MASSACHUSETTS WATER RESOURCES AUTHORITY
Charlestown Navy Yard
100 First Avenue, Building 39
Boston, MA 02129

Frederick A. Laskey
Executive Director

Telephone: (617) 242-6000
Fax: (617) 788-4899
TTY: (617) 788-4971

May 28, 2021

Kathleen A. Theoharides, Secretary
Executive Office of Energy and Environmental Affairs
100 Cambridge St, Suite 900
Attn: MEPA Office
Boston, MA 02114

Subject: Quinapoxet Dam Removal
Expanded Environmental Notification Form
West Boylston, Massachusetts

Dear Secretary Theoharides,

The Massachusetts Water Resources Authority (MWRA) is pleased to submit the attached Expanded Environmental Notification Form (EENF) for the dam removal and channel restoration project of Quinapoxet Dam in West Boylston, Massachusetts. The project team is comprised of the MWRA, the Massachusetts Department of Conservation and Recreation (MADCR), the Massachusetts Division of Ecological Restoration (MADER), and MWRA's design engineer, SLR International Corporation (SLR). The goals of the project are to restore the Quinapoxet River in-stream habitat, enable fish and wildlife passage, maintain public river access, maintain flood control, project water quality, ensure climate change resiliency, and reduce long-term maintenance costs. The project includes: 1) removal of the obsolete Quinapoxet Dam, 2) management of in-stream sediment, 3) construction of an earthen berm to separate the main channel from the transfer aqueduct, and 4) construct a pedestrian access path to the river's edge. Removal of the dam and construction of aquatic habitat structures within the channel will result in significant ecological benefits.

The Quinapoxet Dam is located on River Road in the town of West Boylston. In 2007, GZA conducted a dam safety inspection and determined the dam to be in "fair" condition; however, it was also categorized as a "Class II hazard" and an obstruction for fish passage. MWRA in association with MADER has elected to pursue dam removal.

The project is categorically included for preparation of an Environmental Impact Report (EIR) because it decreases the impoundment capacity of the existing structure (301 CMR 11.03[3][a][4]), it alters 500 or more linear feet of bank along a fish run or inland bank (301 CMR 11.03[3][b][1b], and it alters one half or more acres of any other wetlands (310 CMR 11.03[3][b][1f]).

The project team believes that a full EIR wavier is appropriate in accordance with 301 CMR 11.11, given that strict compliance with the requirement would result in an undue hardship and would not serve to avoid or minimize damage to the environment. Preparation of an EIR will not serve to avoid or minimize damage to the environment but will only lengthen the time to complete the project, increase costs and increase the potential for future damage to the environment.

The proponent respectfully requests a **Waiver of the Mandatory EIR,** as required, under Massachusetts Environmental Policy Act regulations. The project exceeds mandatory EIR thresholds, however, as a carefully planned and comprehensive restoration project, the project will cause significant benefits to environmental resources as detailed in this filing. The subsequent permitting associated with this project will enable additional public and regulatory input.

The EENF has been directly forwarded on behalf of the project team by SLR to the required state and local entities as well as other interested stakeholders identified on the circulation list attached to the document.

Please note in the Environmental Monitor that additional copies may be obtained by contacting Aidan Barry at (203) 271-1773 or abarry@slrconsulting.com. An electronic copy of the EENF is also available of MWRA's website at:
https://www.mwra.com/01news/2021/030121-quinapoxet-dam-notice.html

Should you have any questions or require additional information regarding this submission, please contact W. Andrew Greene, US Manager of Water Resources Engineering and Project Manager for SLR International Corporation. Mr. Greene can be reached at agreene@slrconsulting.com or (203) 271-1773

Sincerely,

Carolyn M. Fiore

Carolyn Fiore
Deputy Chief Operating Officer
Massachusetts Water Resources Authority

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs
Massachusetts Environmental Policy Act (MEPA) Office

Environmental Notification Form

For Office Use Only

EEA#: _____

MEPA Analyst: _____

The information requested on this form must be completed in order to submit a document electronically for review under the Massachusetts Environmental Policy Act, 301 CMR 11.00.

Project Name: Quinapoxet Dam Removal		
Street Address: River Road		
Municipality: West Boylston	Watershed: Nashua	
Universal Transverse Mercator Coordinates: 404,7859.63E 1,505,642.69N	Latitude:42.387224 Longitude:-71.802536	
Estimated commencement date: 10/1/2022	Estimated completion date: 5/30/2023	
Project Type: Dam Removal	Status of project design: 60 % complete	
Proponent: Massachusetts Water Resources Authority		
Street Address: 100 First Avenue, Building 39		
Municipality: Boston	State: MA	Zip Code: 02129
Name of Contact Person: Matt Sanford		
Firm/Agency: Milone & MacBroom, Inc.	Street Address: 99 Realty Drive	
Municipality: Cheshire	State: CT	Zip Code: 06410
Phone: 203-271-1773	Fax: 203-272-9733	E-mail: msanford@slrconsulting.com

Does this project meet or exceed a mandatory EIR threshold (see 301 CMR 11.03)?
☒Yes ☐No

If this is an Expanded Environmental Notification Form (ENF) (see 301 CMR 11.05(7)) or a Notice of Project Change (NPC), are you requesting:

a Single EIR? (see 301 CMR 11.06(8)) ☐Yes ☒No
a Special Review Procedure? (see 301CMR 11.09) ☐Yes ☒No
a Waiver of mandatory EIR? (see 301 CMR 11.11) ☒Yes ☐No
a Phase I Waiver? (see 301 CMR 11.11) ☐Yes ☒No
(Note: Greenhouse Gas Emissions analysis must be included in the Expanded ENF.)

Which MEPA review threshold(s) does the project meet or exceed (see 301 CMR 11.03)?

301 CMR 11.03(3)(a)4., structural alteration of an existing dam that causes an expansion of 20% or decrease in impoundment capacity – removal of 250-feet of existing dam
301 CMR 11.03(3)(b)1.b., alteration of 500 or more linear feet of bank along a fish run or inland bank – alteration of 2,190 feet of inland bank
301 CMR 11.03(3)(b)1.f., alteration of one half or more acres of any other wetlands – alteration of 0.79 acres of bordering vegetated wetlands

Which State Agency Permits will the project require?

Order of Conditions; 401 Water Quality Certification; Chapter 91 Waterways License; Chapter 253 Dam Safety Permit; MHC

Identify any financial assistance or land transfer from an Agency of the Commonwealth, including the Agency name and the amount of funding or land area in acres:
No land transfers required. Funding source are likely from various agencies and grants.

Summary of Project Size & Environmental Impacts	Existing	Change	Total
LAND			
Total site acreage	2.85 acres		
New acres of land altered		0 acres	
Acres of impervious area	0.06 acres	0.04 acres	0.02 acres
Square feet of new bordering vegetated wetlands alteration		+ 34, 385 SF	
Square feet of new other wetland alteration		0 acres	
Acres of new non-water dependent use of tidelands or waterways		N/A	
STRUCTURES			
Gross square footage	N/A	N/A	N/A
Number of housing units	N/A	N/A	N/A
Maximum height (feet)	N/A	N/A	N/A
TRANSPORTATION			
Vehicle trips per day	N/A	N/A	N/A
Parking spaces	N/A	N/A	N/A
WASTEWATER			
Water Use (Gallons per day)	N/A	N/A	N/A
Water withdrawal (GPD)	N/A	N/A	N/A
Wastewater generation/treatment (GPD)	N/A	N/A	N/A
Length of water mains (miles)	N/A	N/A	N/A
Length of sewer mains (miles)	N/A	N/A	N/A

Has this project been filed with MEPA before?
☐ Yes (EEA #_____) ☒No

Has any project on this site been filed with MEPA before?
☐ Yes (EEA #_____) ☒No

GENERAL PROJECT INFORMATION – all proponents must fill out this section

PROJECT DESCRIPTION:

Describe the existing conditions and land uses on the project site:

The Quinapoxet Dam (MA#02523) is located due east of State Route 190 in West Boylston, Massachusetts. Adjacent to the dam is the Oakdale Transfer Facility at the outlet of the Quabbin Aqueduct. The dam is located upstream of two sediment basins serving the Wachusett Reservoir. The first being the Quinapoxet Basin, formed by the railroad causeway, and the second, downstream basin is called the Thomas Basin. The current dam acts as a barrier to fish passage. The proposed project will restore fish passage through this reach.

The dam impoundment extends approximately 500 feet upstream of the structure. The impoundment is shallow and fairly narrow. The rocky cobble bottom river is located within an unnumbered FEMA designated floodplain.

The dam includes a 250-foot long, 18-foot high earthen embankment and a 135-foot long, 6-foot high stone masonry and concrete horseshoe-shaped spillway weir that spans the Quinapoxet River from bank to bank: the earthen embankment portion of the dam is adjacent to the terminus of MWRA's Quabbin Aqueduct at the Oakdale Power Station. A concrete pool/weir fishway, 86 feet long and 4 feet wide, is located along the northern abutment.

The primary goals of the Quinapoxet River Dam removal project are to remove the Quinapoxet Dam, to restore the Quinapoxet River in-stream habitat, enable fish and wildlife passage, maintain public river access, maintain flood control, protect water quality, ensure climate change resiliency, and reduce long-term maintenance costs

Figure 1 of Appendix A and Sheets EX-1 of the project plans in Appendix B of the report provide an overview of existing conditions in the vicinity of the project. Please refer to the Supplemental Information Report, Section 2.0, and relevant technical appendices for more detailed discussion of existing conditions.

Describe the proposed project and its programmatic and physical elements:

NOTE: The project description should summarize both the project's direct and indirect impacts (including construction period impacts) in terms of their magnitude, geographic extent, duration and frequency, and reversibility, as applicable. It should also discuss the infrastructure requirements of the project and the capacity of the municipal and/or regional infrastructure to sustain these requirements into the future.

The dam was constructed below the pre-existing grade of the riverbed, and material downstream of the dam was dredged to create the 9-foot-high drop. As such, removal of the dam will not involve the magnitude of sediment management that many dam removals face. Instead, it will be native substrate that is to be removed from behind the dam.

The plan includes removal of the wingwalls and spillway as well as cut, fill and grading extending approximately 600 feet upstream and fill immediately downstream of the dam. The creation of riffles and pools upstream of the existing dam will provide adequate water depths and appropriate flow velocities favorable for fish passage. The target fish species are trout and landlocked salmon. The channel width will decrease around the impoundment upstream of the dam as well as

downstream of the dam. Several vegetated point bars exist downstream of the dam. These point bars will be mechanically dredged. The result will be a uniform stream width in the area of the existing dam.

Approximately 3,950 cubic yards of material will be removed from the channel. Most of the clean dredging sediment, 2,530 cubic yards, will be relocated to the southern bank of the Quinapoxet River. The relocation of sediment will be used to formalize an earthen berm between the main channel and the Quabbin aqueduct outlet. This action, as well as creating a uniform channel width, will directly impact 1490 linear feet of inland banks and decrease the total inland banks within the project site by 120 feet. Approximately 1.81 acres of Land under water resource areas will be directly impacted. These alterations include the conversion of Land under water into bordering vegetated wetlands. There are no direct impacts to bordering vegetated wetlands, however the conversion of land under water will result in an additional 0.79 acres of bordering vegetated wetlands. Bordering land subject to flooding and riverfront area will increase by 0.62 acres as the channel is reconstructed to a uniform width. This will result in portions of land under water are converted to bordering vegetated wetlands. Existing conditions within the project site include 2,799 square feet of impervious surface. With the removal of the spillway, wingwalls, and concrete fish ladder, and the addition of the walkway adjacent to the Quabbin aqueduct Shaft 1 building the proposed impervious surface will be decreased to approximately 869 square feet.

