted section less pier width, ft

k1 = Exponent determined in Section 6.3 HEC No. 18

$V^* = (gy_1S_1)^{1/2}$, ft/sec

T = Fall velocity of bed material based on the D50, Figure 6.8 HEC No. 18 multiplied 3.28, ft/sec

g = acceleration of gravity, (32.2 ft/sec)

S_1 = Slope of energy grade line of main channel, ft/ft

τ = Shear stress on the bed, lb/ft^2

Δ = Density of water (1.94 $slugs/ft^3$)

Data Input
1.8
2.1
1.8
95
95
20
16
0.69
0.37
0.20
32.2
0.002
0.99
1.94

Data Output

y_2 = **2.1** ft average depth from water surface

$y_s = y_2 - y_o$ = **0.3** ft average depth of scour

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177
Frequency Event:	50-year (Alternative 1)

Determine Critical Velocity

$V_c = K_u y^{1/6} D^{1/3}$

V_c = Critical velocity above which bed material of D and smaller will be transported, ft/s

y = Average depth of flow upstream of the bridge, ft

D = Particle size for V_c, ft

D_{50} = Particle size in a mixture of which 50% are smaller, ft

K_u = 11.17

Data Input

y =	2.0	ft
D =	0.006173	ft
K_u =	11.17	

Velocity Upstream of Bridge = 3.0 ft/sec

Data Output

V_c = **2.3** ft/sec

Critical Velocity V_c is less than mean velocity V therefore Live Bed conditions

Modified Laursen's 1960 Equation for Contraction Scour (Live Bed Condition)

$y2/y1 = (Q2/Q1)^{6/7} (W1/W2)^{k1}$

y_1 = Average depth in the upstream main channel, ft

y_2 = Average depth in the contracted section, ft

y_o = Existing depth in the contracted section before scour, ft

Q_1 = Flow in the upstream channel transporting sediment, ft3/s

Q_2 = Flow in the contracted channel, ft3/s

W_1 = Bottom width of the upstream main channel that is transporting bed material, ft

W_2 = Bottom width of main channel in contracted section less pier width, ft

k1 = Exponent determined in Section 6.3 HEC No. 18

$V^* = (gy_1S_1)^{1/2}$, ft/sec

T = Fall velocity of bed material based on the D50, Figure 6.8 HEC No. 18 multiplied 3.28, ft/sec

g = acceleration of gravity, (32.2 ft/sec)

S_1 = Slope of energy grade line of main channel, ft/ft

τ = Shear stress on the bed, lb/ft^2

Δ = Density of water (1.94 slugs/ft^3)

Data Input
2.0
2.3
2.0
115
115
20
16
0.69
0.38
0.20
32.2
0.002
0.99
1.94

Data Output

y_2 = **2.3** ft average depth from water surface

$y_s = y_2 - y_o$ = **0.3** ft average depth of scour

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177
Frequency Event:	25-year (Alternative 2)

Determine Critical Velocity

$V_c = K_u y^{1/6} D^{1/3}$

V_c = Critical velocity above which bed material of D and smaller will be transported, ft/s

y = Average depth of flow upstream of the bridge, ft

D = Particle size for V_c, ft

D_{50} = Particle size in a mixture of which 50% are smaller, ft

K_u = 11.17

Data Input

y =	2.7	ft
D =	0.006173	ft
K_u =	11.17	

Velocity Upstream of Bridge = 2.9 ft/sec

Data Output

V_c = **2.4** ft/sec

Critical Velocity V_c is less than mean velocity V therefore Live Bed conditions

Modified Laursen's 1960 Equation for Contraction Scour (Live Bed Condition)

$y2/y1 = (Q2/Q1)^{6/7} (W1/W2)^{k1}$

y_1 = Average depth in the upstream main channel, ft

y_2 = Average depth in the contracted section, ft

y_o = Existing depth in the contracted section before scour, ft

Q_1 = Flow in the upstream channel transporting sediment, ft3/s

Q_2 = Flow in the contracted channel, ft3/s

W_1 = Bottom width of the upstream main channel that is transporting bed material, ft

W_2 = Bottom width of main channel in contracted section less pier width, ft

k1 = Exponent determined in Section 6.3 HEC No. 18

$V^* = (gy_1S_1)^{1/2}$, ft/sec

T = Fall velocity of bed material based on the D50, Figure 6.8 HEC No. 18 multiplied 3.28, ft/sec

g = acceleration of gravity, (32.2 ft/sec)

S_1 = Slope of energy grade line of main channel, ft/ft

τ = Shear stress on the bed, lb/ft^2

Δ = Density of water (1.94 slugs/ft^3)

Data Input
2.7
3.6
2.8
95
95
12
8
0.69
0.34
0.20
32.2
0.001
0.99
1.94

Data Output

y_2 = **3.6** ft average depth from water surface

$y_s = y_2 - y_o$ = **0.7** ft average depth of scour

Project Name:	Miscoe Brook over South Street
Project Location:	South Street Franklin, MA
Project Job Number:	22-0177
Frequency Event:	50-year (Alternative 2)

Determine Critical Velocity

$V_c = K_u y^{1/6} D^{1/3}$

V_c = Critical velocity above which bed material of D and smaller will be transported, ft/s

y = Average depth of flow upstream of the bridge, ft

D = Particle size for V_c, ft

D_{50} = Particle size in a mixture of which 50% are smaller, ft

K_u = 11.17

Data Input

y =	3.1	ft
D =	0.006173	ft
K_u =	11.17	

Velocity Upstream of Bridge = 3.1 ft/sec

Data Output

V_c = **2.5** ft/sec

Critical Velocity V_c is less than mean velocity V therefore Live Bed conditions

Modified Laursen's 1960 Equation for Contraction Scour (Live Bed Condition)

$y2/y1 = (Q2/Q1)^{6/7} (W1/W2)^{k1}$

y_1 = Average depth in the upstream main channel, ft

y_2 = Average depth in the contracted section, ft

y_o = Existing depth in the contracted section before scour, ft

Q_1 = Flow in the upstream channel transporting sediment, ft3/s

Q_2 = Flow in the contracted channel, ft3/s

W_1 = Bottom width of the upstream main channel that is transporting bed material, ft

W_2 = Bottom width of main channel in contracted section less pier width, ft

k1 = Exponent determined in Section 6.3 HEC No. 18

$V^* = (gy_1S_1)^{1/2}$, ft/sec

T = Fall velocity of bed material based on the D50, Figure 6.8 HEC No. 18 multiplied 3.28, ft/sec

g = acceleration of gravity, (32.2 ft/sec)

S_1 = Slope of energy grade line of main channel, ft/ft

τ = Shear stress on the bed, lb/ft^2

Δ = Density of water (1.94 $slugs/ft^3$)

Data Input
3.1
4.1
3.2
115
115
12
8
0.69
0.35
0.20
32.2
0.001
0.99
1.94

Data Output

y_2 = **4.1** ft average depth from water surface

$y_s = y_2 - y_o$ = **0.9** ft average depth of scour

SPECIFICATIONS AND SPECIAL PROVISIONS

CONSTRUCTION SPECIFICATIONS

Please refer to the MassDOT *Standard Specifications for Highways and Bridges* dated 2023 for standard items. The following items are not standard and are provided to supplement the contract.

ITEM 148.01 **DREDGING AND STOCKPILING OF STREAMBED MATERIAL** **CUBIC YARD**

GENERAL

Work under this item shall conform to the relevant provisions of Section 148 of the MassDOT Standard Specifications for Highways and Bridges and the following:

The work under this item shall include dredging of approved native streambed material to be stockpiled for re-use as shown on the Plans and as directed by the Engineer.

Streambed material may be stockpiled on site at a location determined by the Contractor. The stockpiled material will be reused on site for streambed restoration. The placement of this material will be paid for under Item 983.521.

When the Contractor is not actively working with the dredged and stockpiled material, the stockpile shall be protected to prevent damage. Providing, installing, adjusting, protecting, and all other work required to cover the stockpiled material shall be considered incidental to this Item.

METHOD OF MEASUREMENT

Item 148.01 will be measured per CUBIC YARD of material dredged and stockpiled within the specified limits as directed by the Engineer.

BASIS OF PAYMENT

Item 148.01 will be paid for at the Contract unit price per CUBIC YARD, which price shall include all labor, materials, equipment, and incidental costs required to complete the work.

The replacement of the stockpiled material shall be included in the bid price for Item 983.521 – Streambed Restoration.

ITEM 153.1 CONTROLLED DENSITY FILL – NON-EXCAVATABLE CUBIC YARD

GENERAL

Work under these Items shall conform to the relevant provisions of Section 150 of the MassDOT Standard Specifications for Highways and Bridges and the following:

The work shall include the placement of CDF – Non Excavatable below precast concrete foundations, above crushed stone for bridge foundations, as shown on the plans and as directed by the Engineer.

MATERIALS

CDF materials shall conform to Section M4.08.0 of the MassDOT Standard Specifications for Highways and Bridges. CDF – Non Excavatable shall be either Type 1 or Type 2, depending on the applications and as required by the Engineer. CDF Type 1 and Type 2 shall have a compressive strength of 200 pounds per square inch (psi) required at 28 days. Controlled Density Fill shall be listed on the MassDOT Qualified Construction Materials List (QCML).

METHOD OF MEASUREMENT

Item 153.1 will be measured per CUBIC YARD of material placed within the specified limits as directed by the Engineer.

BASIS OF PAYMENT

Item 153.1 will be paid for at the Contract unit price per CUBIC YARD of material placed, which price shall include all labor, materials, equipment, and incidental costs required to complete the work.

ITEM 620.12 **GUARDRAIL, TL-2 (SINGLE FACED)** **FOOT**

GENERAL

Work under this item shall conform to the relevant provisions of Section 601 of the MassDOT Standard Specifications for Highways and Bridges and the following:

Work shall include the furnishing and installing TL-2 Guardrail at locations indicated on the Plans and as required by the Engineer in conformance with the dimensions and details shown on the Plans.

METHODS

Guardrail shall be installed per the relevant MassDOT Construction Details. In the event that the Contractor needs to minimize disturbance of utilities or other items adjacent to the location of a guardrail post, as required by Engineer and Utility Companies, the Contractor shall install guardrail posts without the use of heavy equipment.

METHOD OF MEASUREMENT

Item 620.12 shall be measured per FOOT of actual guardrail installed and accepted by the Engineer, complete in-place.

BASIS OF PAYMENT

Item 620.12 shall be paid for at the Contract Unit Price per FOOT of actual guardrail installed and accepted by the Engineer, complete in-place. This item shall include full compensation for all labor, equipment, materials, and incidentals required to complete the work described under this Item.

ITEM 634.11 **STEEL THRIE BEAM HIGHWAY GUARD** **FOOT**

GENERAL

Work under this Item shall conform to the relevant provisions of Section 601 of the Standard Specifications and the following:

Work under this Item shall include installation of double nested steel thrie beam at locations indicated on the Plans and as required by the Engineer in conformance with the dimensions and details shown on the Plans. This work includes all required steel guardrail posts and shall include two sections of MassDOT standard steel thrie beam highway guard, where one section is nested inside the other. All guardrail materials/hardware and installation procedures shall be in accordance with relevant MassDOT Standard Construction Details and additional details provided in the Construction Drawings.