All disturbed upland areas will receive a minimum of 6” of topsoil and be seeded with appropriate seed mixes. To further restore the watercourse, boulders of various size will be relocated within the Quinapoxet River. These boulders will reduce flow velocities and serve as habitat refuge for fishery species. These channel improvements have been designed to be sustainable long-term. If additional boulders are necessary, they will be obtained via the contractor.

Construction will require temporary and/or permanent impacts to bordering vegetated wetlands, land under water, bordering land subject to flooding, and mean annual high water adjacent to and/or within Quinapoxet River. It is anticipated that construction will commence October 2022 and be completed By May 2023. The removal of the dam will occur in three phases. Phase 1 includes the cofferdamming of low flows around the southern portion of the dam and the partial removal of the dam. Phase 2 will disassemble the remaining dam, fish ladder, and appurtenances as well as remove the downstream islands and reconstruct the channel. Phase 3 will finalize the berm between the reconstructed channel and the Quabbin aqueduct outlet.

Figure 1-7 and Sheets SP-4, SP-5, and SP-6 of project plans in Appendix B of the Supplemental Information Report provide an overview of the proposed conditions. Please see Supplemental Information Report, Section 3.0, for a complete description of proposed activities; Section 5.0 for discussion of Construction sequence, water handling during construction, and sediment management; and Section 6.0 for a discussion of project impacts to wetlands and waterways.

Describe the on-site project alternatives (and alternative off-site locations, if applicable), considered by the proponent, including at least one feasible alternative that is allowed **under current zoning**, and the reasons(s) that they were not selected as the preferred alternative:

The goals of the project include the restoration of free passage of fish and wildlife, naturalization of riverine hydrology, management of sediment during and after construction, and protection of water quality. These Goals are to be met by removing the dam and modifying the channel without impacting the MWRA and Massachusetts Department of Conservation and Recreation (DCR) water supply mission, the operations of the Quabbin Shaft #1 facility, or the downstream Wachusett Reservoir. The design team has carefully evaluated several channel design alternatives for achieving the goals of the project and include:

No Action
The "do nothing" alternative would leave the Quinapoxet dam in place. Fish passage would continue to be blocked. Since this option maintains the status quo and proposes no construction or work, it therefore would not necessitate environmental review or permitting. However, it would result in continued impairment of habitat functionality and fragmented river conditions.

If this alternative were selected it would require the continued maintenance and upkeep of this Significant Hazard Class dam which is in fair condition at the time of the latest inspection performed by GZA in 2007 (Appendix I of the Supplemental Information Report). According to the inspection report, it is estimated that up to $500,000 would be required for upkeep studies, design, and repair work. This cost estimate would include items such as engineering costs, removal of sediment immediately upstream of the spillway and repoint the right training wall. It does not include the dredging of the entire impoundment nor a reconstruction of the fish ladder.

Upstream Riffle-Pool Channel (Preferred Alternative)
This alternative includes the removal of the dam and creation of riffles and pools upstream of the existing dam. The point bars located downstream of the existing dam will be dredged. The sediment material will be relocated to formalize the berm between the Quinapoxet River and the Quabbin aqueduct discharge outlet. This alternative would restore free-flowing habitat on the Quinapoxet River and provide fish passage. Removal of the dam and reconstruction of the channel will provide significant enhancements to the riparian area and to aquatic wildlife and water quality while limiting the downstream channel modifications. Wetland functions and values will increase as a result of converting open water habitat to palustrine emergent and scrub shrub wetlands downstream of the existing dam. This alternative meets all the goals for the restoration project and therefore has been selected as the preferred alternative.

Constant Channel Bed Slope
This alternative involves the removal of the dam and regrading of the channel bed at a constant slope. This alternative was not selected because it does not meet the fish passage goals of the project. The proposed flow depth at the upstream portion of the project would match the depth with the existing dam at current conditions. The constant slope design would result in high velocities through the channel. Both of these conditions result in conditions that are insufficient for fish passage.

Riffle-Pool Channel
Implementing a riffle-pool geometry limits upstream grading and extends channel grading downstream. The incorporation of these riffles and channel roughness (i.e. boulder clusters) reduces predicted velocities through the restored reach. The geometry is similar to the preferred alternative, but is focused downstream of the existing dam. Although this alternative reduces the predicted velocities as compared with Constant Channel Bed Slope alternative, the proposed grading would extend beyond the immediate dam area and would fail to preserve the existing confluence of the Quabbin Reservoir Aqueduct and therefore was eliminated from further consideration.

NOTE*: The purpose of the alternatives analysis is to consider what effect changing the parameters and/or siting of a project, or components thereof, will have on the environment, keeping in mind that the objective of the MEPA review process is to avoid or minimize damage to the environment to the greatest extent feasible. Examples of alternative projects include alternative site locations, alternative site uses, and alternative site configurations.*

Summarize the mitigation measures proposed to offset the impacts of the preferred alternative:
Temporary project impacts will be minimized through construction Best Management Practices for water control and erosion and sedimentation. Permanent mitigation measures involve construction of stabilized channel and sustainable riverbanks using a combination of bioengineering and biotechnical techniques. The temporary and permanent impacts will be offset by the improved ecological benefits including unrestricted fish passage, enhanced aquatic habitat, and recreational opportunities.

If the project is proposed to be constructed in phases, please describe each phase:
The project will be constructed in three phases.

Phase 1 will consist of cofferdamming low flows around the southern portion of the dam. The removal of a portion of the dam and sediment excavations shall be completed once the work area is isolated from the active flow in the Quinapoxet River and fully dewatered.

Phase 2 involves cofferdamming, diverting water through gravity-fed bypass pipe and pumping low flows around the work area, to maintain dry conditions. Phase 2 will require a culvert crossing under the temporary construction access road to allow access to the work area. Disassembling of the remaining dam, fish ladder, and appurtenances; removal of existing point bars; and construction of the new channel can be completed in dry conditions during Phase 2.

Phase 3 will require cofferdamming of the exit flows from the Oakdale Power Station outlet channel. As soon as the exit channel is fully dewatered, installation of fish-deterrent features on the side channel can be performed. All discharges from temporary bypass pipes shall end in a plunge pool designed to provide a soft landing for out-migrating fish. Once the channel is complete, floodplain work outside the wetted portion of the channel can be completed.

AREAS OF CRITICAL ENVIRONMENTAL CONCERN:
Is the project within or adjacent to an Area of Critical Environmental Concern?
☐Yes (Specify_____)
☒No
if yes, does the ACEC have an approved Resource Management Plan? ___ Yes ___ No;
If yes, describe how the project complies with this plan.
_____
Will there be stormwater runoff or discharge to the designated ACEC? ___ Yes ___ No;
If yes, describe and assess the potential impacts of such stormwater runoff/discharge to the designated ACEC.
_____

RARE SPECIES:
Does the project site include Estimated and/or Priority Habitat of State-Listed Rare Species? (see http://www.mass.gov/dfwele/dfw/nhesp/regulatory_review/priority_habitat/priority_habitat_home.htm)
☐Yes (Specify_____) ☒No

HISTORICAL /ARCHAEOLOGICAL RESOURCES:
Does the project site include any structure, site or district listed in the State Register of Historic Place or the inventory of Historic and Archaeological Assets of the Commonwealth?
☒Yes (Specify: Quinapoxet Dam (WBY.905)) ☐No
If yes, does the project involve any demolition or destruction of any listed or inventoried historic or archaeological resources? ☒Yes (Specify: The project proposes to remove the Quinapoxet Dam (WBY.905).)
☐No

WATER RESOURCES:
Is there an Outstanding Resource Water (ORW) on or within a half-mile radius of the project site? X Yes ___No; if yes, identify the ORW and its location. Public Water Supply Watershed – Wachusett Reservoir.

(NOTE: Outstanding Resource Waters include Class A public water supplies, their tributaries, and bordering wetlands; active and inactive reservoirs approved by MassDEP; certain waters within Areas of Critical Environmental Concern, and certified vernal pools. Outstanding resource waters are listed in the Surface Water Quality Standards, 314 CMR 4.00.)

Are there any impaired water bodies on or within a half-mile radius of the project site? X Yes ___No; if yes, identify the water body and pollutant(s) causing the impairment: The Quinapoxet River, headwaters, outlet Quinapoxet Reservoir, Holden to mouth at inlet Wachusett Reservoir (Thomas Basin), West Boylston, are impaired by dewatering. Dewatering is noted as a non-pollutant and TDML is not required.

Is the project within a medium or high stress basin, as established by the Massachusetts Water Resources Commission? X Yes ___No

STORMWATER MANAGEMENT:

Generally describe the project's stormwater impacts and measures that the project will take to comply with the standards found in MassDEP's Stormwater Management Regulations: No stormwater impacts are proposed by the removal of the dam.

MASSACHUSETTS CONTINGENCY PLAN:
Has the project site been, or is it currently being, regulated under M.G.L.c.21E or the Massachusetts Contingency Plan? Yes X No ___ ; if yes, please describe the current status of the site (including Release Tracking Number (RTN), cleanup phase, and Response Action Outcome classification): RTN: 2-14334 - Arsenic was first detected in groundwater in October 2001 during a hydrogeological study that was performed to evaluate the feasibility of recharging non-contact cooling water from the power station into the subsurface. The MassDEP was notified of the release and a Phase I Initial Site Investigation (ISI) was performed. Subsequent sampling confirmed the presence of arsenic in groundwater at concentrations exceeding the applicable GW-1 Method 1 cleanup standard of 0.05 milligrams per liter (mg/L). The Site was tier classified as Tier II and the Phase I/Trier Classification was filed with the MassDEP in May 2003. A combined Phase II Comprehensive Site Assessment (CSA) and Class B-1 Response Action outcome (RAO) statement was filed with the MassDEP on May 31, 2005. The Phase II CSA demonstrated that the following three lines of evidence existed at the Site:

- No anthropogenic sources (past or current) of arsenic exist on-Site.
- Soil and/or rock at the Site contain arsenic-bearing minerals.
- On-Site geochemical conditions are favorable for arsenic mobilization in groundwater.

The Phase II CSA concluded that arsenic is naturally occurring and not associated with a release of oil or hazardous materials (OHM). Since compounds attributed to naturally occurring background conditions are not considered torepresent Contaminants of Concern (COC), a condition of “No Significant Risk” exists for current and future conditions. Pursuant to 310 CMR 40.1046, the Site was closed with the filing of a Class B-1 RAO. As of June 20, 2014, all B-1 RAO are considered to be Permanent Solutions with No Conditions per 310 CMR 40.1055(1).

Is there an Activity and Use Limitation (AUL) on any portion of the project site? Yes ___ No X; if yes, describe which portion of the site and how the project will be consistent with the AUL: _____.

Are you aware of any Reportable Conditions at the property that have not yet been assigned an RTN? Yes ___ No X ; if yes, please describe:_____

SOLID AND HAZARDOUS WASTE:

If the project will generate solid waste during demolition or construction, describe alternatives considered for re-use, recycling, and disposal of, e.g., asphalt, brick, concrete, gypsum, metal, wood: Concrete, rubble, And wood waste will be generated as a result of demolition activities. The construction contracts will Specify that these materials be segregated from one another and recycled to the extent feasible.

(NOTE: Asphalt pavement, brick, concrete and metal are banned from disposal at Massachusetts landfills and waste combustion facilities and wood is banned from disposal at Massachusetts landfills. See 310 CMR 19.017 for the complete list of banned materials.)

Will your project disturb asbestos containing materials? Yes ___ No X ;
if yes, please consult state asbestos requirements at http://mass.gov/MassDEP/air/asbhom01.htm

Describe anti-idling and other measures to limit emissions from construction equipment: The construction contracts will stipulate that the contractors abide by all anti-idling laws.