METHOD OF MEASUREMENT

Item 634.11 shall be measured per FOOT of actual guardrail installed and accepted by the Engineer, complete in-place.

BASIS OF PAYMENT

Item 634.11 shall be paid for at the Contract Unit Price per FOOT of actual steel thrie beam highway guard installed and accepted by the Engineer, complete in-place. This item shall include full compensation for all labor, equipment, materials, and incidentals required to complete the work described under this Item.

ITEM 697.2 **FLOATING SILT FENCE** **FOOT**

GENERAL

Work under this Item shall conform to the relevant provisions of Section 670 of the Standard Specifications and the following:

Work under this Item shall include installation, maintenance, and removal of a temporary floating silt fence to prevent any sediment disturbed during construction from reaching adjacent waterways and to prevent any further sediment dispersion into Miscoe Brook. The fence shall be installed downstream of the existing culvert, as shown on the plans.

MATERIALS

Floating silt fence shall be made of a woven polypropylene with a minimum 200 lb. tensile strength. The Contractor shall submit to the Engineer, for review and approval, product specifications and technical data provided by the manufacturer, prior to installation. The fence shall be continuously weighted at the bottom to maintain a vertical submerged position. Anchors shall be placed at both ends of the curtain and at intermediate locations, as necessary, to hold the fence securely in place. The fence shall be installed to withstand the forces of the flow of the waterway.

INSTALLATION

Floating silt fence shall be installed before construction begins and earth is disturbed. Silt fences shall be inspected and approved by the Town of Franklin Conservation Commission Agent after installation and prior to commencement of further construction activities.

The Contractor shall inspect silt fence weekly to ensure continuous effectiveness. The Contractor shall always maintain the intent of the fence by making any/all necessary adjustments, should the need arise. If any part of the fence becomes damaged or dislodged, construction activities shall be halted until all deficiencies are corrected by the Contractor with no additional compensation. The floating silt fence shall be removed after all construction activities are completed and in such a way that no collected sediment is dispersed into waterways.

METHOD OF MEASUREMENT

Item 697.2 shall be measured per FOOT installed.

BASIS OF PAYMENT

Item 697.2 shall be paid for at the Contract unit price per FOOT installed. This item shall include full compensation for all labor, equipment, maintenance, materials, and incidentals required to complete the work for the duration of the Contract.

No separate payment will be made for any adjustments or repairs that may be required to provide a floating silt fence that is continuously effective for the duration of construction.

No separate payment will be made for the removal of the floating silt fence.

ITEM 698.1 GEOTEXTILE FABRIC FOR STABILIZATION SQUARE YARD

GENERAL

The work under this Item shall conform to the Standard Specifications of Section M9.50.0 for the intended application, and the following:

The work under this item shall consist of furnishing and placing of geotextile fabric for stabilization under the crushed stone beneath the precast three-sided culvert and wingwall footings as shown on the Plans and as directed by the Engineer.

The geotextile fabric shall be handled and installed per the manufacturer's recommendations.

MATERIALS

Filter fabric shall be a material suitable for the intended applications and shall be selected from the most current version of the Qualified Construction Materials List (QCML) for Geotextile Fabrics found at:

https://www.mass.gov/service-details/qualified-construction-materials-list

METHODS

Geotextile shall be placed in direct contact with soils without wrinkles or folds and shall be anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlaying materials will not excessively stretch or tear it.

Adjacent geotextile sheets shall be joined by either sewing or overlapping. At roll ends, overlapped seams shall overlap a minimum of 12 inches, except when placed under water, where they shall overlap a minimum of 3 feet. Adjacent rolls shall overlap a minimum of 12 inches.

Care shall be taken during the placement of crushed stone to avoid stretching and subsequent tearing of the geotextile. Stones shall not be dropped from a height exceeding 3 feet.

Field monitoring shall be performed to verify that the crushed stone placement does not damage the geotextile.

Any section of fabric that is damaged shall be repaired in accordance with the manufacturer's requirements and AASHTO M 288 and to the satisfaction of the Engineer or it shall be replaced at the Contractor's expense.

METHOD OF MEASUREMENT

Item 698.1 shall be measured by the SQUARE YARD furnished and installed. Overlapping for seams and joints shall be measured as one layer of fabric.

BASIS OF PAYMENT

Item 698.1 shall be paid for at the contract unit bid price per SQUARE YARD furnished and installed. This item shall include full compensation for all labor, materials, equipment, and incidental costs required to complete the work.

ITEM 698.4 **GEOTEXTILE FABRIC FOR PERMANENT EROSION CONTROL** **SQUARE YARD**

GENERAL

The work under this Item shall conform to the Standard Specifications of Section M9.50.0 for the intended application, and the following:

The work under this Item shall consist of furnishing and installing geotextile fabric below riprap embankments as shown on the Plans or as required by the Engineer.

The geotextile fabric shall be handled and installed per the manufacturer's recommendations.

MATERIALS

Filter fabric shall be a material suitable for the intended applications and shall be selected from the most current version of the Qualified Construction Materials List (QCML) for Geotextile Fabrics found at:

https://www.mass.gov/service-details/qualified-construction-materials-list

METHODS

Geotextile shall be placed in intimate contact with soils without wrinkles or folds and shall be anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlaying materials will not excessively stretch or tear it. Adjacent geotextile sheets shall be joined by either sewing or overlapping. At roll ends, overlapped seams shall overlap a minimum of 12 inches, except when placed under water, where they shall overlap a minimum of 3 feet. Adjacent rolls shall overlap a minimum of 12 inches.

The Riprap placement shall begin at the toe of slope and proceed up the slope. Placement shall take place so as to avoid stretching and subsequent tearing of the geotextile. Stones shall not be dropped from a height exceeding 3 feet.

Care shall be taken to avoid damage to the geotextile during handling and installation. Field monitoring shall be performed to verify that the riprap placement does not damage the geotextile.

Any section of fabric that is damaged due to the Contractor's operations shall be repaired in accordance with the manufacturer's requirements and AASHTO M 288 and to the satisfaction of the Engineer or it shall be replaced at the Contractor's expense.

METHOD OF MEASUREMENT

Item 698.4 shall be measured by the SQUARE YARD furnished and installed. Overlapping for seams and joints shall be measured as one layer of fabric.

BASIS OF PAYMENT

Item 698.4 shall be paid for at the contract unit bid price per SQUARE YARD furnished and installed. This item shall include full compensation for all labor, materials, equipment, and incidental costs required to complete the work.

ITEM 767.121 **SEDIMENT CONTROL BARRIER** **FOOT**

GENERAL

The work under this Item shall conform to the relevant provisions of Sections 670, 751 and 767 of the MassDOT Standard Specifications for Highways and Bridges and the following:

This work shall include the furnishing and placement of a sediment control barrier for the purpose of slowing the velocity of and filtering suspended sediments from storm water flow. Barriers shall be in place prior to excavation work. No work shall take place outside the barriers. Sediment barrier shall be used as perimeter barriers, to contain stockpile sediments, to break slope length, and to slow or prevent up gradient water from flowing into a work zone. The Contractor shall be responsible for ensuring that barriers fulfill the intent of adequately controlling siltation and runoff.

Sedimentation control shall be a minimum 12-inch diameter compost filter tubes.

With approval from the Engineer the following may be used to control sediments for small, disturbed areas with minimal slope and slope length:

- 9-inch diameter composts filter tubes or fiber logs

Additional barriers (adding depth or height) shall be used at specific locations of concentrated flow such as at gully points, steep slopes, or identified failure points in the sediment capture line. Additional barriers shall be incidental to this item.

Maintenance of control barriers and removal of accumulated sediment shall be as specified below, as required by the Engineer, and shall conform to the requirements of relevant environmental permits.

Upon completion of work and stabilization of soil, sediment control barriers shall be dismantled and/or removed as specified below for the site context (naturalized or urban). Site shall be restored as specified for specific barrier used. All non-biodegradable materials, including silt fence, twine, plastic netting, and photodegradable fabric, shall be removed, and disposed off-site for all projects.

Location of sediment barrier shall be based on the site's contours and such that it provides maximum effectiveness. Barriers shall be staked, trenched and/or wedged as specified herein and shall be securely in contact with existing soil such that there is no flow beneath the barrier and so that no excavated or disturbed soil can enter mitigation areas or adjacent wetlands or waterways. Prior to initial placement of barriers, the Contractor and the Engineer shall review locations specified on the plans to ensure that the placement will provide maximum effectiveness. If necessary to accommodate field conditions and to maximize effectiveness, barrier locations may be shifted with approval from the Engineer.

MATERIALS AND CONSTRUCTION

Compost Filter Tube

Compost material inside the filter tube shall meet section M1.06.0 of the MassDOT Standard Specifications for Highways and Bridges, except for the following: no manure or bio-solids shall be used; no kiln dried

wood or construction debris shall be allowed; material shall pass through a 2-inch sieve; and the C:N ratio shall be disregarded.

Outer tube fabric shall be made of 100% biodegradable materials (i.e., cotton, hemp, or jute) and shall have a knitted mesh with openings that allow for sufficient water flow and effective sediment capture.

Tubes shall be tamped, but not trenched, to ensure good contact with soil. When reinforcement is necessary, tubes shall be stacked as shown on the detail plans.

MAINTENANCE

Maintenance of sediment control barriers shall conform to the requirements of the Standard Specifications or the Order of Conditions, whichever is more restrictive.

The contractor shall inspect the sediment barrier in accordance with relevant permits. At a minimum, barriers shall be inspected at least once every 7 calendar days, after a rain event resulting in 0.25 inches or more of rainfall, and at least daily during prolonged rainfall.

Contractor shall be responsible for ensuring that an effective barrier is in place and working effectively for all phases of the Contract. Contractor shall remove accumulated sediments when they reach half the height of the barrier or sediment fence.

The Contractor shall immediately correct all deficiencies including washouts, overtopping, clogging due to sediment, and erosion. The contractor shall review location of barriers in areas where construction activity causes drainage runoff to ensure that the barriers are properly located for effectiveness. Where deficiencies exist, such as overtopping or wash-out, additional staking or additional barriers shall be installed as required by the Engineer.

Barriers that decompose naturally such that they no longer provide the function required shall be repaired or replaced as directed. If the resulting berm of compost within the fabric tube is sufficiently intact (despite fabric decay) and continues to provide effective water and sediment control, barrier does not necessarily require replacement if approved by the Engineer.

At specific locations, such as at gully points, steep slopes, or identified failure points in the sediment capture line, barriers shall be reinforced as required by the Engineer. Such reinforcing shall be incidental to the cost of this item and shall not exceed 10 percent of the overall length of barrier required for the project.

Barriers that are decomposing, cut, or otherwise compromised shall be repaired or replaced as directed by the Engineer. Repair and/or replacement shall be incidental to this item.

DISMANTLING & REMOVING

Barriers shall be dismantled and/or removed when construction work is complete and when site conditions are sufficiently stable to prevent surface erosion and after receiving permission to do so from the Engineer.

Regardless of site context, nonbiodegradable material and components of the sediment barriers, including photo-biodegradable fabric, plastic netting, nylon twine, and silt fence, shall be removed and disposed off-site by the Contractor.

ITEM 767.121 (CONTINUED)

For naturalized areas, biodegradable, natural fabric, and material shall be left in place to decompose on-site unless required otherwise by the Engineer. Compost filter tubes may be left as they are with stakes removed. Wooden stakes may be left on site, placed neatly and discreetly.

On urban, residential, and other locations where aesthetics is a concern, the following shall apply:

- Compost filter tube fabric shall be cut and removed, and compost shall be raked to blend evenly (as would be done with a soil amendment or mulch). Not more than a 2-inch depth shall be left on soil substrate.

Dismantling, removal, and seeding shall be incidental to this item.

METHOD OF MEASUREMENT

Item 767.121 shall be measured per FOOT furnished and installed, complete in place.

BASIS OF PAYMENT

Item 767.121 shall be paid for at the contract unit bid price per FOOT which price shall include all labor, equipment, materials, maintenance, dismantling, removal, restoration of site, silt fence if required, and incidental costs required to complete the work. Additional barrier, such as double or triple stacking of compost filter tubes, shall be considered incidental under this Item.

Barriers that have been driven over or otherwise damaged by construction activities shall be repaired or replaced as directed by the Engineer at the Contractors expense.

Installation of a limit of work barrier and limit of work signage shall be considered incidental under this Item.

ITEM 983.521 **STREAMBED RESTORATION** **CUBIC YARD**

GENERAL

The work to be done under this Item shall conform to the relevant provisions of Section 983 of the Standard Specifications and the following:

This work shall consist of placing natural streambed material or equivalent substrate, angular riprap mixed with natural streambed material or equivalent substrate, crushed stone, and geotextile fabric for stabilization on the riverbed inside, upstream, and downstream of the proposed bridge to set a desired channel profile, maintain a natural bed appearance, and to provide passage for aquatic organisms and an upland bank along the face of the new structure for wildlife passage. The placement of these materials shall be as specified herein and on the Plans. The ultimate product will replicate the function and appearance of the existing stream, to the extent possible.

MATERIALS

The streambed restoration areas shall be comprised of the following:

- 12" layer of natural streambed (previously dredged and stockpiled under Item 148.01) or equivalent substrate over
- 36" layer of riprap (paid under Item 983.1) blended with natural streambed material or equivalent substrate
- 12" layer of crushed stone for bridge foundations (paid under Item 156.1) over
- Geotextile fabric for stabilization (paid under Item 698.1)

The natural streambed material shall be that material previously excavated from the surrounding area and stockpiled. The dredging and stockpiling of materials will be paid for under Item 148.01 – Dredging and Stockpiling of Material. If the contractor must bring in non-native material due to shortage, the Engineer shall review and approve all materials to be installed. If additional non-native material is required due to shortage, it shall be considered incidental to this item.

Any gravel, cobble, or boulders excavated and stockpiled from the existing streambed (as part of Item 148.01) shall be reused for streambed restoration, provided the excavated stone is characteristic of the existing stream material upstream and downstream of the work area. The elevations and conditions of the existing streambed adjacent to the project site shall be maintained to the maximum extent practicable.

The angular riprap shall be in accordance with materials specifications M2.02.0 of the Standard Specifications. Riprap must be locked together at the base to resist rolling and sliding.

CONSTRUCTION

The two components shall be pre-blended outside the project area at a volume ratio of 30% natural streambed material and 70% angular riprap. The pre-blending shall be done in a way that will prevent the mass from being contaminated by work-place soils.

The streambed material, riprap, crushed stone, and geotextile fabric shall be placed as detailed on the plans and as described in this specification. The placement of the streambed restoration materials under this Item shall not be placed until the Engineer approves the crushed stone layer along the precast structure. The Contractor shall submit to the Engineer for approval prior to the start of operations, his/her Placement Plan and Method of Placement.

ITEM 983.521 (CONTINUED)

The initial placement of streambed material shall include the random placement of natural boulders on top of the 36" riprap layer. The boulders shall be placed randomly throughout the riprap limits, approximately 10'-0" apart. After boulders are installed, the natural streambed material (previously dredged and stockpiled – Item 148.01) shall be spread over the riprap as shown on the plans to a 12" depth. Boulders shall be flush or extend up approximately 6" above and through the 12" layer of natural streambed.

Natural streambed material shall be tamped down in order to fill / choke the voids in the underlying riprap layer. Fill voids by hand tamping with metal tamping rods, by shaking stone with the teeth of an excavator bucket, and/or by spraying water to settle fines between large stones. Plate compactors shall not be used. The purpose for filling the voids is to prevent subsurface flow where water disappears into the large voids in the stone fill below the channel bed surface. It is recommended that lifts of riprap and streambed material shall be installed to achieve the full depth of stream bed restoration shown on the Plans.

A 12" layer of natural streambed material shall be installed on top of the riprap to restore streambed habitat and aesthetics. The material shall be installed during dewatered conditions behind cofferdams in accordance with the environmental permits. Where appropriate based on existing conditions at the site, a higher proportion of larger native boulders from the natural streambed material mix shall be placed along the edge of the channel to protect the banks or structures. Larger material shall also be installed in the channel to maintain a natural level of hydraulic roughness and re-establish fish habitat.

Once all material has been placed in the stream channel and approved by the Engineer, the Contractor shall remove the water control structures in such a way to slowly wet the stream to minimize the initial sediment pulse. Every attempt shall be made to minimize the downstream movement of sediment.

The final streambed shall look like a natural river, shall match nearby river reaches, and there shall be minimal to no subsurface flow upon final inspection by the Engineer.

METHOD OF MEASUREMENT

Item 983.521 shall be measured by CUBIC YARD of natural streambed/boulders re-laid, complete in place.

BASIS OF PAYMENT

Item 983.521 shall be paid for at the Contract unit price per CUBIC YARD complete and in place which price shall be considered full compensation for all labor, tools, equipment, and materials necessary to rebuild the streambed.

ITEM 991.1 **CONTROL OF WATER** **LUMP SUM**
STRUCTURE NO. F-XX-XXX (XXX)

The work to be done under this Item shall conform to the relevant provisions of Section 140 and consists of the work required for the control of water to remove the existing structure and complete construction of the proposed 3-sided precast concrete culvert in the dry, to the limits shown on the Plans and as specified herein.

It is the responsibility of the Contractor to design the water control structures to be used as part of the dewatering for the removal of the existing culvert and for the installation of the proposed 3-sided precast box culvert. Additionally, as part of the work under this Item, it is the responsibility of the Contractor to determine the need and extent of sand bags, sedimentation basins, dewatering techniques, sedimentation controls, system maintenance, etc. needed to control water and sediment at the site. Construction operations shall be conducted in such a manner as to minimize siltation and prevent contamination of the waterway. The work also includes furnishing, installing, maintaining, and removing Turbidity Curtains (floating silt fences) where required during in-water work under these items that may produce turbidity or sedimentation, in order to avoid or minimize impacts to Essential Fish Habitat (EFH) by preventing construction materials, debris, and sedimentation from entering the waterway and surrounding areas.

The water control structures at locations shall be fully designed by the Contractor. All earth support shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications and MassDOT LRFD Bridge Manual with all interims published as of the bid opening date.

The Contractor is responsible for determining all geotechnical criteria, lateral earth pressures, and hydrostatic pressures associated with the water control structures. Additional lateral earth pressures due to surcharges caused by equipment operation and/or material storage near the water control structures shall be considered and incorporated into the design.

SUBMITTALS

Prior to the commencement of any work at the site, the Contractor shall submit to the Engineer for review and approval, a detailed plan for water control, including the construction of the water control system, and a footing placement sequence plan with a timetable and details specific to each of the phases of construction in relation to the control of water system. The submittal shall include working drawings and calculations. Detailing the methods and materials proposed to account for all anticipated loads and construction conditions necessary to permit the work while maintaining a safe work area and protecting property from damage.

Any drawings and calculations prepared as part of the submittal must be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts.

The Water Control Plan shall include a Sedimentation and Erosion Control Plan and a Water Flow Diversion and Containment Plan. The plans shall be adequate in detail to define specifics regarding materials, sizes, connections, and incidental items associated with the work. The furnishing of such plans shall not serve to relieve the Contractor's responsibility for the safety of the work or his/her responsibility for the successful completion of the project. The proposed plans submitted shall be designed and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts.

ITEM 991.1 (CONTINUED)

The Contractor shall make his/her own evaluation of existing conditions, groundwater level, water flow, the effects of his/her proposed temporary works and construction methods and shall provide in his/her design for all loads and construction conditions necessary to permit construction of the specified structures while maintaining public safety and protecting completed work and all third-party property from damage due to his/her operations.

Sedimentation and Erosion Control Plan:

The Contractor shall submit to the Engineer plans and details of the intended sedimentation/retention tank system that will be used along with dewatering techniques, and its location at the bridge site. All discharge resulting from dewatering activities shall be directed to temporary sedimentation/retention tank at locations approved by the Engineer. At no time shall said discharge be directly released into the stream. The proposed plan shall include methods and equipment necessary to discharge water from the sedimentation treatment basins. Sedimentation/retention tank shall be sized appropriately to adequately dewater from the proposed work zone while allowing sufficient time for sediments to settle out of the water, and with a depth such that a minimum of 18 inches of freeboard is maintained throughout its use.

Water Flow Diversion and Containment Plan:

The Contractor shall submit plans and details along with a complete description showing any proposed systems for control of water and dewatering plan to the Engineer for his/her approval prior to the start of the work. The proposed plan shall include methods and equipment necessary to perform the work and shall include water discharge methods and equipment to bring water from the work zone to sedimentation/retention tank.

METHODS

This work shall also include dewatering the work areas as needed to complete demolition and construction in the dry.

The system shall be designed so that there are no adverse effects on the adjacent properties. The control of water system shall be sized in such a way that the system is overtopped with elevated stream water before any adjacent properties are inundated.

Where sandbags are used, the bags shall not decay nor rip or tear during the installation, its service life within the waterway, or during the removal process. The Contractor shall not disturb the streambed in order to avoid migration of silts and sands further downstream. All in-stream work required to install, adjust, and remove the control of water system must be performed by hand or by hoisting equipment positioned upland. The Contractor is responsible for researching the seasonal groundwater levels and flow characteristics of Miscoe Brook to determine appropriate details.

Measures to control the discharge of sediment or pollutants into the water resource areas shall include, but not be limited to the following:

- Site construction areas outside the buffer zones and on relatively flat ground.
- Management of construction operations involving hazardous materials, such as refueling and maintenance of equipment within the resource areas.
- Formulation of contingency plans to control accidental spillage from potentially hazardous materials.

ITEM 991.1 (CONTINUED)

- Installation and continuous maintenance of water control measures throughout the project.
- Treatment of all discharge resulting from dewatering activities through a sedimentation/retention tank to control turbidity. At no time shall the discharge from dewatering activities be directly released into a resource area.
- Perform as much work as possible outside the stream banks.

These measures shall be maintained for the duration of the contract.

The locations of any sedimentation/retention tank will be determined by the Contractor based on the selected methods of construction. Placement of the tank shall be in an upland area that is within the existing right of way and temporary easements.

If necessary, a sumping basin shall be constructed to collect any stream waters able to bypass the diversion system that may enter any work areas. The basin shall be equipped with a pump to convey water to a sedimentation/retention tank. Water shall be discharged downstream after passing through the sumping basin and sedimentation/retention tank. No water pumped from the work areas shall be discharged back to the stream until sediment is filtered using the sedimentation/retention tank.