DESIGNATED WILD AND SCENIC RIVER:

Is this project site located wholly or partially within a defined river corridor of a federally designated Wild and Scenic River or a state designated Scenic River? Yes ___ No X ;
if yes, specify name of river and designation:

If yes, does the project have the potential to impact any of the "outstandingly remarkable" resources of a federally Wild and Scenic River or the stated purpose of a state designated Scenic River?
Yes ___ No ___ ; if yes, specify name of river and designation: _____;
if yes, will the project will result in any impacts to any of the designated "outstandingly remarkable" resources of the Wild and Scenic River or the stated purposes of a Scenic River.
Yes ___ No ___ ;
if yes,describe the potential impacts to one or more of the "outstandingly remarkable" resources or stated purposes and mitigation measures proposed.

ATTACHMENTS:

All cross-referenced materials refer to their location in the Supplemental Information Report

1. List of all attachments to this document. See Table of Contents.
2. U.S.G.S. map (good quality color copy, 8-½ x 11 inches or larger, at a scale of 1:24,000) indicating the project location and boundaries. See Figure 2-1 in Appendix A of the Supplemental Information Report.
3.. Plan, at an appropriate scale, of existing conditions on the project site and its immediate environs, showing all known structures, roadways and parking lots, railroad rights-of-way, wetlands and water bodies, wooded areas, farmland, steep slopes, public open spaces, and major utilities. See Figures 1-1 and 2-2 in Appendix A of the Supplemental Information Report and Sheets SP-1, SP-2, SP-3, and SP-4 in Appendix B.
4 Plan, at an appropriate scale, depicting environmental constraints on or adjacent to the project site such as Priority and/or Estimated Habitat of state-listed rare species, Areas of Critical Environmental Concern, Chapter 91 jurisdictional areas, Article 97 lands, wetland resource area delineations, water supply protection areas, and historic resources and/or districts. See Figures 1-1 and 2-2 in Appendix A of the Supplement Information Report. Sheets of the project plans in Appendix B, and Historical and Archaeological Resources Correspondence in Appendix E of the same report.
5. Plan, at an appropriate scale, of proposed conditions upon completion of project (if construction of the project is proposed to be phased, there should be a site plan showing conditions upon the completion of each phase). See Figure 2-6 in Appendix A of the Supplemental Information Report and Sheets SP-6, CP-1, CP-2, in Appendix B of the same report.
6. List of all agencies and persons to whom the proponent circulated the ENF, in accordance with 301 CMR 11.16(2). See Appendix G of the Supplemental Information Report.
7. List of municipal and federal permits and reviews required by the project, as applicable. See Table 1-1 in Supplemental Information Report.

LAND SECTION – all proponents must fill out this section

I. Thresholds / Permits

A. Does the project meet or exceed any review thresholds related to **land** (see 301 CMR 11.03(1)
___ Yes X No; if yes, specify each threshold:

II. Impacts and Permits

A. Describe, in acres, the current and proposed character of the project site, as follows:

	Existing	Change	Total
Footprint of buildings	_____	_____	_____
Internal roadways	_____	_____	_____
Parking and other paved areas	_____	_____	_____
Other altered areas	_____	_____	_____
Undeveloped areas	_____	_____	_____
Total: Project Site Acreage	_____	_____	_____

B. Has any part of the project site been in active agricultural use in the last five years?
___ Yes X No; if yes, how many acres of land in agricultural use (with prime state or locally important agricultural soils) will be converted to nonagricultural use?

C. Is any part of the project site currently or proposed to be in active forestry use?
___ Yes X No; if yes, please describe current and proposed forestry activities and indicate whether any part of the site is the subject of a forest management plan approved by the Department of Conservation and Recreation:

D. Does any part of the project involve conversion of land held for natural resources purposes in accordance with Article 97 of the Amendments to the Constitution of the Commonwealth to any purpose not in accordance with Article 97? ___ Yes X No; if yes, describe:

E. Is any part of the project site currently subject to a conservation restriction, preservation restriction, agricultural preservation restriction or watershed preservation restriction? ___ Yes X No; if yes, does the project involve the release or modification of such restriction? ___ Yes ___ No; if yes, describe:

F. Does the project require approval of a new urban redevelopment project or a fundamental change in an existing urban redevelopment project under M.G.L.c.121A? ___ Yes X No; if yes, describe:

G. Does the project require approval of a new urban renewal plan or a major modification of an existing urban renewal plan under M.G.L.c.121B? Yes ___ No X; if yes, describe:

III. Consistency

A. Identify the current municipal comprehensive land use plan
Title: West Boylston, Massachusetts Master Plan Date: 2005

B. Describe the project's consistency with that plan with regard to:

1) economic development

The removal of the Quinapoxet dam will restore the watercourse and passage for important fishery species such as landlocked salmon and trout. Such improvements will increase recreational opportunities that will benefit the community.

2) adequacy of infrastructure

The plan vision includes a focus on naturalization of the river and improving ecological values of the surrounding area. Dam removal will remove several components of the infrastructure to allow the Quinapoxet River to flow unobstructed. Enhancing the accessibility of public facilities is another goal of the plan. Installation of walkways will contribute to this goal.

3) open space impacts

The primary goal of the project is to improve the ecological health and quality of wildlife habitat within the Quinapoxet River corridor. Removal of the Quinapoxet dam and naturalizing the channel will improve fish passability and connectivity of the open space to adjacent developed areas.

3) compatibility with adjacent land uses

It will have no impact on the suitability of the surrounding land uses and will enhance general access to public open space amenities.

C. Identify the current Regional Policy Plan of the applicable Regional Planning Agency (RPA)

RPA: Central Massachusetts Regional Planning Commission

Title: Land Use Priority Process Summary Date: December 2014

D. Describe the project's consistency with that plan with regard to:

1) economic development

The removal of the Quinapoxet dam will improve the naturalization of the Quinapoxet River and improve fish passability. Enhancing the ecological health and connectivity of the Quinapoxet River will increase recreational and tourism opportunities such as fishing. The project therefore supports the economic development goals of enhancing existing districts and encouraging redevelopment.

2) adequacy of infrastructure

The goal of the plan is to protect water quality. The removal of the Quinapoxet Dam will maintain water quality flowing through the Quinapoxet River into the Wachusett Reservoir.

3) open space impacts

The project is consistent with this plan, which seeks to preserve open space. The naturalization and channel improvements to the Quinapoxet River meet the goals of the Central Massachusetts Regional Planning Commission plan.

RARE SPECIES SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **rare species or habitat** (see 301 CMR 11.03(2))? ___ Yes X No; if yes, specify, in quantitative terms:

(NOTE: If you are uncertain, it is recommended that you consult with the Natural Heritage and Endangered Species Program (NHESP) prior to submitting the ENF.)

B. Does the project require any state permits related to **rare species or habitat**? ___ Yes X No

C. Does the project site fall within mapped rare species habitat (Priority or Estimated Habitat?) in the current Massachusetts Natural Heritage Atlas (attach relevant page)? ___ Yes X No.

D. If you answered "No" to all questions A, B and C, proceed to the **Wetlands, Waterways, and Tidelands Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Rare Species section below.

II. Impacts and Permits

A. Does the project site fall within Priority or Estimated Habitat in the current Massachusetts Natural Heritage Atlas (attach relevant page)? ___ Yes ___ No. If yes,

1. Have you consulted with the Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program (NHESP)? ___Yes ___No; if yes, have you received a determination as to whether the project will result in the "take" of a rare species? ___ Yes ___ No; if yes, attach the letter of determination to this submission.

2. Will the project "take" an endangered, threatened, and/or species of special concern in accordance with M.G.L. c.131A (see also 321 CMR 10.04)? ___ Yes ___ No; if yes, provide a summary of proposed measures to minimize and mitigate rare species impacts

3. Which rare species are known to occur within the Priority or Estimated Habitat?

4. Has the site been surveyed for rare species in accordance with the Massachusetts Endangered Species Act? ___ Yes ___ No

4. If your project is within Estimated Habitat, have you filed a Notice of Intent or received an Order of Conditions for this project? ___ Yes ___ No; if yes, did you send a copy of the Notice of Intent to the Natural Heritage and Endangered Species Program, in accordance with the Wetlands Protection Act regulations? ___ Yes ___ No

B. Will the project "take" an endangered, threatened, and/or species of special concern in accordance with M.G.L. c.131A (see also 321 CMR 10.04)? ___ Yes ___ No; if yes, provide a summary of proposed measures to minimize and mitigate impacts to significant habitat:

WETLANDS, WATERWAYS, AND TIDELANDS SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **wetlands, waterways, and tidelands** (see 301 CMR 11.03(3))? X Yes ___ No; if yes, specify, in quantitative terms:
301 CMR 11.03(3)(a)4., structural alteration of an existing dam that causes an expansion of 20% or decrease in impoundment capacity – removal of 250-feet of existing dam.
301 CMR 11.03(3)(b)1.b., alteration of 500 or more linear feet of bank along a fish run or inland bank – alteration of 2,190 feet of inland bank.
301 CMR 11.03(3)(b)1.f., alteration of one half or more acres of any other wetlands – alteration of 1.81 acres of land under water, 0.62 acres of riverfront area, 0.62 acres of bordering land subject to flooding.

B. Does the project require any state permits (or a local Order of Conditions) related to **wetlands, waterways, or tidelands**? X Yes ___ No; if yes, specify which permit:
Order of Conditions, 401 Water Quality Certificate, Chapter 253 Dam Safety Permit, and Chapter 91 Waterways License

C. If you answered "No" to both questions A and B, proceed to the **Water Supply Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Wetlands, Waterways, and Tidelands Section below.

II. Wetlands Impacts and Permits

A. Does the project require a new or amended Order of Conditions under the Wetlands Protection Act (M.G.L. c.131A)? X Yes ___ No; if yes, has a Notice of Intent been filed? ___ Yes X No; if yes, list the date and MassDEP file number: _____; if yes, has a local Order of Conditions been issued? ___ Yes ___ No; Was the Order of Conditions appealed? ___ Yes ___ No. Will the project require a Variance from the Wetlands regulations? ___ Yes X No.