All dewatering and related water control work shall be conducted in such a manner as to prevent siltation or contamination of the waterway. At a minimum, the sedimentation/retention tank shall be constructed of an earthen berm lined with geotextile fabric and surrounded by staked hay bales. The tank shall meet or exceed the following criteria:

- The size and location of the tank shall be determined based on the size of the Contractor's pump and the anticipated groundwater levels.
- The outlet/weir of the sedimentation/retention tank shall not cause erosion of the surrounding area. An approved method of controlling erosion, such as an erosion control blanket, stone, etc., shall be used at the outlet of the tank.
- The Contractor shall not allow any sediment within the sedimentation/retention tank to accumulate to a depth of greater than 12 inches at any point in the tank, nor shall the water level be allowed to rise to a height of more than 24 inches.
- The sedimentation/retention tank shall be designed with a minimum of 18 inches of freeboard, which must be maintained at all times.
- The Contractor shall inspect the sedimentation/retention tank at least daily when in operation.
- Damages shall be repaired immediately.
- The sedimentation/retention outlet shall be cleaned daily.
- The sediments within the sedimentation/retention tank shall be disposed of as described in the Order of Conditions or as approved by the Engineer.

Upon completion of water control, the materials and equipment used to maintain the control of water system, sumping basin, and sedimentation/retention tank shall become the property of the Contractor and shall be removed by the Contractor from the site. The area affected shall be restored to its natural condition in a manner subject to the Engineer's approval.

The Contractor is advised that the effectiveness of the water control method used will vary based on the field conditions and the time at which the actual excavation work is being performed. The Engineer has the right to order the Contractor to stop all excavation operations when in his/her judgment the Contractor's water control operations are failing to produce adequate results or are posing a threat to the environment.

ITEM 991.1 (CONTINUED)

METHOD OF MEASUREMENT

Item 991.1 shall be measured per LUMP SUM.

BASIS OF PAYMENT

Item 991.1 will be paid at the Contract unit price per LUMP SUM, which price shall include all labor, materials, equipment, engineering, and incidental costs required to complete the work as indicated on the Contract Documents. Any riprap used for dewatering discharge shall be considered incidental to the work and shall be paid for under this Item.

In general, the payment method for Item 991.1 is partial progressive payment of the LUMP SUM Contract Unit Bid Price of this Item. The partial payment schedule will be as follows:

- The first payment of Item 991.1 (30% of the LUMP SUM bid price) will be made upon complete installation of Stage 1 of the water control system to the satisfaction and approval of the Engineer.
- The second payment of Item 991.1 (30% of the LUMP SUM bid price) will be made upon complete installation of Stage 2 of the water control system to the satisfaction and approval of the Engineer.
- The final payment of Item 991.1 (40% of the LUMP SUM bid price) will be made upon the satisfactory removal of the water control system after bridge construction is complete.

All adjustments and repositioning of water control shall be considered as included under this item.

No separate payment will be made for the removal and disposal of the sediment material collected from the dewatering systems, but all costs in connection therewith shall be included in the Contract unit price bid.

ITEM 995.01 BRIDGE STRUCTURE, BRIDGE NO. F-XX-XXX (XXX) LUMP SUM

The work done under this Item shall conform to the applicable portions of Section 995 of the Standard Specifications and the specific requirements stipulated below for component parts of the subject Item. For those component parts where no specific requirement is stipulated, the Standard Specifications shall apply, except for payment.

Work under this Item shall include all materials, equipment, and labor needed for the following:

- Three-sided precast concrete culvert (culvert, footings, and headwall);
- Precast concrete wingwalls (footings and wall stems);
- Epoxy coated reinforcing steel;
- Damp proofing

The work does not include any items listed separately in the proposal. Payment for materials shown on the Plans as being part of the bridge structure or which may be incidental to its construction and are not specifically included for payment under another Item shall be considered incidental to the work performed under this Item and shall be included in the unit price of the component of which they are a part.

PRECAST CONCRETE ELEMENTS

Work under this heading shall conform to the relevant provisions of Section 901 of the Standard Specifications.

The following concrete mixes shall be used:
5000 PSI, 3/4 INCH, 685 HP CEMENT CONCRETE shall be used for the precast rigid frame culvert, headwalls, wingwalls, and footings.

All concrete products must be listed on the MassDOT Qualified Construction Material List as an approved producer. Preformed or pre-molded fillers, joint sealers, waterstops, and closed cell foam shall be considered incidental to the work involved in the furnishing and placing of all concrete. All structural concrete shall be placed in the dry.

STEEL REINFORCEMENT FOR STRUCTURES – EPOXY COATED

The work under this heading shall conform to the applicable provisions of section 901.40, 901.62, 901.80, and 901.81 of the MassDOT Standard Specifications for Highways and Bridges as modified by the following:

Special procedures shall be used during handling, storage, and installation to prevent damaging epoxy coating, as outlined in the Concrete Reinforcing Steel Institute (CRSI) report titled "Guidelines for Inspection and Acceptance of Epoxy Coated Reinforcing Steel at the Jobsite". Any damage to the epoxy coating shall be repaired following this report. A copy of this report must be available at the jobsite for reference.

Accessories supporting epoxy coated bars or welded wire fabric shall be epoxy coated. Individual and continuous slab bolsters and chairs shall be of a type to suit various conditions encountered and must be capable of supporting a 300 lb. load without damage or permanent distortion.

ITEM 995.01 (CONTINUED)

DAMP-PROOFING

All work to be done under this heading shall conform to the applicable provisions of Section 970 of the Standard Specifications.

Damp-Proofing shall be used to coat the backs and top of the 3-sided precast culvert and the backs of the precast concrete wingwalls.

PRECAST CONCRETE THREE-SIDED CULVERT, PRECAST CONCRETE CULVERT FOOTINGS, PRECAST CONCRETE WINGWALL FOOTINGS, PRECAST CONCRETE WINGWALL STEMS

A. General.
The work under this Heading consists of fabricating, transporting and installing the three-sided precast concrete culvert, precast concrete culvert footings, precast concrete wingwall footings, precast concrete wingwall stems, and includes all necessary labor, materials, and equipment to complete the work as shown on the Plans. The work shall also include the full structural design of the three-sided arch and footings. The work shall conform with the MassDOT Standard, Supplemental, and Interim Specifications and the requirements of the current AASHTO LRFD Bridge Construction Specifications, supplemented by the current relevant provisions of the latest edition of PCI MNL-116 (The Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products), except as noted herein.

QUALITY ASSURANCE

A. General.
Quality Assurance includes all the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. It is an all-encompassing term that includes Quality Control (performed by the Fabricator) and Acceptance (performed by the Engineer). Quality Control is the system used by the Contractor and Fabricator to monitor and assess their production processes at the plant facility and installation activities at the project site to ensure that the final product will meet the specified level of quality. Acceptance includes all factors used by the Engineer to determine the corresponding value for the product. Inspection at the plant facility is intended as a means of evaluation of compliance with contract requirements. Contractor and Fabricator Quality Control activities and Engineer Acceptance activities shall remain independent from one another. Engineer Acceptance activities shall not replace Fabricator Quality Control activities.

B. Fabricator Quality Control.
Quality Control shall be performed by the Fabricator to ensure that the product is fabricated in conformance with the specifications herein. The Fabricator shall maintain a Quality Control system to monitor, assess, and adjust placement and fabrication processes to ensure the Precast Concrete Bridge Element(s) meet the specified level of quality, through sufficient Quality Control sampling, testing, inspection, and corrective action (where required). The Fabricator's Quality Control system shall address all key activities during the placement and fabrication and shall be performed in conformance with the Fabricator's NPCA or PCI Certification. Quality Control documentation shall meet the requirements of the *Fabricator Quality Control – Documentation* section below. Upon request, Fabricator Quality Control documentation shall be provided to the Engineer.

ITEM 995.01 (CONTINUED)

1. Plant.

Prior to the fabrication of Precast Concrete Bridge Elements, the Fabricator's precast concrete plant shall obtain the following:

(a) Certification by the National Precast Concrete Association (NPCA) Plant Certification Program or Precast/Prestressed Concrete Institute (PCI) Plant Certification Program, for the applicable types of Precast Concrete Bridge Element(s) being fabricated
(b) MassDOT Prequalification
(c) MassDOT Mix Design Approval

All concrete for a given Precast Concrete Bridge Element shall be produced by a single company and plant, unless otherwise approved by the Engineer.

2. Personnel.

The Fabricator shall provide adequate training for all QC personnel in accordance with NPCA or PCI certification. There shall be sufficient personnel trained and certified to perform the tests listed under Subsection M4.02.13, Part D. At a minimum, the Fabricator's Quality Control Personnel shall maintain the following qualifications and certifications:

(a) QC Manager with an active NETTCP Field Technician or ACI Concrete Field Testing Technician – Grade I certification or higher, and a minimum of 4 years continuous experience in the manufacture of Precast Concrete Bridge Elements for state transportation departments.
(b) A Technician/Inspector having the Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level I or NorthEast Transportation Training and Certification Program (NETTCP) Precast Concrete Inspector, or higher.

The Contractor shall submit to the Engineer a copy of the Fabricator's Quality Control Personnel required qualifications, as specified above.

3. Laboratory.

The Fabricator shall provide a room of sufficient size to house all equipment and to adequately perform all testing. The room shall have either a separate moisture storage room or curing box for concrete cylinders, and it shall be thermostatically controlled to maintain temperatures consistent with AASHTO T 23. It shall include a desk and file cabinet for proper record keeping, and have good lighting and ventilation.

This room shall be kept for testing and quality control and not used for any other purpose. An additional desk and file cabinet shall be provided for exclusive use of the Engineer. No exception from these requirements will be allowed without the express written permission of the Engineer.

4. Testing Equipment.
At a minimum, the Fabricator's plant facility shall have the following testing equipment:

(a) Air Content Meter Type A or B: AASHTO T 152
(b) Air Content Meter Volumetric Method: AASHTO T 196 (Required for Lightweight Concrete)
(c) Slump Cone: AASHTO T 119
(d) Cylinder Molds AASHTO M 205
(e) Concrete Testing Machine: AASHTO T 22
(f) Screening Sieve: AASHTO T 27, AASHTO T 11
(g) Curing Box: AASHTO T 23
(h) Spread Test Base Plate for Self-Consolidating Concrete (SCC): ASTM C1611
(i) All other equipment prescribed by AASHTO and ASTM standards for the tests to be performed by the Fabricator as specified

5. Inspection.
Quality Control personnel shall monitor and inspect the fabrication of each Precast Concrete Bridge Element. Quality Control personnel shall report all inspection activities on Quality Control Inspection Reports and non-conformances on Non-Conformance Reports (NCRs) throughout the entire fabrication process, as speciefied herein.

6. Temperature Monitoring.
At a minimum, the Fabricator shall monitor, record, and report the temperatures of the form, ambient temperatures surrounding the concrete, and temperatures of the concrete continuously, without interruption as specified below:

(a) Prior to placement of concrete to verify that $Ti \geq 50°F$.
(b) Immediately after placement to verify that $T_i \geq 50°F$ is maintained.
(c) Throughout the entire duration of the curing cycle, at regular intervals not to exceed one hour until 100% Design Strength (f'_c) is attained and concrete has cooled to within 40°F of the ambient temperature surrounding the Precast Concrete Bridge Element.

At a minimum, the temperature measuring devices shall record and report the temperature of the concrete to the nearest 2°F. At least two temperature sensors (thermocouples) shall be positioned to record the maximum and minimum anticipated concrete temperatures. The anticipated minimum temperature shall be measured with one or more thermocouples at a distance no greater than 2 inches from the surface of the thinnest section. The anticipated maximum temperature shall be measured with one or more thermocouples at the center of the thickest section. Proposed temperature measurement locations shall be submitted to the Engineer for approval. Temperature recording devices shall be located within the curing enclosure and calibrated as required by PCI MNL-116 Section 4.18.4. Maximum heat increase and cool down rates shall comply with PCI MNL-116, Section 4.19. The Contractor shall furnish temperature logs recorded at a minimum frequency of once per hour to the Inspector as required, with each post-pour QC inspection report.

7. Sampling and Testing.

At a minimum, the Fabricator shall perform random Quality Control sampling and testing as specified in *Table 1: Quality Control Sampling and Testing*. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during fabrication. Test Specimens shall conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60, with the exception of the stripping (80% f'_c) set of cylinders. Stripping (80 % f'_c) cylinders shall be cured in the same location and environment as the Precast Bridge Elements they represent. If approved by the Engineer, compressive strength cylinder match curing equipment, that maintains the same concrete conditions that the corresponding Precast Bridge Element is exposed to, may be utilized in lieu of Stripping (80 % f'_c) field cured cylinders, with the use of thermocouples, controllers, and heaters.

Table 1: Quality Control Sampling and Testing

Quality Characteristic	Test Method	Sample Size	Specification Limit	Lot Size [(c)]	Sublot Size [(d)]	Frequency	Point of Sampling
Slump (in.) [(a)]	AASHTO T 119	Per AASHTO	≤ 8 in. or as approved by the Engineer	Total Quantity of Concrete (cy) produced on a Contract, per Type of Element fabricated, per Mix Design	20 cy	One (1) per Sublot or fraction thereof	Point of Discharge
Air Content (%)	AASHTO T 152	Per AASHTO	5% ≤ % ≤ 8%				
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F				
Compressive Strength (psi)	AASHTO T 22 AASHTO T 23	Stripping Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 80% f'_c at Stripping				
		7-day Cylinders: One (1) set of Three (3) 4 x 8 in.	For Information at 7 days				
		28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 28 days				
		56-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 56 days [(b)]				

Notes:

(a) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(b) 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f'_c).
(c) Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
(d) Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

8. Certificate of Compliance.
The Fabricator shall provide a Certificate of Compliance in accordance with Standard Specifications, Division I, Section 6.01, stating that QC test cylinders have achieved the design strength, f'_c. A Certificate of Compliance shall accompany each shipment and shall be presented to the Engineer or designee upon delivery to the site.

9. Documentation.
At a minimum, the Fabricator shall maintain a filing system for the following QC records and documentation. All QC records and documentation shall be made available to the Engineer upon the request.

(a) Current MassDOT Approved Mix Design Sheet(s) and Approval Letter(s)
(b) PCI or NPCA Certification
(c) Current Qualifications and Certifications for QC Manager(s) and QC Technician(s)
(d) Most current set of Approved Shop Drawings
(e) Approved Placement, Finishing and Curing Plan
(f) Approved Dunnage Plan
(g) Fabricator Certificate of Compliance for each fabricated Precast Concrete Bridge Element
(h) Admixture Manufacturer's Certification of Compliance for each approved Admixture
(i) Completed QC Inspection Report for each fabricated Precast Concrete Bridge Element
(j) Identification Number for each fabricated Precast Concrete Bridge Element
(k) Time and date of casting of each fabricated Precast Concrete Bridge Element
(l) Date of stripping of each fabricated Precast Concrete Bridge Element
(m) Batch Ticket Printout reporting the quantity of concrete produced for each batch of concrete produced
(n) Concrete temperature records for each Precast Concrete Bridge Element fabricated
(o) QC Test Report Forms for each sublot of concrete produced
(p) Non-Conformance Reports (NCRs)
(q) Documentation of Repairs (if applicable)

ITEM 995.01 (CONTINUED)

MATERIALS

A. Materials.
Materials shall meet the following specifications (if applicable):

General	M4.00.00
Portland Cement	M4.01.0
Blended Hydraulic Cements	M4.01.1
Fly Ash	M4.01.2
Cement Concrete	M4.02.00
Cement	M4.02.01
Cement Mortar	M4.02.15
Aggregates	M4.02.02
Lightweight Aggregates	M4.02.03
Water	M4.02.04
Cement Concrete Additives	M4.02.05
Proportioning	M4.02.06
Mixing and Delivery	M4.02.10
Test Specimens	M4.02.13
Mortar for Filling Keyways	M4.04.0
Slag	AASHTO M 302
High Performance Cement Concrete	M4.06.1
Self-Consolidating Concrete (SCC)	M4.02.17
Controlled Density Fill – Non-Excavatable	M4.08.0
Reinforcing Bars	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Galvanized Reinforcing Bars	M8.01.8
Welded Wire Reinforcement	M8.01.2
Mechanical Reinforcing Bar Splicer	M8.01.9
Lifting Devices	PCI MNL-116
Corrugated Metal Pipe	AASHTO M 36

1. Cement Concrete Mix Design.
The cement concrete shall be comprised of specified proportions of water and MassDOT approved aggregates, cement, supplementary cementitious materials (SCMs), and admixtures to form a homogenous composition. Cement concrete for Precast Concrete Bridge Elements shall meet the requirements of M4.06.1 High Performance Cement Concrete, with the exception that the "Total Cementitious Content" specified shall be considered the "Maximum Allowable Cementitious Content". When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

Prior to production of cement concrete, the Fabricator shall report and submit all proposed mix design formulations and its constituent materials to the Engineer for review and approval. All mix design yields shall be designed for 1.0 cubic yards of concrete, with an allowable tolerance of +/- 1.0 %. All liquids incorporated into the proposed mix design(s) shall include both water and admixtures in the liquid mass calculation.

During production of cement concrete, the Fabricator shall not alter the previously approved mix design formulation or its constituent materials. Proposed alterations in source, type, batch quantity, or gradation to any of the constituent materials of the previously approved mix design formulation shall require a new Mix Design submission to the Engineer for review and approval. Fabrication shall not occur without prior mix design approval.

2. Vertical Adjustment Assembly.
Vertical Adjustment Assembly details and material requirements shall be as shown on the plans. Alternate devices may be used provided that they are adjustable and can support the anticipated loads. The design of the leveling devices, with necessary calculations, shall be submitted to the Engineer for approval.

3. Grout.
Grout used for shear keys, vertical adjustment assembly voids, and hand holes shall be in accordance with M4.04.0.

4. Reinforcement.
All reinforcing steel shall be epoxy coated Grade 60 unless otherwise noted on the plans. Mechanical reinforcing bar splicers shall be epoxy coated.

5. Threaded Inserts.
Threaded inserts are permissible to facilitate forming the keyway pours. Threaded inserts shall be hot dip galvanized or made of stainless steel. The number of threaded inserts shall be minimized, and the inserts shall not come in contact with the reinforcing steel.

6. Corrugated Metal Pipe.
Corrugated Metal Pipe to be used for forming voids as specified on the plans shall be fabricated from steel and shall have a protective metallic coating of zinc (galvanizing).

CONSTRUCTION METHODS – PLANT FABRICATION

A. Shop Drawings.
Prior to performing any work under this Section, the Contractor shall receive approval for all shop drawings for the Precast Concrete Bridge Element being worked on and any special Contract requirements, provided that a complete shop drawing package is provided. The Contractor shall not order materials or begin work before receiving approved shop drawings. The Engineer will reject Precast Concrete Bridge Elements that deviate from the approved drawings or are fabricated prior to receiving written approval of the shop drawings. The Contractor shall bear full responsibility and costs for all materials ordered or work performed prior to the approval of the shop drawings or written authorization from the Engineer.

Contractor shall submit scaled shop drawings to the Engineer for review and approval. Design calculations for the precast arch and footings shall not be included in the submittal. The Fabricator's name and address shall appear on each sheet.

Resubmittal of "Approved as Noted" shop drawings is not necessary for minor revisions, provided that the correction can be clearly understood and is unambiguous without possibility of misinterpretation. Shop drawings with questions or comments that require a response and/or additional information from the Fabricator must be resubmitted.

Detailed shop drawings shall be prepared in accordance with the relevant provisions of Subsection 5.02 and shall, at a minimum, contain the following:

(a) Number and type and/or piece mark of the precast concrete bridge element including overall length, width, and height.
(b) Skew angle.
(c) Location, size, and geometry of all steel reinforcement, including mechanical reinforcing bar splicers to be used for connecting Precast Concrete Bridge Elements together in the field.
(d) Location and details of all inserts, anchors, Vertical Adjustment Assemblies, and any other items required to be cast into the Precast Concrete Bridge Elements (whether detailed on the plans by the Engineer of Record or provided for the Contractor's convenience). Precast Concrete Bridge Elements shall not be fired or drilled into for attachment purposes. All hardware shall be galvanized except as noted.
(e) Locations and details of the lifting devices, including supporting calculations, type and amount of any additional reinforcing required for lifting. The Fabricator shall design all lifting devices based on the no cracking criteria in Chapter 8 of the PCI Design Handbook (7^{th} edition).
(f) The minimum compressive strength required prior to handling the precast concrete bridge element.

The shop drawings shall not include procedures for placement, finishing, and curing of concrete. These details shall be included in the Placement, Finishing and Curing Plan that is to be submitted to the Engineer as described under *Placement, Finishing, and Curing Plan*.

B. Fabrication.
All Precast Concrete Bridge Elements shall be fabricated in accordance with the latest edition of PCI MNL-116 as modified herein.

C. Placement, Finishing and Curing Plan.
At least 30 days prior to start of fabrication, the Contractor shall submit the Fabricator's proposed Placement, Finishing and Curing Plan to the Engineer for approval. This shall be an independent submittal, separate from the fabrication shop drawings and design calculations. The Placement, Finishing and Curing Plan shall include the following:

(a) Method of Mixing
(b) Method of Placement
(c) Method of Consolidation
(d) Method of Finishing
(e) Method of Initial Curing
(f) Method of Intermediate Curing
(g) Method of Final Curing
(h) Moisture Retention Materials and Equipment (water spray equipment, saturated covers, sheet materials, liquid membrane-forming compounds, accelerated curing equipment, etc.)
(i) Cylinder Curing Methods, Location, and Environmental Control (temperature, humidity, etc.)
(j) Temperature Monitoring, Recording, and Reporting

D. Precast Three-Sided Culvert and Footings
The Contractor shall submit design computations for the precast three-sided culvert and footings to the Engineer for review and approval. The computations shall be prepared in accordance with the latest AASHTO LRFD Bridge Design Specifications, the 2013 MassDOT LRFD Bridge Design Manual, and the Plans using English units and HL-93 live loading. The design computations shall consider all Strength,

Extreme Event and Service Limit States as are appropriate for each stage of fabrication, shipment, construction, and for the final in-service condition. Design computations and shop drawings shall be prepared and stamped by a Professional Engineer licensed to practice in the Commonwealth of Massachusetts. The shop drawings shall be prepared and submitted in accordance with the section, Drawings, above.