B. Describe any proposed permanent or temporary impacts to wetland resource areas located on the project site:

The project meets the definition of an Ecological Restoration Project as defined in 310 CMR 10.04 and as further clarified in subsequent sections of the Wetlands Protection Act (WPA) regulations. It is understood that such projects "may result in the temporary or permanent loss of Resource Areas and/or the conversion of one Resource Area to another where such loss is necessary to the achievement of the project's ecological restoration goals" [(310 CMR10.53(4)(b)]. Impacts to wetland resource areas are described in further detail in the attached Supplemental Information Report Section 6.0. Conversions of wetland types, such as the conversion of LUW to BVW proposed in this project, are expressly anticipated under 310 CMR 10.53(4)(b). Note that permanent impacts will generally result in an increase in the functional benefits of the overall wetland system and that temporary impacts to jurisdictional wetlands are necessary to achieve the restoration goals of the project

C. Estimate the extent and type of impact that the project will have on wetland resources, and indicate whether the impacts are temporary or permanent:

Coastal Wetlands	Area (square feet) or Length (linear feet)	Temporary or Permanent Impact?
Land Under the Ocean	N/A	N/A
Designated Port Areas	N/A	N/A
Coastal Beaches	N/A	N/A
Coastal Dunes	N/A	N/A
Barrier Beaches	N/A	N/A

Coastal Banks	N/A	N/A
Rocky Intertidal Shores	N/A	N/A
Salt Marshes	N/A	N/A
Land Under Salt Ponds	N/A	N/A
Land Containing Shellfish	N/A	N/A
Fish Runs	N/A	N/A
Land Subject to Coastal Storm Flowage	N/A	N/A

Inland Wetlands (Direct Impacts*)

Bank (lf)*	__1,490 lf_____	____Permanent_____
Bordering Vegetated Wetlands	__+34,384 sf_____	____Permanent_____
Isolated Vegetated Wetlands	__N/A_____	____N/A_____
Land under Water*	__79,060 sf (1.81 acres)	____Permanent_____
Isolated Land Subject to Flooding	__N/A_____	____N/A_____
Bordering Land Subject to Flooding*	__27,050 sf (0.62 acres)	____Permanent_____
Riverfront Area*	__27,050 sf (0.62 acres)	____Permanent_____

D. Is any part of the project:

1. proposed as a **limited project**? ___ Yes X No; if yes, what is the area (in sf)?____
2. the construction or alteration of a **dam**? X Yes ___ No; if yes, describe:
   This project will remove the Quinapoxet dam to improve fish passage.
3. fill or structure in a **velocity zone** or **regulatory floodway**? __Yes X No
4. dredging or disposal of dredged material? X Yes ___ No; if yes, describe the volume of dredged material and the proposed disposal site: Approximately 3,950 cubic yards will be dredged. On-site re-use is estimated to be 2,530 of the 3,950 cubic yards to be dredged. The additional 860 cubic yards of clean sediments will be disposed of offsite.
5. a discharge to an **Outstanding Resource Water (ORW)** or an **Area of Critical Environmental Concern (ACEC)**? X* Yes ___ No
   *Discharge is the placement of rock to the watercourse to ensure channel stability
6. subject to a wetlands restriction order? ___ Yes X No; if yes, identify the area (in sf):
7. located in buffer zones? X Yes ___No; if yes, how much (in sf): 124,146 sf (2.85 acres)

E. Will the project:

1. be subject to a local wetlands ordinance or bylaw? X Yes ___ No
2. alter any federally-protected wetlands not regulated under state law? ___ Yes X No; if yes, what is the area (sf)?

III. Waterways and Tidelands Impacts and Permits

A. Does the project site contain waterways or tidelands (including filled former tidelands) that are subject to the Waterways Act, M.G.L.c.91? X Yes ___ No; if yes, is there a current Chapter 91 License or Permit affecting the project site? ___ Yes X No; if yes, list the date and license or permit number and provide a copy of the historic map used to determine extent of filled tidelands:

C. Does the project require a new or modified license or permit under M.G.L.c.91? X Yes ___ No; if yes, how many acres of the project site subject to M.G.L.c.91 will be for non-water-dependent use? Current 0.003 Change +0.017 Total 0.20

If yes, how many square feet of solid fill or pile-supported structures (in sf)? 726 SF

C. For non-water-dependent use projects, indicate the following:

Area of filled tidelands on the site: N/A
Area of filled tidelands covered by buildings: N/A
For portions of site on filled tidelands, list ground floor uses and area of each use:
N/A

Does the project include new non-water-dependent uses located over flowed tidelands?
Yes ___ No X
Height of building on filled tidelands: N/A

Also show the following on a site plan: Mean High Water, Mean Low Water, Water-dependent Use Zone, location of uses within buildings on tidelands, and interior and exterior areas and facilities dedicated for public use, and historic high and historic low water marks.

D. Is the project located on landlocked tidelands? ___ Yes X No; if yes, describe the project's impact on the public's right to access, use and enjoy jurisdictional tidelands and describe measures the project will implement to avoid, minimize or mitigate any adverse impact:

E. Is the project located in an area where low groundwater levels have been identified by a municipality or by a state or federal agency as a threat to building foundations? ___Yes X No; if yes, describe the project's impact on groundwater levels and describe measures the project will implement to avoid, minimize or mitigate any adverse impact:

F. Is the project non-water-dependent **and** located on landlocked tidelands **or** waterways or tidelands subject to the Waterways Act **and** subject to a mandatory EIR? ___ Yes X No;
(NOTE: If yes, then the project will be subject to Public Benefit Review and Determination.)

G. Does the project include dredging? X Yes ___No; if yes, answer the following questions:
What type of dredging? Improvement X Maintenance ___ Both ____
What is the proposed dredge volume, in cubic yards (cys): 2,876 cys
What is the proposed dredge footprint 720 length (ft) 65 width (ft) 2.15 depth (ft);
Will dredging impact the following resource areas?
Intertidal Yes__ No X; if yes, ___ sq ft
Outstanding Resource Waters Yes X No__; if yes, 46,800 sq ft
Other resource area (i.e. shellfish beds, eel grass beds) Yes__ No X; if yes __ sq ft
If yes to any of the above, have you evaluated appropriate and practicable steps to: 1) avoidance; 2) if avoidance is not possible, minimization; 3) if either avoidance or minimize is not possible, mitigation?
Yes the project team has evaluated appropriate and practicable steps for avoidance, minimization, and mitigation. Please see preliminary design report.
If no to any of the above, what information or documentation was used to support this determination?
Provide a comprehensive analysis of practicable alternatives for improvement dredging in accordance with 314 CMR 9.07(1)(b). Physical and chemical data of the sediment shall be included in the comprehensive analysis.
See Section 2.5 of the Supplemental Information Report.
Sediment Characterization
Existing gradation analysis results? X Yes ___No: if yes, provide results.
See Appendix C in the Supplemental Information Report.
Existing chemical results for parameters listed in 314 CMR 9.07(2)(b)6? X Yes ____No; if yes, provide results.
See Appendix C of the Supplemental Information Report.
Do you have sufficient information to evaluate feasibility of the following management options for dredged sediment? If yes, check the appropriate option.

Beach Nourishment ___
Unconfined Ocean Disposal ___
Confined Disposal:

Confined Aquatic Disposal (CAD) ___
Confined Disposal Facility (CDF) ___
Landfill Reuse in accordance with COMM-97-001 ___
Shoreline Placement ___
Upland Material Reuse X
In-State landfill disposal____
Out-of-state landfill disposal ____
(NOTE: This information is required for a 401 Water Quality Certification.)

IV. Consistency:

A. Does the project have effects on the coastal resources or uses, and/or is the project located within the Coastal Zone? ___ Yes X No; if yes, describe these effects and the projects consistency with the policies of the Office of Coastal Zone Management:

B. Is the project located within an area subject to a Municipal Harbor Plan? ___ Yes X No; if yes, identify the Municipal Harbor Plan and describe the project's consistency with that plan:

WATER SUPPLY SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **water supply** (see 301 CMR 11.03(4))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **water supply**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Wastewater Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Water Supply Section below.

II. Impacts and Permits

A. Describe, in gallons per day (gpd), the volume and source of water use for existing and proposed activities at the project site:

	Existing	Change	Total
Municipal or regional water supply	_____	_____	_____
Withdrawal from groundwater	_____	_____	_____
Withdrawal from surface water	_____	_____	_____
Interbasin transfer	_____	_____	_____

(NOTE: Interbasin Transfer approval will be required if the basin and community where the proposed water supply source is located is different from the basin and community where the wastewater from the source will be discharged.)

B. If the source is a municipal or regional supply, has the municipality or region indicated that there is adequate capacity in the system to accommodate the project? ___ Yes ___ No

C. If the project involves a new or expanded withdrawal from a groundwater or surface water source, has a pumping test been conducted? ___ Yes ___ No; if yes, attach a map of the drilling sites and a summary of the alternatives considered and the results. _____

D. What is the currently permitted withdrawal at the proposed water supply source (in gallons per day)? _____Will the project require an increase in that withdrawal? ___Yes ___No; if yes, then how much of an increase (gpd)? _____

E. Does the project site currently contain a water supply well, a drinking water treatment facility, water main, or other water supply facility, or will the project involve construction of a new facility? ___ Yes ___No. If yes, describe existing and proposed water supply facilities at the project site:

	Permitted Flow	Existing Avg Daily Flow	Project Flow	Total
Capacity of water supply well(s) (gpd)	_____	_____	_____	_____
Capacity of water treatment plant (gpd)	_____	_____	_____	_____

F. If the project involves a new interbasin transfer of water, which basins are involved, what is the direction of the transfer, and is the interbasin transfer existing or proposed?

G. Does the project involve:

1. new water service by the Massachusetts Water Resources Authority or other agency of the Commonwealth to a municipality or water district? ___ Yes ___ No
2. a Watershed Protection Act variance? ___ Yes ___ No; if yes, how many acres of alteration?
3. a non-bridged stream crossing 1,000 or less feet upstream of a public surface drinking

water supply for purpose of forest harvesting activities? ___ Yes ___ No

III. Consistency

Describe the project's consistency with water conservation plans or other plans to enhance water resources, quality, facilities and services:

WASTEWATER SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **wastewater** (see 301 CMR 11.03(5))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **wastewater**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Transportation -- Traffic Generation Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Wastewater Section below.

II. Impacts and Permits

A. Describe the volume (in gallons per day) and type of disposal of wastewater generation for existing and proposed activities at the project site (calculate according to 310 CMR 15.00 for septic systems or 314 CMR 7.00 for sewer systems):

	Existing	Change	Total
Discharge of sanitary wastewater	_____	_____	_____
Discharge of industrial wastewater	_____	_____	_____
TOTAL	_____	_____	_____

	Existing	Change	Total
Discharge to groundwater	_____	_____	_____
Discharge to outstanding resource water	_____	_____	_____
Discharge to surface water	_____	_____	_____
Discharge to municipal or regional wastewater facility	_____	_____	_____
TOTAL	_____	_____	_____

B. Is the existing collection system at or near its capacity? ___ Yes ___ No; if yes, then describe the measures to be undertaken to accommodate the project's wastewater flows:

C. Is the existing wastewater disposal facility at or near its permitted capacity? ___ Yes___ No; if yes, then describe the measures to be undertaken to accommodate the project's wastewater flows:

D. Does the project site currently contain a wastewater treatment facility, sewer main, or other wastewater disposal facility, or will the project involve construction of a new facility? ___ Yes ___ No; if yes, describe as follows:

	Permitted	Existing Avg Daily Flow	Project Flow	Total
Wastewater treatment plant capacity (in gallons per day)	_____	_____	_____	_____

E. If the project requires an interbasin transfer of wastewater, which basins are involved, what is the direction of the transfer, and is the interbasin transfer existing or new?

(NOTE: Interbasin Transfer approval may be needed if the basin and community where wastewater will be discharged is different from the basin and community where the source of water supply is located.)

F. Does the project involve new sewer service by the Massachusetts Water Resources Authority (MWRA) or other Agency of the Commonwealth to a municipality or sewer district? ___ Yes ___ No

G. Is there an existing facility, or is a new facility proposed at the project site for the storage, treatment, processing, combustion or disposal of sewage sludge, sludge ash, grit, screenings, wastewater reuse (gray water) or other sewage residual materials? ___ Yes ___ No; if yes, what is the capacity (tons per day):

	Existing	Change	Total
Storage	_____	_____	_____
Treatment	_____	_____	_____
Processing	_____	_____	_____
Combustion	_____	_____	_____
Disposal	_____	_____	_____

H. Describe the water conservation measures to be undertaken by the project, and other wastewater mitigation, such as infiltration and inflow removal.

III. Consistency

A. Describe measures that the proponent will take to comply with applicable state, regional, and local plans and policies related to wastewater management:

B. If the project requires a sewer extension permit, is that extension included in a comprehensive wastewater management plan? ___ Yes ___ No; if yes, indicate the EEA number for the plan and whether the project site is within a sewer service area recommended or approved in that plan:

TRANSPORTATION SECTION (TRAFFIC GENERATION)

I. Thresholds / Permit

A. Will the project meet or exceed any review thresholds related to **traffic generation** (see 301 CMR 11.03(6))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **state-controlled roadways**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Roadways and Other Transportation Facilities Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Traffic Generation Section below.