The dimensions provided on the plans are shown to establish the size of the proposed opening. The width and thickness of each culvert unit may vary depending upon the manufacturer's specifications provided that the opening size is maintained. The Contractor shall be responsible for modifying the dimensions of the elements to compensate for elastic shortening, shrinkage, grade corrections, and other phenomena that make in-process fabricating dimensions different from those shown on the drawings. Approval of the shop drawings shall not relieve the Contractor from responsibility for the correctness of the dimensions shown.

1. Joints.
The precast reinforced concrete three-sided culvert shall be produced with grout-filled keyways per the details on the plans, the manufacturer's recommendations, and as approved by the Engineer. The ends shall be manufactured such that when the sections are laid together they will make a continuous line of frames with a smooth interior surface free of appreciable irregularities, and in compliance with the permissible variations.

2. Marking.
The following information shall be clearly marked on the interior of each frame by indentation, waterproof paint, or other approved means:

(a) Frame span and rise
(b) Date of manufacture and lot number
(c) Name and trademark of the manufacturer

E. Reinforcement.
The reinforcing bars shall be installed in accordance with Section 901.62 of the Supplemental Specifications, including tolerances for cover and horizontal spacing of bars. Components of mechanical reinforcing bar splicers shall be set with the tolerances shown on the plans. The reinforcing bars and mechanical reinforcing bar splicers shall be assembled into a rigid cage that will maintain its shape in the form and which will not allow individual reinforcing bars to move during the placement of concrete. This cage shall be secured in the form so that the clearances to all faces of the concrete, as shown on the plans, shall be maintained.

Where reinforcing bars are to protrude from one Precast Concrete Bridge Element in order to mate with reinforcing bar splicers in a second precast concrete element, the fabricator shall set the reinforcing bars and the reinforcing bar splicers with a template in order to ensure proper fit up within the tolerances specified on the plans.

F. Tolerances.
Fabrication shall comply with tolerances specified on the plans. Tolerances for steel reinforcement placement shall be in accordance with 901.62. In the absence of specifications on the plans, tolerances shall comply with the latest version of the PCI MNL 135, Precast Tolerance Manual.

G. Forms.
Concrete shall be cast in rigidly constructed forms, which will maintain the Precast Concrete Bridge Elements within specified tolerances to the shapes, lines and dimensions shown on the approved fabrication drawings. Forms shall be constructed from flat, smooth, non-absorbent material and shall be sufficiently tight to prevent the leakage of the plastic concrete. When wood forms are used, all faces in contact with the concrete shall be laminated or coated with a non-absorbent material. All worn or damaged forms, which cause irregularities on the concrete surface or damage to the concrete during form removal, shall be repaired or replaced before being reused. Any defects or damage of more than "Category 2, Minor Defects" made to the concrete, due to form work, stripping or handling, shall be subject to repair or rejection, as defined in the *Repairs and Replacement* section. If threaded inserts are cast into the elements for support of formwork, the inserts shall be recessed a minimum of 1 inch and shall be plugged after use with a grout of the same color as that of the precast cement concrete.

H. Mixing of Concrete.
The concrete shall be proportioned and mixed in conformance with the Fabricator's approved mix design and M4.02.10 Mixing and Delivery Fabrication shall not occur without prior mix design approval. The Fabricator shall provide copies of batch tickets to the Engineer.

I. Placement of Concrete.
Prior to the placement of concrete, the temperature of the forms shall be greater than or equal to 50°F. Quality Control inspection shall be performed by the Fabricator as specified in the *Fabricator Quality Control* section. The Fabricator shall verify all materials and equipment required for protecting and curing the concrete are readily available and meet the requirements of the *Final Curing Methods* section below. All items encased in the concrete shall be accurately placed in the position shown on the Plans and firmly held during the placing and setting of the concrete. Clearance from the forms shall be maintained by supports, spacers, or hangers and shall be of approved shape and dimension.

During placement, the concrete shall maintain a concrete temperature range between 50°F and 90°F. The Fabricator shall minimize the time to concrete placement (measured from start of mixing to completion of placement). In no event shall time to placement exceed 90 minutes. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during the placement of the concrete as specified in the *Fabricator Quality Control* section above. Delays or shutdowns of over 30 minutes shall not be allowed during the continuous filling of individual forms.

J. Consolidation of Concrete.
Suitable means shall be used for placing concrete to prevent segregation or displacement of reinforcing steel or forms. The concrete shall be thoroughly consolidated by external or internal vibrators or a combination of both. Vibrators shall not be used to move concrete within the forms. Vibrators shall be used as specified in 901.63C and as directed by the Engineer. Concrete shall be placed and consolidated in a way that minimizes the presence of surface voids or bug holes on the formed surfaces. When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

K. Finishing of Concrete.

The finish of the Precast Concrete Bridge Elements shall be as indicated on the plans. Where Precast Concrete Bridge Elements have keyways for grout or closure pours, the surfaces of these shear keys shall be abrasive blasted prior to shipment. The Fabricator may utilize a surface retarder with water blast, sandblast, or a combination of both to achieve the desired keyway finish. At a minimum, the profile of the keyway surfaces shall be like that of 60 grit sandpaper. The exposed reinforcing steel in the precast slab shall be protected from damage during the cleaning of the keyways. Damaged epoxy coating of steel reinforcement shall be repaired, and the reinforcing steel shall be cleaned as directed by the Engineer.

The Fabricator shall permanently mark each precast concrete bridge element with its type and/or piece mark, date of casting, and supplier identification either by stamp markings in fresh concrete, waterproof paint, or other approved means on a surface that will not be exposed after assembly.

L. Exposed Surfaces of Precast Concrete Bridge Elements.

As soon as conditions permit, before the concrete has fully hardened, all dirt, laitance, and loose aggregate shall be removed from the exposed concrete surfaces. Contractor shall not allow foot traffic on the uncured concrete until it has reached sufficient strength to prevent damage.

M. Exposed Surfaces of Closure Pour Shear Keys.

The closure pour shear key cast in the sides of the beam flanges shall have an exposed aggregate finish. The closure pour reinforcing steel and its coating shall not be damaged by the process for creating the exposed aggregate surface. Fabricator may utilize a surface retarder with water blast, abrasive blast, or a combination of both to achieve the desired shear key finish. The abrasive blast shall use oil free compressed air. The profile of the shear key surfaces shall be like that of 60 grit sandpaper.

N. Initial Curing Methods.

After the placement of concrete and prior to concrete finishing, the Fabricator shall initiate initial curing methods when the concrete surface begins to dry, to reduce moisture loss from the surface. Application of one or more of the following initial curing methods shall occur immediately after the bleed water sheen has disappeared.

1. Fogging.

Fogging nozzles shall atomize water into a fog-like mist. The fog spray shall be directed and remain visibly suspended above the concrete surface, to increase the humidity of the air and reduce the rate of evaporation. Water from fogging shall not be worked into the surface during finishing operations and shall be removed or allowed to evaporate prior to finishing.

2. Liquid-applied Evaporation Reducers

Evaporation reducers shall be sprayed onto the freshly placed concrete surface to produce an effective monomolecular film that reduces the risk of plastic-shrinkage cracking and rate of evaporation of the bleed water from the concrete surface. Evaporation reducers shall be applied in accordance with manufacturer's recommendations.

O. Intermediate Curing Methods.
The Fabricator shall initiate intermediate curing methods if concrete finishing has taken place prior to the concrete reaching final set. The freshly finished concrete surface shall be protected from moisture loss, by the continuation of initial curing methods (fogging and evaporation reducers) until final curing methods are applied or by the use of liquid membrane-forming curing compounds (see *Liquid Membrane-Forming Compounds for Curing* section).

P. Final Curing Methods.
The Fabricator shall initiate and apply final curing methods to the concrete immediately after the following conditions are met:

(a) Completion of concrete finishing
(b) Final set of concrete
(c) Concrete has hardened sufficiently enough to prevent surface damage

During fabrication of Precast Concrete Bridge Elements, the Fabricator shall maintain the required concrete temperature ranges throughout the entire duration of the final curing method cycle as specified herein. Controlled and gradual termination of the final curing method shall occur after all specified conditions are met. The concrete temperature shall be reduced at a rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the final curing method enclosure. The Fabricator shall maintain a minimum concrete temperature of 40°F until 100% f'c is attained (see *Handling and Storage* section below).

1. Water Spray Curing.
All exposed concrete surfaces shall remain moist with a continuous fine spray of water throughout the entire duration of the final curing method cycle (see *Table 4: Final Curing Method Cycle for Water Spray*).

Table 4: Final Curing Method Cycle for Water Spray

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Five (5) days	≥ 80% f'_c

2. Saturated Covers for Curing.
All exposed concrete surfaces shall remain moist with a continuous application of saturated covers throughout the entire duration of the final curing method cycle (see *Table 5: Final Curing Method Cycle for Saturated Covers*). Saturated covers shall be allowed to dry thoroughly before removal to provide uniform, slow drying of the concrete surface.

Table 5: Final Curing Method Cycle for Saturated Covers

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Three (3) days	≥ 80% f'_c

Saturated covers, such as burlap, cotton mats, and other coverings of absorbent materials shall meet the requirements of AASHTO M 182, Class 3. Saturated covers shall be in good condition, free from holes, tears, or other defects that would render it unsuitable for curing concrete. Saturated covers shall be dried to prevent mildew when storing. Prior to application, saturated covers shall be thoroughly rinsed in water and free of harmful substances that are deleterious or cause discoloration to the concrete. Saturated covers shall have sufficient thickness and proper positioning onto the concrete surface to maximize moisture retention.

Saturated covers shall contain a sufficient amount of moisture to prevent moisture loss from the surface of the concrete. Saturated covers shall be kept continuously moist so that a film of water remains on the concrete surface throughout the entire duration of the final curing method cycle. The Fabricator shall not permit the saturated covers to dry and absorb water from the concrete. Use of polyethylene film (see *Polyethylene Film* section) may be applied over the saturated cover to potentially decrease the need for continuous watering.

3. Sheet Materials for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of curing sheet materials throughout the entire duration of the final curing method cycle (see *Table 6: Final Curing Method Cycle for Curing Sheet Materials*).

Table 6: Final Curing Method Cycle for Sheet Materials

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
$50°F \leq °F \leq 90°F$	$\geq$ Three (3) days	$\geq 80\%$ f'_c

Sheet Materials used for curing, such as polyethylene film, white burlap-polyethylene sheeting, and reinforced paper shall meet the requirements of ASTM C171 and the specifications herein. Sheet materials shall inhibit moisture loss and reduce temperature rise in concrete exposed to radiation from the sun during the final curing method cycle. Adjoining covers shall overlap not less than 12 inches. All edges of the covers shall be secured to maintain a moist environment.

(a) Polyethylene Film.

Polyethylene film shall meet the requirements of ASTM C171, consist of a single sheet manufactured from polyethylene resins, be free of visible defects, and have a uniform appearance. Careful considerations shall be taken by the Fabricator to prevent the film from tearing during storage and application, so as to not disrupt the continuity of the film (polyethylene film reinforced with glass or other fibers is more durable and less likely to be torn). The Fabricator shall monitor the application of the film to prevent uneven spots from appearing (mottling) on the concrete surface, due to variations in temperature, moisture content, or both. The Fabricator shall prevent mottling from occurring on the concrete surface by applying additional water under the film or applying a combination of polyethylene film bonded to absorbent fabric to the concrete surface to retain and evenly distribute the moisture.