II. Traffic Impacts and Permits

A. Describe existing and proposed vehicular traffic generated by activities at the project site:

	Existing	Change	Total
Number of parking spaces	_____	_____	_____
Number of vehicle trips per day	_____	_____	_____
ITE Land Use Code(s):	_____	_____	_____

B. What is the estimated average daily traffic on roadways serving the site?

Roadway	Existing	Change	Total
1. _____	_____	_____	_____
2. _____	_____	_____	_____
3. _____	_____	_____	_____

C. If applicable, describe proposed mitigation measures on state-controlled roadways that the project proponent will implement:

D. How will the project implement and/or promote the use of transit, pedestrian and bicycle facilities and services to provide access to and from the project site?

C. Is there a Transportation Management Association (TMA) that provides transportation demand management (TDM) services in the area of the project site? ____ Yes ____ No; if yes, describe if and how will the project will participate in the TMA:

D. Will the project use (or occur in the immediate vicinity of) water, rail, or air transportation facilities? ____ Yes ____ No; if yes, generally describe:

E. If the project will penetrate approach airspace of a nearby airport, has the proponent filed a Massachusetts Aeronautics Commission Airspace Review Form (780 CMR 111.7) and a Notice of Proposed Construction or Alteration with the Federal Aviation Administration (FAA) (CFR Title 14 Part 77.13, forms 7460-1 and 7460-2)?

III. Consistency

Describe measures that the proponent will take to comply with municipal, regional, state, and federal plans and policies related to traffic, transit, pedestrian and bicycle transportation facilities and services:

TRANSPORTATION SECTION (ROADWAYS AND OTHER TRANSPORTATION FACILITIES)

I. Thresholds

A. Will the project meet or exceed any review thresholds related to **roadways or other transportation facilities** (see 301 CMR 11.03(6))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **roadways or other transportation facilities**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Energy Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Roadways Section below.

II. Transportation Facility Impacts

A. Describe existing and proposed transportation facilities in the immediate vicinity of the project site:

B. Will the project involve any

1. Alteration of bank or terrain (in linear feet)? _____
2. Cutting of living public shade trees (number)? _____
3. Elimination of stone wall (in linear feet)? _____

III. Consistency -- Describe the project's consistency with other federal, state, regional, and local plans and policies related to traffic, transit, pedestrian and bicycle transportation facilities and services, including consistency with the applicable regional transportation plan and the Transportation Improvements Plan (TIP), the State Bicycle Plan, and the State Pedestrian Plan:

ENERGY SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **energy** (see 301 CMR 11.03(7))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **energy**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Air Quality Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Energy Section below.

II. Impacts and Permits

A. Describe existing and proposed energy generation and transmission facilities at the project site:

	Existing	Change	Total
Capacity of electric generating facility (megawatts)	_____	_____	_____
Length of fuel line (in miles)	_____	_____	_____
Length of transmission lines (in miles)	_____	_____	_____
Capacity of transmission lines (in kilovolts)	_____	_____	_____

B. If the project involves construction or expansion of an electric generating facility, what are:

1. the facility's current and proposed fuel source(s)?
2. the facility's current and proposed cooling source(s)?

C. If the project involves construction of an electrical transmission line, will it be located on a new, unused, or abandoned right of way? ___Yes ___No; if yes, please describe:

D. Describe the project's other impacts on energy facilities and services:

III. Consistency

Describe the project's consistency with state, municipal, regional, and federal plans and policies for enhancing energy facilities and services:

AIR QUALITY SECTION

I. Thresholds

A. Will the project meet or exceed any review thresholds related to **air quality** (see 301 CMR 11.03(8))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **air quality**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Solid and Hazardous Waste Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Air Quality Section below.

II. Impacts and Permits

A. Does the project involve construction or modification of a major stationary source (see 310 CMR 7.00, Appendix A)? ___ Yes ___ No; if yes, describe existing and proposed emissions (in tons per day) of:

	Existing	Change	Total
Particulate matter	_____	_____	_____
Carbon monoxide	_____	_____	_____
Sulfur dioxide	_____	_____	_____
Volatile organic compounds	_____	_____	_____
Oxides of nitrogen	_____	_____	_____
Lead	_____	_____	_____
Any hazardous air pollutant	_____	_____	_____
Carbon dioxide	_____	_____	_____

B. Describe the project's other impacts on air resources and air quality, including noise impacts:

III. Consistency

A. Describe the project's consistency with the State Implementation Plan:

B. Describe measures that the proponent will take to comply with other federal, state, regional, and local plans and policies related to air resources and air quality:

SOLID AND HAZARDOUS WASTE SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **solid or hazardous waste** (see 301 CMR 11.03(9))? ___ Yes X No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **solid and hazardous waste**? ___ Yes X No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Historical and Archaeological Resources Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Solid and Hazardous Waste Section below.

II. Impacts and Permits

A. Is there any current or proposed facility at the project site for the storage, treatment, processing, combustion or disposal of solid waste? ___ Yes ___ No; if yes, what is the volume (in tons per day) of the capacity:

	Existing	Change	Total
Storage	_____	_____	_____
Treatment, processing	_____	_____	_____
Combustion	_____	_____	_____
Disposal	_____	_____	_____

B. Is there any current or proposed facility at the project site for the storage, recycling, treatment or disposal of hazardous waste? ___ Yes ___ No; if yes, what is the volume (in tons or gallons per day) of the capacity:

	Existing	Change	Total
Storage	_____	_____	_____
Recycling	_____	_____	_____
Treatment	_____	_____	_____
Disposal	_____	_____	_____

C. If the project will generate solid waste (for example, during demolition or construction), describe alternatives considered for re-use, recycling, and disposal:

D. If the project involves demolition, do any buildings to be demolished contain asbestos? ___ Yes ___ No

E. Describe the project's other solid and hazardous waste impacts (including indirect impacts):

III. Consistency

Describe measures that the proponent will take to comply with the State Solid Waste Master Plan:

HISTORICAL AND ARCHAEOLOGICAL RESOURCES SECTION

I. Thresholds / Impacts

A. Have you consulted with the Massachusetts Historical Commission? X Yes ___ No; if yes, attach correspondence.
See Appendix E of the Supplemental Information Report for cultural resources correspondence.

For project sites involving lands under water, have you consulted with the Massachusetts Board of Underwater Archaeological Resources? X Yes ____ No; if yes, attach correspondence

B. Is any part of the project site a historic structure, or a structure within a historic district, in either case listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth? X Yes ___ No; if yes, does the project involve the demolition of all or any exterior part of such historic structure? X Yes ___ No; if yes, please describe: The dam structure (ID WBY.905) and the aqueduct (ID WBY.907) are listed as historical places. The project will fully removal the dam structure.

C. Is any part of the project site an archaeological site listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth? ___ Yes X No; if yes, does the project involve the destruction of all or any part of such archaeological site? ___ Yes ___ No; if yes, please describe:

D. If you answered "No" to all parts of both questions A, B and C, proceed to the **Attachments and Certifications** Sections. If you answered "Yes" to any part of either question A or question B, fill out the remainder of the Historical and Archaeological Resources Section below.

II. Impacts

Describe and assess the project's impacts, direct and indirect, on listed or inventoried historical and archaeological resources:
The Quinapoxet dam is a man-made structure along Quinapoxet River. The dam is located just upstream of the two sediment basins, the Quinapoxet and Thomas, that are adjacent to the Wachusett Reservoir. Sedimentation and water quality would not be impacted by the removal of the dam. The design would seek to remove the dam and modify the channel to enhance the ecological health of the river and promote fish passability.

III. Consistency

Describe measures that the proponent will take to comply with federal, state, regional, and local plans and policies related to preserving historical and archaeological resources:
An assessment of the historical and archaeological importance of the Quinapoxet dam site was conducted by the Archeological & Historical Services, Inc. (AHS) Cultural Resource Management. The findings are currently pending.

A project notification form was submitted to the MHC on October 6, 2020. Resources from these agencies will be taken into account during advancement of project design plans.

CERTIFICATIONS:

1. The Public Notice of Environmental Review has been/will be published in the following newspapers in accordance with 301 CMR 11.15(1):

   (Name) Worcester Telegram & Gazette (Date) June 1, 2021

2. This form has been circulated to Agencies and Persons in accordance with 301 CMR 11.16(2).

Signatures:

5/28/21	Carolyn M. Fiore	5/28/21	Martha S
Date	Signature of Responsible Officer or Proponent	Date	Signature of person preparing ENF (if different from above)

Carolyn Fiore	Matthew Sanford
Name (print or type)	Name (print or type)
MWRA	SLR International Corporation
Firm/Agency	Firm/Agency
100 First Avenue	99 Realty Drive
Street	Street
Boston, MA 02129	Cheshire, CT 06410
Municipality/State/Zip	Municipality/State/Zip
(617) 788-4929	(203) 271-1773
Phone	Phone

RIVER ROAD, WEST BOYLSTON / QUINAPOXET DAM REMOVAL

Expanded Environmental Notification Form
Supplemental Information Report

Prepared for:

The Massachusetts Water Resources Authority

SLR #141.14673.00003.0030

May 2021

Massachusetts Department of Fish and Game
Division of Ecological Restoration
Invested in Nature and Community

global **environmental** and **advisory** solutions

SLR

Expanded Environmental Notification Form
Supplemental Information Report

Prepared for:
The Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue, Building 39
Boston, Massachusetts 02129

This document has been prepared by SLR International Corporation (SLR). The material and data in this report were prepared under the supervision and direction of the undersigned.

W. Andrew Greene, PE
US Manager of Water Resources Engineering

Matthew J. Sanford, MS, PWS, RSS
US Manager of Ecology

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ACRONYMS

AHS	Archeological & Historical Services, Inc.
BLSF	Bordering Land Subject to Flooding
BMP	Best Management Practices
BVW	Bordering Vegetated Wetlands
cfs	cubic feet per second
CMR	Code of Massachusetts Regulations
CY	cubic yard
DCR	Department of Conservation and Recreation
DEP	Department of Environmental Protection
EENF	Expanded Environmental Notification Form
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
E&S	erosion and sedimentation
ETPH	extractable total petroleum hydrocarbons
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
fps	feet per second
ft	feet
GHG	greenhouse gas
GPS	global positioning system
GZA	GZA GeoEnvironmental, Inc.
HEC-SSP	Hydrologic Engineering Center – Statistical Software Package
ISO	International Organization for Standardization
LUW	Land Under Waterbodies
MA	Massachusetts
MADCR	Massachusetts Department of Conservation & Recreation
MADER	Massachusetts Division of Ecological Restoration
MCP	Massachusetts Contingency Plan

MADWSP	Massachusetts Division of Water Supply Protection
MEPA	Massachusetts Environmental Policy Act
MHC	Massachusetts Historical Commission
MMI	Milone & MacBroom, Inc.
MWRA	Massachusetts Water Resources Authority
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidmeter Unit
ODS	Office of Dam Safety
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PNF	Public Notification Form
RFA	Riverfront Area
SLR	SLR International Corporation
STA	river station
SWPPP	Stormwater Pollution Prevention Plan
TCLP	toxicity characteristic leaching procedure
TMP	Turbidity Monitoring Plan
USACE	United States Army Corps of Engineers
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
WPA	Wetlands Protection Act
WSEl	water surface elevation

1. INTRODUCTION

The Quinapoxet River Dam removal project is a joint effort by multiple state agencies that will achieve considerable environmental goals including, but not limited to restoration of the Quinapoxet River in-stream habitat, enabling fish and wildlife passage, maintaining public river access, maintaining flood control, protecting water quality, ensuring climate change resiliency, and reducing long-term maintenance costs. The project includes: (1) removal of the Quinapoxet Dam, (2) management of in-stream sediment, (3) construction of an earthen berm to separate the main channel from the transfer aqueduct, and (4) construction of a pedestrian access path to the river's edge. The project team is made up of the Massachusetts Water Resources Authority (MWRA), the Massachusetts Department of Conservation and Recreation (MADCR), and the Massachusetts Division of Ecological Restoration (MADER).