Immediately following final finishing, polyethylene film shall be placed over the surface of the fresh concrete surface, so as to not damage the surface of the concrete and shall be placed and weighted so that it remains in contact with the concrete throughout the entire duration of the final curing method cycle. The film shall extend beyond the edges of the concrete surface. The film shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling. Edges of

adjacent polyethylene film shall overlap a minimum of 6 inches and be tightly sealed with the use of sand, wood planks, pressure-sensitive tape, mastic, or glue to maintain close contact with the concrete surface, retain moisture, and prevent the formation of air pockets throughout the entire duration of the final curing method cycle.

(b) White Burlap-Polyethylene Sheeting
White burlap-polyethylene sheeting shall meet the requirements of ASTM C171, be securely bonded to the burlap so to avoid separation of the materials during handling and curing of the concrete and be applied in the same manner as the polyethylene film.

(c) Reinforced Impervious Paper.
Reinforced impervious paper shall meet the requirements of ASTM C171, consist of two sheets of kraft paper cemented together with a bituminous adhesive and reinforced with embedded cords or strands of fiber running in both directions, and be white in color. Reinforced impervious paper shall be treated to prevent tearing when wetted and dried.

Reinforced impervious paper can be reused so long as it is effective in retaining moisture on the concrete surface. The Fabricator shall visually inspect the reinforced impervious paper for all holes, tears, and pin holes from deterioration of the paper through repeated use by holding the paper up to the light. The paper shall be discarded and prohibited from use when the moisture is no longer retained.

After the concrete has hardened sufficiently to prevent surface damage, the concrete surface shall be thoroughly wetted prior to the application of the reinforced impervious paper and be applied in the same manner as the polyethylene film.

4. Liquid Membrane-Forming Compounds for Curing.
All exposed concrete surfaces shall remain moist with a continuous application of liquid membrane-forming compounds throughout the entire duration of the final curing method cycle (see *Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds*).

Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Seven (7) days	≥ 80% f'_c

Liquid membrane-forming compounds shall meet the requirements of ASTM C 1315, Type I, Class A and shall exhibit specific properties, such as alkali resistance, acid resistance, adhesion-promoting quality, and resistance to degradation by ultraviolet light, in addition to moisture-retention capabilities. Liquid membrane-forming compounds shall consist of waxes, resins, chlorinated rubber, or other materials to reduce evaporation of moisture from concrete. Liquid membrane-forming compounds shall be applied in accordance with the manufacturer's recommendations.

ITEM 995.01 (CONTINUED)

Liquid membrane-forming compounds shall be applied immediately after the disappearance of the surface water sheen following final finishing. All exposed surfaces shall be wetted immediately after form removal and kept moist to prevent absorption of the compound, allowing the curing membrane to remain on the concrete surface for proper membrane moisture retention. The concrete shall reach a uniformly damp appearance with no free water on the surface prior to the application of the compound.

If patching or finishing repairs are to be performed prior to the application of the compound, the Precast Concrete Bridge Element shall be covered temporarily with saturated covers until the repairs are completed and the compound is applied. Only areas being repaired shall be uncovered during this period. While the saturated covers are removed to facilitate the patching process, the work shall continue uninterrupted. If for any reason the work is interrupted, saturated covers shall be placed onto the uncovered concrete surface, until the work continues and is completed, at which time the curing compound shall be applied to the repaired area.

Careful considerations shall be made by the Fabricator to determine if the evaporation rate is exceeding the rate of bleeding, thus causing the surface to appear dry even though bleeding is still occurring. Under such conditions, the application of liquid membrane-forming compounds to the concrete surface shall be delayed, in order to prevent bleed water from being sealed below the concrete surface and avert map cracking of the membrane films, reduction in moisture-retention capability, and reapplication of the compound. To diagnose and prevent this condition, the Fabricator shall place a transparent plastic sheet over a test area of the uncured and unfinished concrete surface and shall determine if any bleed water accumulates under the plastic.

The compound shall be applied in two applications at right angles to each other to ensure uniform and more complete coverage. On very deeply textured surfaces, the surface area to be treated shall be at least twice the surface area of a troweled or floated surface. In such cases, two separate applications may be needed, each at 200 ft^2/gal., with the first being allowed to become tacky before the second is applied.

The curing compound shall be applied by power sprayer, using appropriate wands and nozzles with pressures between 25 and 100 psi. For very small areas such as repairs, the compound shall be applied with a wide, soft-bristled brush or paint roller. The compound shall be stirred or agitated before use and applied uniformly in accordance with the manufacturer's recommended rate. The Fabricator shall verify the application rates are in accordance with the manufacturer's recommended rate.

When the concrete surface is to receive paint, finishes, or toppings that require positive bond to the concrete, it is critical that the curing procedures and subsequent coatings, finishes, or toppings be compatible to achieve the necessary bond.

After the termination of the final curing method cycle has occured, liquid membrane-forming compounds shall be removed by blast-cleaning from any concrete surface that is to receive paint, finishes, plastic concrete from secondary pour, grout, or any other toppings that require bonding to the concrete surface. These surfaces shall be further blast-cleaned to remove the cement matrix down to exposed aggregate to ensure proper bonding to the material. The method used to remove the curing compound shall not damage the reinforcement and coating. Compounds are prohibited on any concrete surface that will have a penetrating or coating type treatment such as a sealer, stain, or waterproofing membrane applied to it.

5. Accelerated Curing.

Accelerated curing shall use live steam or radiant heat with moisture in accordance with PCI MNL-116 as modified herein. The concrete temperature shall meet the maximum heat increase and cool down rates as specified herein. Concrete temperature monitoring shall meet the requirements of the *Temperature Monitoring* section. Excessive and fluctuating rates of heating and cooling shall be prohibited. The concrete temperature shall not exceed 158°F at any time. The Fabricator shall meet the following accelerated curing sequencing and requirements.

(a) Initial Delay Period.

The initial delay period shall be defined as the duration immediately following the placement of the concrete and the attainment of initial set of the concrete. The Fabricator shall determine the time of initial set in accordance with AASHTO T 197 specifications. Throughout the entire duration of the preset period, initial curing shall be implemented. The temperature increase period (see *Temperature Increase Period* section) shall not occur until initial set of the concrete is attained. During the initial delay period, the concrete temperature shall meet the following requirements:

i. Concrete temperature rate of increase shall not exceed 10°F per hour.
ii. Total concrete temperature increase shall not exceed 40°F higher than the placement concrete temperature or 100°F, whichever is less

(b) Temperature Increase Period.

The temperature increase period shall be defined as the duration immediately following the completion of the initial delay period (after initial set) and immediately prior to the start of the constant maximum temperature period. Application of steam to the enclosure shall not occur until the initial delay period is complete. After the initial delay period is complete, all exposed concrete surfaces shall be cured in a moist environment where the concrete temperature increases at a rate not to exceed 36°F per hour.

(c) Constant Maximum Temperature Period.

The constant maximum temperature period shall be defined as the duration immediately following the completion of the temperature increase period and immediately prior to the start of the temperature decrease period. After the temperature increase period is complete, all exposed concrete surfaces shall be cured in a moist environment at a controlled and constant elevated temperature throughout the entire duration of the constant maximum temperature period. Termination of the constant maximum temperature period and the start of the termination decrease period shall occur after all specified conditions are met (see *Table 8: Constant Maximum Temperature Period*).

Table 8: Constant Maximum Temperature Period

Sustained Concrete Temperature	Constant Maximum Temperature Period	Compressive Strength
120°F ≤ °F ≤ 158°F	6 hrs ≤ Time ≤ 48 hrs	≥ 80% f'_c

(d) Temperature Decrease Period.

After the constant maximum temperature period is complete, the concrete temperature shall be cured in a moist environment at a controlled and reduced rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the curing enclosure.

Q. Stripping.
The Fabricator shall not strip forms or handle the Precast Concrete Bridge Element until Quality Control compressive strength cylinders attain a minimum compressive strength of 80% Design Strength (f'_c) or the value indicated on the approved drawings has been achieved. After removal from the form, all exposed concrete surfaces shall continue to be cured in conformance with the *Final Curing Methods* sections until completion.

R. Handling and Storage of Precast Concrete Bridge Elements.
Precast Concrete Bridge Elements may be exposed to temperatures below freezing (32°F) when the chosen curing cycle has been completed, provided that the following conditions are met:

(a) Precast Concrete Bridge Elements are protected from precipitation with polyethylene curing covers until 100% f'_c is attained.
(b) Precast Concrete Bridge Elements maintain a minimum concrete temperature of 40°F until 100% f'_c is attained.

Precast Concrete Bridge Elements damaged during handling and storage will be repaired or replaced at the Engineer's direction at no cost to the Town. Precast Concrete Bridge Elements shall be lifted at the designated points by approved lifting devices embedded in the concrete and in accordance with proper lifting and handling procedures. Storage areas shall be smooth and well compacted to prevent damage due to differential settlement. Precast Concrete Bridge Elements shall be supported on the ground by means of continuous blocking, in accordance with the approved dunnage plan.

Precast Concrete Bridge Elements shall be loaded on a trailer with blocking as described above, in accordance with the approved dunnage plan. Shock-absorbing cushioning material shall be used at all bearing points during transportation of the Precast Concrete Bridge Elements. Blocking shall be provided at all locations of tie-down straps. Precast Concrete Bridge Elements stored prior to shipment shall be inspected by the Contractor prior to being delivered to the site to identify damage that would be cause for repair or rejection.

S. Repairs and Replacement.
In the event defects are identified, they shall be classified in the following categories and a non-conformance report (NCR) shall be filed if required. The NCR shall be submitted to the Engineer for review. Defects in all categories shall be documented by plant Quality Control personnel and made available to the Engineer upon request. Any required repairs shall utilize materials listed on the MassDOT QCML.

Where noted, defects shall be repaired according to the PCI Northeast Region Guidelines for Resolution of Non-Conformances in Precast Concrete Bridge Elements, Report Number PCINE-18-RNPCBE. Please note that reference to PCINE-18-RNPCBE is made for repair details only. In the case of conflicts with this Special Provision, this Special Provision shall govern.

1. Category 1, Surface Defects.
Category 1 defects do not need to be repaired, and an NCR does not need to be filed. Surface defects are defined as the following:

(a) Surface voids or bug holes that are less than 5/8-inch in diameter and less than ¼-inch deep, except when classified as Category 4
(b) Cracks less than or equal to 0.006 inches wide
(c) Cracks less than or equal to 0.125 inches wide on surfaces that will receive a field-cast concrete overlay

2. Category 2, Minor Defects.
Category 2 defects shall be repaired, but an NCR does not need to be filed. Minor defects are defined as the following:

(a) Spalls, honeycombing, surface voids that are less than 2 inches deep and have no dimension greater than 12 inches
(b) Cracks less than or equal to 0.016 inches that will not receive a concrete overlay
(c) Broken or spalled corners that will be covered by field-cast concrete

Minor defects shall be repaired according to PCINE-18-RNPCBE. Cracks shall be sealed according to the PCI Repair Procedure #14 in PCINE-18-RNPCBE.