The Quinapoxet Dam is owned by the MADCR Division of Water Supply Protection (MADWSP), and it was constructed in the early 1900s as part of the Wachusett Reservoir construction project. The existing dam is a 250-foot-long, 18-foot-high earthen embankment and stone masonry structure. The stone masonry and concrete arched spillway is 135 feet long and 9 feet high. The earthen embankment portion is limited to the southern abutment, adjacent to the granite block Quabbin Reservoir transfer aqueduct station (See Figure 1-1). A concrete pool/weir type of fishway is located along the northern abutment and appears to be in good condition; however, this type of fishway structure is poorly suited for the fish species living inthe reservoir.

A dam removal feasibility study was completed by Milone & MacBroom, Inc. (MMI) in June 2016 (see Appendix C – Basis of Design). After completing an evaluation of alternative dam removal and channel improvement strategies, MADCR and MWRA selected full dam removal and channel modifications to be the preferred alternative to achieve the project's environmental goals.

The proposed design has been developed to minimize negative impacts associated with removing the dam and to enhance the wetland resource areas within the project site. The technical basis for the preferred alternative as presented in this Expanded Environmental Notification Form (EENF) is described in detail in a document entitled "*Quinapoxet Dam Removal Project Quinapoxet River Preliminary Design,*" provided as Appendix B. Sections of this report are reprinted in this EENF for ease of review for the required circulation list while readers interested in more in-depth detail are encouraged to access additional information in the technical appendices.

Activities associated with replacements, repairs, or removals of dams typically involve several environmental permits or review processes due to their intersection with water bodies. Further, many obsolete dams can be considered locally historic and/or have sensitive archeological resources within or adjacent to the structure, so consultation with state and local historic commissions is required. Correspondence with the Massachusetts Historical Commission (MHC) is underway and all appropriate historical and archaeological investigations will be performed.

There is no proposed filing with the MADWSP thatis typically required under 313 Code of Massachusetts Regulations (CMR) 11.05(6) since MADWSP is a project proponent. Table 1-1 provides a summary of anticipated permits and environmental review processes associated with the project.

The proposed Quinapoxet Dam removal will exceed the Mandatory Environmental Impact Report (EIR) review threshold criteria defined by 301 CMR 11.03(3)(a)4: structural alteration of an existing dam that causes an expansion of 20% or decrease in impoundment capacity; 301 CMR 11.03(3)(b)1.b: alteration of 500 or more linear feet of bank along a fish run or inland bank; and 301 CMR 11.03(3)(b)1.f: alteration of one half or more acres of any other wetlands. The documentation provided herein is submitted to support the EENF and to request a full waiver of the requirement for an EIR for this removal of a dam that limits wildlife and fish passage. Justification for the waiver requested is provided in Section 1.1: Request for Waiver, below.

Table 1-1 Summary of Anticipated Environmental Reviews and Permits

Entity	Permit or Review Process	Comments
MEPA	Secretary's Certificate/Record of Decision	• Several thresholds triggered. EENF required requesting a waiver from a Mandatory EIR.
DCR/Office of Dam Safety	Chapter 253 Permit(s)	• For alterations to a jurisdictional dam structure
DEP	401 Water Quality Certificate and Dredging	• Required due to in-water dredging activities for both dam removal/channel reconstruction
DEP	Chapter 91 License	• Potentially required for construction of earthen berm located between Quinapoxet River and the Quabbin Reservoir transfer aqueduct
West Boylston Conservation Commission	Order of Conditions under Town of West Boylston Wetland Protection Act Rules and Regulations	• Required for alterations to various state jurisdictional wetland resource areas necessary for dam removal and bank stabilization
USACE	Clean Water Act Section 404	• General Permit #23 (Aquatic Habitat Restoration, Establishment & Enhancement Activities)
MHC	Section 106 Review	• Concurrent with Section 404 review process

MEPA = Massachusetts Environmental Policy Act
DCR = Department of Conservation and Recreation
DEP = Department of Environmental Protection
USACE = United States Army Corps of Engineers
MHC = Massachusetts Historical Commission

1.1 REQUEST FOR WAIVER

Due to the project resulting in the structural alteration of an existing dam that causes a decrease in its impoundment capacity [301 CMR 11.03(3)(a)4)], the project is categorically included for preparation of an EIR. The project also exceeds several other MEPA review thresholds as follows:

- 301 CMR 11.03(3)(b)1.b., alteration of 500 or more linear feet of bank along a fish run or inland bank
- 301 CMR 11.03(3)(b)1.f., alteration of ½ or more acres of any other wetlands

This EENF requests a full waiver of this EIR requirement.

The project team is seeking a full EIR waiver in accordance with 301 CMR 11.11 given that strict compliance with the requirement would result in an undue hardship and would not serve to avoid or minimize damage to the environment. It is anticipated that project implementation will be funded by limited public funds. Parties involved will not realize any private financial gain associated with the project. Preparation of an EIR will not serve to avoid or minimize damage to the environment but will only lengthen the time to complete the project, increase costs, and increase the potential for future damageto the environment. A project delay may increase project design costs and impact implementation fundraising. The specific regulatory rationale for the Waiver Request includes the following:

> *301 CMR 11.11(1):* **Compliance with the requirement to prepare an EIR would (a) result in undue hardship for the proponent and (b) not serve to avoid or minimize Damage to the Environment**. Project partners have performed 5 years of assessment, planning, and design work to date summarized in the EENF. Requirement of an EIR would not produce new information and would delay the project and the associated ecological restoration benefits.
>
> An EIR would not serve to avoid or minimize Damage to the Environment in this case. Moreover, an EIR will not yield new or helpful information as the project's goal is to reverse past Damage to the Environment and has been designed with input from experienced and well-trained technical experts in the field. Along with the experienced staff from MADER, the project has also received substantial input from MADCR and MWRA. The project engineer is SLR, one of the leading ecological restoration design firms in Massachusetts.
>
> *301 CMR 11.11(2):* The goals and results of this project are contrary to the presumption of significant environmental impact for the EIR threshold; restoration of the river and

wetlands as a result of the project will produce particularly significant environmental benefits.

301 CMR 11.11(3): In accordance with 310 CMR 11.11(3)(c), **the project is likely to cause no Damage to the Environment**. The proposed restoration was designed specifically for this site to address stressors to critical natural river processes, improve water quality, and establish conditions for a self-sustaining, high-quality, restored, riverine network. Dams such as the Quinapoxet Dam cause a blockage to fish passage and habitat continuity from upstream to downstream, causing habitat fragmentation. Fragmented populations that are forced to survive independently can be destroyed without the ability to adapt to changing food supply, impacts on breeding areas, predation concerns, and the need for genetic diversity. As such, the connectivity of viable habitat that was lost due to the construction of the Quinapoxet River Dam is one of the primary stated goals of the dam removal initiative.

In accordance with 301 CMR 11.11(3)(d), **ample and unconstrained infrastructure facilities and services exist to support the project** (in the case of a project undertaken by an agency or involving financial assistance). Existing roadways within the project area provide ample opportunities for access and staging to support project implementation. The project site is easily accessible from existing public roadways within the town of West Boylston. The restored river system will require no supporting infrastructure moving forward.

The subsequent narrative and supporting documentation provide evidence as to the extensive analyses that have been undertaken that led to the identification of the preferred alternative for dam removal and the ecological and resiliency benefits that will be achieved by project implementation.

Figure 1-1: Existing Conditions: Quinapoxet Dam (right) and Quabbin Reservoir Transfer Aqueduct Station (left) and fishing access (left foreground)

2. EXISTING CONDITIONS

The Quinapoxet Dam (National ID: MA02523) is located on the Quinapoxet River in the town of West Boylston, Massachusetts. It is located north of River Road approximately 1,500 feet west of the Thomas Street intersection at coordinates 42°23'13.6" N -71°48'09.1" W (Figure 2-1, appended). The Quinapoxet Dam is located amidst the picturesque setting of the MWRA's Oakdale Transfer Facility at the outlet of the Quabbin Aqueduct Shaft #1.

The Quinapoxet Dam is located upstream of two of the upper basins serving the Wachusett Reservoir. The Quinapoxet Basin, the upstream basin, was formed by the railroad causeway, which predated the reservoir. The Thomas Basin, the downstream basin, was formed by the causeway created by the Route 12 access during the reservoir construction. The Thomas Basin flows into the main body of the Wachusett Reservoir at the same water surface elevation as the reservoir.

The Mass Central Rail Trail is located north of the river, approximately 100 feet from the dam. This is an active recreational trail for walkers, bikers, and runners and is the primary vista to the site and the spillway.

2.1 SURROUNDING LAND USES AND HISTORIC RESOURCES

The Quinapoxet River enters the Wachusett Reservoir from the west, where a semicircular dam was constructed across the river in the Oakdale Village of West Boylston (Figure 2-2, appended). The dam was constructed in 1905 as part of the Wachusett Reservoir construction project to help supply water to the greater Boston area. The original 1902 design plans refer to the dam as *"the circular concrete dam on the Quinapoxet River, Wachusett Reservoir Section 10."* The DCR Office of Dam Safety (ODS) inventory of dams lists this dam as the Quinapoxet Accretion Dam – MA Dam #02523. The term "accretion dam" has created some confusion regarding the construction and original purpose of this dam.

Normally, dams are constructed across an existing river channel, and the dam structure itself extends vertically above the streambed to create an impoundment of water behind the dam above the normal stream channel elevation. This change in the river hydraulics slows the velocity of the river and subsequently causes sediment that is carried in the river to settle out behind the dam as the velocity slows. Almost all dams accumulate sediment in their impoundments. However, this is not the case with the Quinapoxet Accretion Dam for reasons described below.

The Metropolitan Water and Sewerage Board annual reports from the early 20th century reference the following activities: *"…excavating earth and gravel from shallow portions of the reservoir at Oakdale, for enlarging a portion of the channel of the Quinapoxet River west of the Worcester, Nashua, & Portland Division, building a concrete dam across the Quinapoxet River at the upper end of this channel."* Review of the original construction drawings, photo documentation, and the original channel profile shows that the crest of the Quinapoxet Dam spillway is only slightly higher than the channel upstream of the dam by a few feet. The spillway height of 9 feet was created by excavating and removing the channel

downstream of the dam to the Wachusett Reservoir. The dam appears to have been constructed not to impound and trap sediment upstream of the dam but to allow lowering of the gradient of the downstream channel reach for the purpose of reducing velocities so that accretion could occur in the downstream channel prior to entering the reservoir. With a spillway constructed at essentially the upstream channel bed elevation, there is likely to be relatively little accumulated sediment upstream of the dam and therefore a reduced risk of high volumes of contaminated materials. The exception is the area along the northern bank, which is now vegetated and above the river elevation.

Adjacent to the south wingwall is the Oakdale Power Station and Shaft 1 outlet of the Quabbin Aqueduct. In 1919, there were concerns about potential water supply for the city of Boston. The Quabbin Reservoir, located further west, was constructed. The interconnection from the Quabbin Reservoir was constructed, allowing the Quabbin Aqueduct to discharge to the Quinapoxet River at Shaft #1 just downstream of the Quinapoxet Dam.