3. Category 3, Major Defects.
For Category 3 defects, the Fabricator shall prepare an NCR that documents the defect and describes the proposed repair procedure. The NCR shall be submitted to the Engineer for approval prior to performing the repair. Major defects are defined as the following:

(a) Spalls, honeycombing and surface voids that are deeper than 2 inches or have any dimension greater than 12 inches, when measured along a straight line
(b) Concentrated area of defects consisting of four or more Category 2 Defects within a 4-square foot area.
(c) Exposed reinforcing steel
(d) Cracks greater than 0.016 inches and less than or equal to 0.060 inches in width that will not receive a concrete overlay
(e) Bearing area spalls with dimensions not exceeding 3 inches
(f) Cracks, spalls and honeycombing that will be encased in cast in place concrete need not be repaired, but the limits and location of the defects shall be documented with an NCR

Upon approval, defects and cracks shall be repaired according to PCINE-18-RNPCBE and this specification. All repairs shall be completed at the expense of the Contractor.

4. Category 4, Rejectable Defects.
Rejectable defects as determined by the Engineer may be cause for rejection. Fabricator may submit an NCR with a proposed repair procedure, requesting approval. Some rejectable defects are defined as the following:

(a) Surface defects on more than 5% of the surface area which will be exposed to view after installation
(b) Minor defects that in total make up more than 5% of the surface area of the unit
(c) Cracks greater than 0.060 inches in width except as noted in Category 1
(d) Elements fabricated outside of the specified tolerances
(e) MassDOT compressive strength testing that does not meet the specified Design Strength, f'_c

T. Shipping.
Prior to shipment, the Fabricator shall perform the following actions and provide the required documentation to the Engineer:

(a) Precast Concrete Bridge Elements shall remain at the Fabricator's plant for a minimum of 7 days after cast date.

(b) QC Inspection Reports shall be signed by the Quality Control Manager and provided to the Engineer.
(c) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative Sublot shall be generated by the Fabricator and provided to the Engineer.
(d) Certificate of Compliance shall be generated by the Fabricator as described under the Fabricator Quality Control section and provided to the Engineer.
(e) All Engineer approved Corrective Actions submitted on the Non-Conformance Reports (NCR), shall be verified to have been completed by the Engineer and Quality Control Manager.
(f) All NCRs shall be signed off by the Quality Control Manager and the Engineer

U. Delivery.
Upon Delivery, the following documentation shall be provided to the Resident Engineer or designee:

(a) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative sublot.
(b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(c) QC Inspection Reports signed by the Quality Control Manager.

The Contractor shall inspect Precast Concrete Bridge Elements upon receipt at the site. Precast Concrete Bridge Elements damaged during delivery shall be repaired or replaced at the Engineer's direction at no additional cost.

CONSTRUCTION METHODS – FIELD CONSTRUCTION

A. General.
All of the Contractor's field personnel involved in the erection and assembly of the Precast Concrete Bridge Elements shall have knowledge of and follow the approved Erection Procedure.

Prior to installation, the following documentation shall be reviewed and confirmed by the Engineer or designee:

(a) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative sublot.
(b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(c) QC Inspection Reports signed by the Quality Control Manager.

Field construction staff shall verify that the Engineer has accepted all Precast Concrete Bridge Elements prior to installation.

B. Erection Procedure
Prior to the erection, the Contractor shall submit an Erection Procedure for approval by the Engineer. This submittal shall include computations and drawings for the transport, hoisting, erection and handling of the Precast Concrete Bridge Elements. The Erection Procedure shall be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts with working knowledge of the Contractor's equipment, approved shop drawings, and materials to build the bridge. The Erection Procedure shall, at a minimum, include the following:

1. Erection Procedure

The Erection Procedure shall be prepared to conform to the requirements of 960.61, Erection and the applicable sections in Chapter 8 of the PCI Design Handbook (seventh edition) for handling, erection, and bracing requirements. At a minimum, the Erection Procedure shall provide:

(a) Minimum concrete compressive strength for handling the Precast Concrete Bridge Elements.
(b) Concrete stresses during handling, transport, and erection.
(c) Crane capacities, pick radii, sling geometry, and lifting hardware.
(d) Verification that the equipment can handle all pick loads and weights with the required factor of safety.
(e) Evaluation of construction sequence and evaluation of any geometric conflicts in the lifting of the Precast Concrete Bridge Elements and setting them as shown on the plans.
(f) Design of crane supports including verification of subgrade for support.
(g) Location and design of all temporary bracing that will be required during erection.

Non-shrink grout and concrete materials, approved by the Engineer, shall be placed as shown on the plans. Fill joints, keyways, and voids, in strict accordance with the specifications and manufacturer's recommendations and instructions.

For footings once these Precast Concrete Bridge Elements have been set to the correct horizontal and vertical alignment, the void between them and the supporting soil shall be filled with Controlled Density Fill – Non-Excavatable to the limits as shown on the plans. Add additional grout ports in the footings to facilitate the bedding process if required.

Joints shall be filled flush to the top with non-shrink grout, and any vertical misalignment between adjacent elements shall be feathered out on a slope of 1 to 12.

Curing of grout or concrete shall be performed in strict accordance with the specifications and manufacturer's recommendations. Filling shall not be completed in cold weather when either the ambient temperature or the precast member's temperature is below the manufacturer's recommendation. No localized heating of either the precast members or of the air surrounding the element will be permitted in an attempt to reach application temperatures.

If the joints or voids are not filled within five days after the Precast Bridge Elements are erected, the Contractor shall cover and protect the openings from weather and debris until they are filled.

C. Survey and Layout.

Working points, working lines, and benchmark elevations shall be established prior to placement of all elements. The Contractor is responsible for field survey as necessary to complete the work. The Engineer reserves the right to perform additional independent survey. If discrepancies are found, the Contractor may be required to verify previous survey data.

D. Preparation of Closure Pour Keyways.

Immediately prior to erecting the Precast Concrete Bridge Elements, the closure pour shear keys shall be cleaned at the job site of all dust, dirt, carbonation, laitance, and other potentially detrimental materials which may interfere with the bonding of the closure pour concrete and precast concrete using a high-pressure water blast. The exposed reinforcing steel in the precast concrete shall be protected from damage during the cleaning of the keyways. Damaged epoxy coating of steel reinforcement shall be repaired, and the reinforcing steel shall be cleaned as directed by the Engineer. The surfaces of the shear keys shall be

wetted so that the surfaces shall have a Saturated Surface Dry (SSD) condition for at least 24 hours prior to the placement of the closure pour concrete.

E. Erection.

The elements shall be placed in sequence and according to the methods outlined in the Erection Procedure. As the erection proceeds, the Contractor shall constantly monitor the assembly to ensure that the precast concrete bridge element is within proper horizontal and vertical location and tolerances prior to releasing it from the crane and setting the next unit. The Contractor may use shims to maintain proper setting tolerances.

The concrete elements shall be lifted only by the lifting devices, and the utmost care shall be taken to prevent distortion of the elements during handling, transportation, or storage.

Suitable spreaders shall be used during lifting so that only a vertical pull will be made on the lifting device. A non-vertical lifting force may be permitted if prior written approval is given by the Engineer. This approval will be contingent on the Contractor demonstrating by calculations, prepared by a Professional Engineer registered in Massachusetts, that the elements will not be damaged by the non-vertical lifting force and by documentation that the capacity of the lifting devices is adequate for the non-vertical lifting force.

Precast components shall be pre-bed with non-shrink grout thicker than shim stacks prior to placing other precast elements on top of them.

After all Precast Concrete Bridge Elements have been placed, the actual overall dimensions of the structure both horizontal and vertical, as laid out shall not deviate from the nominal dimensions shown on the plans beyond a tolerance of +0 inches and -1 inches. Once the layout of Precast Concrete Bridge Elements has been accepted by the Engineer, the Contractor shall cut all lifting devices off below the surfaces of the elements.

F. Precast Concrete Culverts, Three-Sided Frames and Arches.

Backfilling operations shall not begin until the following checks have been made:

(a) The frame to footing key joints are grouted as shown on the plans;
(b) The joints between exterior frame bridge elements and wingwall stems are complete as shown on the plans;
(c) All joint seals are properly placed.

Backfill shall be paid for under separate items. The backfilling procedures shall be in accordance with Sections 120, 150, and 170 of the Standard Specifications and Supplemental Specifications modified as follows:

(a) Fill shall be placed and compacted in layers not exceeding one foot in depth.
(b) Dumping of fill shall not be allowed any nearer to the structure than 3.25 feet from a vertical plane extending from the back of the footing.
(c) Backfill shall be placed as symmetrically as possible around the structure with differential depths of backfill on each side of the structure not exceeding 1.5 feet with respect to each other.
(d) Compaction shall be achieved using hand compaction equipment for all fill within one foot of the structure.

ITEM 995.01 (CONTINUED)

(e) The bare structure shall not be crossed by any equipment heavier than that specified by the frame manufacturer. All damage resulting from equipment damage shall be rectified to the satisfaction of the Engineer at no cost to the Town.
(f) Construction equipment will not be permitted atop an uncompleted structure.
(g) Construction equipment whose weight exceeds the design capacity shall not be permitted atop the completed structure under any circumstances.
(h) The use of vibratory rollers for compaction purposes will not be permitted.

A representative of the manufacturer shall be on site at the commencement of the installation, at no cost to the Town, to assist the Contractor. The representative shall offer advisory assistance only and shall not supplant the Contractor's representative, or the Engineer.

G. Filling of Blockouts for Lifting Devices and Threaded inserts.
If the blockouts in the Precast Concrete Bridge Elements where the lifting devices were located will be exposed and visible after assembly is complete, the Contractor shall fill these blockouts with Cement Mortar (M4.02.15) or grout.

SCHEDULE OF BASIS FOR PARTIAL PAYMENT

At the time of bid, the Contractor shall submit on his/her proposal a schedule of unit prices for the major component Sub-Items that make up Item 995.01 as well as his/her total bridge structure Lump Sum cost. The bridge structure Lump Sum breakdown quantities provided in the proposal form are estimated and not guaranteed.

The total of all partial payments to the Contractor shall equal the LUMP SUM contract price regardless of the accuracy of the quantities furnished by the Engineer for the individual bridge components.

The cost of labor and materials for any Item not listed but required to complete the work shall be considered incidental to Item 995.01 and no further compensation will be allowed.

The schedule on the proposal form applies only to the Bridge Structure. Payment for similar materials and construction at locations other than at this bridge structure shall not be included under this Item. Sub-Item numbering is presented for information only in coordination with MassDOT Standard Nomenclature.

BRIDGE STRUCTURE NO F-XX-XXX (XXX)

SUB-ITEM NO.	ITEM	QTY.	UNIT	UNIT PRICE	TOTAL
107.48	PREFORMED JOINT FILLER	40	FT	$50.00	$2,000.00
904.3	5000 PSI, ¾", 685 HP CEMENT CONCRETE	175	CY	$1,500.00	$262,500.00
910.1	STEEL REINFORCEMENT FOR STRUCTURES – EPOXY COATED	45825	LB	$3.00	$137,475.00
970.	DAMP-PROOFING	120	SF	$9.50	$11,400.00