Several features within the project and adjacent area are listed on the State Register of Historic Places. The Quinapoxet Dam is listed as the "Quinepoxet River Circular Control Dam" (WBY.905). Other features include the Quabbin Aqueduct (WBY.C), Quabbin Aqueduct Outlet Works (WBY.G), and the Quabbin Aqueduct Outlet Chamber (Shaft #1) (WBY.907).

2.2 QUINAPOXET DAM

The Quinapoxet Dam is a 250-foot-long, 18-foot-high earthen embankment and stone masonry structure. An important feature of the dam is its 135-foot-long, 9-foot-high stone masonry and concrete arched spillway. The following table provides information from the MA ODS relating to the dam. The dam impoundment extends 400 to 500 feet upstream of the structure.

Table 2-1 MA ODS Dam Information

Id No.	Dam Name	Latitude	Longitude	Owner	Hazard Potential Classification	Department of Ecological Restoration Potential Restoration Score
#MA02523	Quinapoxet Accretion Dam	42°23'24.0"N	71°48'00.0"W	DCR – Department of Conservation & Recreation	Significant	95

The Quinapoxet Dam was identified by the MADER to have a high potential for restoration (Table 2-1). The model score is dependent on the dam's location within the watershed, the ecological integrity surrounding the dam, and the potential improvement to connectivity if the dam were removed. The score is out of 100, and the Quinapoxet Dam had a score of 95, suggesting the removal of the Quinapoxet Dam would provide significant environmental impact and stream health.

A dam inspection by Fuss & O'Neill in February 2007 identified the Quinapoxet Dam as a non-jurisdictional structure (structure less than 6 feet in height or having storage capacity of less than 15 acre-feet) based upon an impoundment size of 4.5 acre-feet and a height of 9 feet. In June 2007, GZA GeoEnvironmental, Inc. (GZA) conducted a more detailed Phase 1 dam inspection and reported the dam to be in fair condition (See Appendix I – 2007 GZA Dam Inspection). GZA further documented the dam to be 18 feet high with 75 acre-feet of floodwater storage and therefore classified it as an intermediate size dam with a significant hazard potential. SLR's review of the two reports indicates that Fuss & O'Neil used the height of the *spillway* and not the height of the *dam* to compute impoundment size and is incorrect. While the ODS database maintains the non-jurisdictional designation,SLR believes this to be in error as the regulations do not allow for this designation for structures over 15 feet high or greater than 50 acre-feet of storage. While the issue of dam designation does not materiallyaffect its removal, it does place a greater sense of importance on the long-term maintenance requirements, which have substantial cost implications.

2.3 WETLANDS AND WATERWAYS

The Quinapoxet River is a 2.4-mile-long watercourse that drains approximately 56 square miles at the Quinapoxet Dam. It generally flows easterly from the Quinapoxet Reservoir in Holden, through West Boylston, before flowing into the Wachusett Reservoir. According to National Wetland Inventory mapping, the Quinapoxet River is classified as a riverine lower perennial unconsolidated bottom system. It passes through the existing dam on site and travels approximately 1,800 feet before draining into two sediment basins, the Quinapoxet and Thomas, before entering the Wachusett Reservoir. The 7-square-mile reservoir provides 63 billion gallons of water to the greater Boston area.

The Quinapoxet Dam serves as a separation between this site's varying upstream and downstream habitats. Under current conditions, the impoundment extends 400 to 500 feet upstream of the dam. It is shallow and fairly narrow, which is consistent with the history and construction. The waterway is dominated by a cobble-gravel bottom with varying water depths that range from 6 inches of water to as much as 3 feet, approximately. Depths of water within the open water are variable based on seasonal flow regimes. Approximately 1,500 feet upstream of the dam, flow splits around a vegetated island, where the river is free flowing with a rocky cobble bottom. River flow recombines into a single channel approximately 600 feet upstream of the dam. Just downstream of the dam, within 500 feet are existing riffles and several vegetated islands. The vegetated islands are located toward the northern bank, and the riffles are adjacent to the discharge area of the Quabbin transfer aqueduct.

The banks of the river consist of a combination of cover types including mixed broad-leaved deciduous hardwood forests, palustrine scrub shrub wetlands, alluvial scrub shrub, and maintained lawn areas. The river is located within a Federal Emergency Management Agency (FEMA) designated Zone A floodplain and has no floodway. Zone A floodplains have no formal base flood elevations determined. Based on a review of FEMA mapping, the entire area is considered to be under the backwater influence of the downstream reservoir and sediment basins.

2.3.1 JURISDICTIONAL WETLAND RESOURCE AREAS

On June 29, 2015, wetlands and watercourses within the immediate vicinity of the dam were delineated subject to the provisions of the Rules and Regulations of the Massachusetts Wetlands Protection Act (WPA) and Section 404 of the Clean Water Act (404). Wetlands were delineated using the methodology provided in the U.S. Army Corps of Engineers (USACE) *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region*, which involves the three-parameter method of soils, vegetation, and hydrology.
Additional detailed information regarding the methodology of the wetland assessment can be found in the wetland delineation report in Appendix D.

Per the U.S. Fish & Wildlife Service's wetland classification system described in *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin, et al., 1979), multiple wetland types exist within the project areas: riverine lower perennial stream with an unconsolidated bottom, palustrine scrub shrub wetlands, and palustrine forested wetlands.

Massachusetts WPA Resource Areas

Resource areas within the project site were delineated and characterized in accordance with the Massachusetts WPA at 310 CMR 10.00. Resource areas within the study area consist of the following:

- 310 CMR 10.54 – Inland Bank
- 310 CMR 10.55 – Bordering Vegetated Wetlands
- 310 CMR 10.56 – Land Under Water Bodies and Waterways
- 310 CMR 10.57 – Bordering Land Subject to Flooding
- 310 CMR 10.58 – Riverfront Area

These regulated resources are depicted on appended Figure 2-3 and described further below.

<u>Inland Bank</u>

Bank associated with the Quinapoxet River is variable in composition and size but generally consists of man-made embankments with riprap and stone walls and natural sloping vegetated banks upstream of the dam and moderate to steeply sloped vegetated banks downstream of the dam. Per 310 CMR 10.54, Inland Bank commences at the mean annual low-flow level and extends to the mean annual high-flood level or the first observable break in slope, whichever is lower.

<u>Bordering Vegetated Wetland</u>

Bordering vegetated wetlands (BVW) exist along the north bank of the Quinapoxet River both upstream and downstream of the existing dam. The BVWs are characterized as palustrine scrub shrub adjacent to the waterway and palustrine forested wetland further inland. The scrub shrub wetland is dominated by red maple (*Acer rubrum*),

speckled alder (*Alnus rugosa*), and silky dogwood (*Swida amomum*), and the understory is composed of sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmundastrum cinnamomeum*), jewelweed (*Impatiens capensis*), and tussock sedge (*Carex stricta*). The forested wetland is dominated by red maple, American beech (*Fagus grandifolia*), yellow birch *(Betula alleghaniensis*), and American hornbeam (*Carpinus caroliniana*) with an understory composed of cinnamon fern, sensitive fern, interrupted fern (*Osmunda claytoniana*), jewelweed *(Impatiens canpensis*), and scouring rush (*Equisetum hyemale*).

Land Under Waterbodies and Waterways

The land below mean annual low water is considered land under waterbodies (LUW) per 310 CMR 10.56. The sediments are unconsolidated and range from silt and sand to cobbles and boulders. Coarser sediments such as cobble and gravel dominate the majority of the stream within the project area.

Bordering Land Subject to Flooding

Bordering Land Subject to Flooding (BLSF) comprises areas within the 100-year floodplain upgradient of the BVW or Inland Bank Line. BLSF is associated with the FEMA mapped zone A within the Quinapoxet River. BLSF is present only where the Zone A extends beyond any BVW or Bank/mean annual high water boundary in the areas where there is no BVW adjacent to the watercourse. BLSF is presumed to be coincident with the current FEMA National Flood Insurance Program (NFIP) mapping, presented on appended Figure 2-4.

Riverfront Area

Quinapoxet River is regulated as a river per 310 CMR 10.58. This river is located within the Nashua River major drainage basin. Collectively, the local watershed to the point of confluence is approximately 57 square miles. The morphological features of this stream corridor are consistent with a perennial stream.

Riverfront Area occupies areas upgradient of the mean high water line to the Quinapoxet River for a distance of 200 feet. The entirety of the site, including both BVW and uplands, is located within the Riverfront Area associated with the Quinapoxet River. Figures 2-6 and 2-7 depict the existing river.

Figure 2-6: Quinapoxet River and Forested Banks West of the Dam, Facing East

Figure 2-7: Quinapoxet River, Quinapoxet Dam, and Oakdale Power Station East of the Dam, Facing West

2.4 SITE HYDROLOGY

A river's flow fluctuates daily as environmental conditions change, increasing with precipitation and runoff and decreasing with dry weather. In order to develop flow data in the Quinapoxet River at the dam site, a hydrologic assessment of the Quinapoxet River was performed for low-flow and high-flow scenarios.

The impacts of dam removal on hydrologic conditions including peak flood flows and normal daily flows were computed and are presented in Appendix C – Basis of Design. The flood flows were used to determine the stability of the post-dam-removal channel and floodplain. The low flows were used to assess fish passage and channel sizing during everyday (i.e., normal) flow conditions.

Information was compiled from multiple sources including the following:

- Watershed size and characteristics as well as bankfull measurements (where water level stage begins to spill out of the channel into the floodplain) were obtained from the United States Geological Survey (USGS) *StreamStats* program.
- A Bulletin 17b assessment was performed using the Hydrologic Engineering Center – *Statistical Software Package* (HEC-SSP) of the annual peak flows recorded at one available gauge nearby, and the results were transferred to the site (by watershed size).
- Monthly flow rates were predicted from the USGS *StreamStats* program and a nearby gauge in order to assess fish passage potential at low flows.

2.4.1 WATERSHED

The contributing watershed of the Quinapoxet River at the Quinapoxet Dam is approximately 56 square miles as delineated by the USGS *StreamStats* program. The watershed extends primarily west of the project site, covering the southern portion of Princeton, eastern portions of Rutland, and central Holden. Appended Figure 2-6 presents a graphic delineation of the watershed of the Quinapoxet River to the Quinapoxet Dam.

Increasing amounts of urbanization in a watershed lead to "flashier" storm events as runoff from impervious surfaces such as pavements and rooftops reaches drainage systems and watercourses much more quickly than in natural, vegetated conditions. Approximately 69 percent of the Quinapoxet River watershed to the Quinapoxet Dam is forested, with the remainder of the watershed being developed with primarily single-family residential land use throughout.

2.4.2 FEMA FLOOD INSURANCE STUDY (FIS)

The most recent detailed FIS of Worcester County, Massachusetts, is dated July 16, 2014. Typically, a hydraulic model would be compared to any published studies performed by FEMA; however, a detailed study of the Quinapoxet River has not been completed by FEMA. The FEMA Flood Insurance Rate Map (FIRM), dated July 4, 2011, indicates Zone A predicted floodplain limits. A flood zone identified as Zone A does not have base flood elevations associated with its limits. Rather, as indicated in the preliminary FIS

for Worcester County, an approximate estimation was used to delineate the floodplain. The methods used to produce a Zone A are not documented by FEMA. Determining floodplain limits with approximate methods includes a combination of USGS Flood Prone Area Maps, USGS topographic maps, wetlands information, aerial photographs, historic observation, field survey, use of a regional relationship developed between the drainage area, and depth of flooding based on regression analyses of gauged streams.

2.4.3 USGS *STREAMSTATS*

StreamStats is a powerful hydrology tool developed by the USGS that predicts flow rates based upon drainage basin characteristics and stream gauge data, assuming natural runoff conditions. Estimated peak discharges for various frequency events at the Quinapoxet Dam were calculated by SLR using *StreamStats* in Table 2-2 below.

Table 2-2 Summary of Peak Flows Derived from USGS *StreamStats*

Location	Drainage Area (square miles)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
at Quinapoxet Dam	55.8	2,240	3,660	4,340	6,170

cfs = cubic feet per second

2.4.4 USGS GAUGE DATA

The USGS maintains a stream gauge on the Quinapoxet River at Canada Mills near Holden, Massachusetts. USGS Gauge 01095375 is located approximately 3.5 miles upstream from the mouth of the Wachusett Reservoir and approximately 3 miles upstream of the Quinapoxet Dam. The drainage area to this gauge is 46.3 square miles as compared to the 55.8-square-mile watershed at the project site (as computed by *StreamStats*). The period of record of the gauge is from 1996 to present.

The gauged watershed area is 46.3 square miles compared to 56 square miles at the project site. Table 2-3 provides monthly mean flows from the data available on the gauging station as computed by the USGS and adjusted for the change in watershed size.

Table 2-3 Summary of Low Flows at Project Site

Month	20th-Percentile Duration Flow (cfs)	Mean Monthly Discharge Flow (cfs)	80th-Percentile Duration Flow (cfs)
January	28	84	125
February	36	89	127
March	67	161	224
April	82	189	257
May	48	99	134
June	24	76	108
July	9	30	42
August	6	20	26
September	4	20	22
October	7	37	53
November	12	57	88
December	18	95	158

Note: Shaded cells represent anticipated construction window.

In order to recalculate a flood frequency curve for the USGS Gauge 01095375, a flood frequency analysis was conducted with the available stream gauge data using the USACE computer model HEC-SSP, which utilizes the national standard bulletin 17B procedure (USGS, 1981). The flows calculated in HEC-SSP were used with Wandle's regression equations and the procedure for "Sites on Gauged Streams" in the article *Estimating Peak Discharges of Small, Rural Streams in Massachusetts* (Wandle 1983). These are summarized in Table 2-4. The ratio of the contributing watershed area for USGS Gauge 01095375 and the watershed area of Quinapoxet Dam were used to calculate the 20 percent (5-year), 10 percent (10-year), and 1 percent (100-year) annual chance flows at the project site.

Table 2-4 Summary of Quinapoxet River Flood Discharges

Source	Design Flow for Annual Recurrence Interval (cfs)		
	5-Year (20%)	10-Year (10%)	100-Year (1%)
HEC-SSP 17B Analysis	1,474	1,791	3,041

Note: cfs = cubic feet per second

In order to assess fish passage potential, mean monthly streamflow rates were predicted based upon *StreamStats* and the Canada Mills gauge. *StreamStats* also provides information on likely seasonal flows that are based on periods of time that correspond to significant ecological conditions as noted in Table 2-5. Actual values vary due to water supply withdrawals or low-flow augmentation release.

Table 2-5 Seasonal Flows from USGS *StreamStats* Analysis

Streamflow Statistics	Definitions	Median discharge (cfs)[1]
D99	Streamflow exceeded 99 percent of the time	3.21
M7D10Y	7-day mean low flow that occurs on average once in 10 years	3.21
M7D2Y	7-day mean low flow that occurs on average once in 2 years	6.47
AUG D50	August streamflow exceeded 50 percent of the time	13.3
Mean May[2]	Mean flow for the month of May	88
Mean June[2]	Mean flow for the month of June	73
Mean July[2]	Mean flow for the month of July	29
Bankfull	Bankfull stream flow	829

Notes:
1. cfs = cubic feet per second
2. Mean May, June, and July flows provided by USGS No. 01095375 gauge data, at Canada Mills, Holden MA, period of record (1996 – 2014)

2.4.5 ASSESSMENT OF CLIMATE CHANGE AND RESILIENCY

The effects of a changing climate have begun to impact how municipalities, government agencies, and planning organizations think about funding large-scale infrastructure improvements. Historically, best engineering practice involved using hindcast precipitation and hydrologic data to design roadway drainage and bridge structures. Such data would often be decades old at the time of use and did not reflect the more severe and frequent storms of the modern day or the changes that could be anticipated in the future life span of the infrastructure.

Watersheds with long-term flow records and little human influence have shown trends toward increasing stream flow over the past few decades (Collins, 2009). In a recent study, 25 of 28 flood series studied in New England showed upward flood trends, with evidence of an increase in flood magnitudes around 1970 (Collins, 2009). Project design guidelines published by Collins through theNational Oceanic and Atmospheric Administration (NOAA) Fisheries Service recommend the following (Collins, 2011):

- The most recent available data should be used to compute statistical flood frequency estimates.
- If the period of flood record allows, pre-1970 and post-1970 flood frequency curves should be computed, and the design team should consider using the larger estimated design flows.
- If little recent data is available, regional regression equations or other estimation strategies could be compared to older gauge data. The same strategy used to estimate more recent flows should also be applied to the older period of record to check for methodological bias.

To account for potential impacts of climate change, proposed conditions modeling was performed for the estimated 100-year flood discharge plus a factor of 20 percent. Results indicate a reasonably uniform rise in water surface elevations, and flood depths of about half a foot would be expected through the project reach with this factor applied. Velocities would be projected to increase by up to about 0.7 feet per second. Summary results are presented in Table 2-6. These low-magnitude changes do not significantly affect the restoration design or anticipated stability of the constructed channel as robust safety factors have been incorporated into the proposed bank and bed treatments to accommodate such contingencies.

Table 2-6 Summary Results of 100-Year Flood Under Climate Change Scenario. Elevations Reference NAVD88.

		100-Year	100-Year + 20%
STA	**Discharge, cfs**	**3,041**	**3,650**
12+00	WSEl, ft	389.5	390.0
	Depth, ft	6.3	6.8
	Velocity, ft/sec	4.7	5.1
14+00	WSEl, ft	390.0	390.5
	Depth, ft	5.6	6.1
	Velocity, ft/sec	6.9	7.4
16+00	WSEl, ft	390.6	391.1
	Depth, ft	5.7	6.2
	Velocity, ft/sec	10.6	11.3
18+00	WSEl, ft	394.8	395.3
	Depth, ft	4.9	5.4
	Velocity, ft/sec	12.9	13.4
20+00	WSEl, ft	399.5	400.0
	Depth, ft	5.4	5.9
	Velocity, ft/sec	10.9	11.4
22+00	WSEl, ft	403.2	403.7
	Depth, ft	6.2	6.7
	Velocity, ft/sec	9.6	9.9

WSEl = water surface elevation
STA = river station
Ft = feet
ft/sec = feet per second

2.5 SEDIMENT SAMPLING AND ANALYSIS

MMI (now SLR) conducted sediment chemical sampling at the Quinapoxet Dam on June 3, 2015. The chemical sampling was used to test for constituents of concern within the impounded sediment.

2.5.1 CHEMICAL SAMPLING METHODOLOGY

SLR staff collected sediment samples from five locations. The location of each sample was recorded with a handheld global positioning system (GPS) unit. Three of the five samples were collected from the bed substrate in the actively flowing river, two of which were collected from the impoundment area upstream and another downstream of the dam. Two additional soil sample test pits were collected in overbank areas, where historical mapping indicates the channel was located prior to installation of the dam. The samples were placed into appropriately labeled laboratory containers and placed on ice immediately following sampling. They were kept cool until received by a laboratory courier from a Massachusetts-certified environmental testing laboratory, Alpha Analytical of Westborough, Massachusetts. Table 2-7 presents a list of the analytes measured.

Table 2-7 Sediment Sample Analytes

Analyte	
Arsenic	Total Organic Carbon
Cadmium	Total Solids
Chromium	Ignitability
Copper	Conductivity
Lead	Organochlorine Pesticides
Mercury	Specific Conductance
Nickel	Cyanide Reactivity
Zinc	Sulfide Reactivity
Polycyclic Aromatic Hydrocarbons (PAHs) (Environmental Protection Agency [EPA] 8270C)	Grain Size Analysis
Polychlorinated Biphenyls (PCBs)	
Extractable Total Petroleum Hydrocarbons (MA DEP ETPH method)	

The Toxicity Characteristic Leaching Procedure (TCLP) analysis for metals was subsequently cancelled based upon the mass-based results as per the provisions of 314 CMR 9.07(2)b. The analytical methods utilized comply with the Commonwealth of Massachusetts *401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States Within the Commonwealth [314CMR 9.07 (2)]*. Additional parameters as included in MA DEP Policy #COMM-97-001 were also specified.

2.5.2 SEDIMENT SAMPLING RESULTS

The sampling conducted in June 2015 consisted of three cores sampled from the Quinapoxet River and two cores from upland soil test pits. The findings support that the currently submerged sediments can be expected to comply with the limits established by the Massachusetts Contingency Plan (MCP) for contaminated soils once the Quinapoxet Dam is removed and the sediments are exposed. Contaminant levels appear consistent upstream, within, and downstream of the impoundment. Based upon the results of the sampling, the sediments will not require special handling or provisions to limit exposure. Onsite and offsite reuse appears to be possible based upon sediment quality assessment, which indicated that none of the samples exceeded MCP S-1/GW-1 levels or ecological effects thresholds. Similarly, the soils in the upland area to the north of the impoundment appear to be absent of anthropogenic contaminants and representative of naturally occurring soil. Based on this analysis, it is assumed that the sediments will not require special handling or provisions to limit exposure. Construction can be initiated without the need for additional sampling or special disposal criteria.

These conclusions are based upon the preliminary characterization of soil and sediment as presented in the Appendix C - Basis of Design. A sediment management plan has been developed to address any concerns related to sediment exposure resulting from the proposed project (Appendix H).

2.5.3 SUMMARY

The proposed approach to the removal of the Quinapoxet Dam involves the excavation of approximately 3,950 cubic yards of accumulated sediment from the area immediately downstream of the dam. Approximately 2,530 cubic yards of this sediment will be relocated on site, and 860 cubic yards will be relocated off site. This sediment, under normal water-level conditions, is generally dewatered and vegetated due to the past breach of the dam. The proposed method to managing the sediment within the former impoundment of Quinapoxet Dam is to excavate the already-dewatered material and to dispose of it on site as part of the island adjacent to the Quabbin Aqueduct discharge area. The preliminary sampling and analysis of this sediment in June 2015 suggest that further downstream releases of sediment, if any, will not result in detrimental conditions with regard to the chemical quality of the sediment.

3. PROPOSED PROJECT

3.1 DAM REMOVAL AND CHANNEL RESTORATION

The preferred alternative includes the following project components: 1) removal of the Quinapoxet Dam and 2) reconstruction of the Quinapoxet River channel at the dam to permit fish passage.

The Quinapoxet Dam is a uniquely designed dam. The accretion-style dam was built by over excavation and dredging of the downstream portion of the channel as opposed to more traditional dams, which are constructed on the bed of the channel to impound water. In order to protect the integrity of the downstream infrastructure, the majority of the material that was excavated downstream of the dam cannot be replaced as part of a restored channel. The primary constraint in evaluating alternatives was the need to create a steeper channel than would form naturally upstream of the former dam while mitigating the erosive forces generated under these conditions.

Adjacent to the dam is the Quabbin Aqueduct's Shaft 1 outlet and hydropower generation facility (the Oakdale Powerhouse). In order to preserve these structures, the existing abutment walls and berms along the river's southern bank are retained, and a peninsula dividing the primary river channel from the Quabbin outlet is proposed. This embankment along the southern bank essentially establishes a tailrace channel for the Quabbin Aqueduct, isolating its tailwaters from the proposed regrading of the Quinapoxet channel. Several fish-deterrent features are proposed in order to discourage fish from being attracted to the cold discharge from the transfer aqueduct in addition to an exit channel for those fish who do enter the tailrace.

The existing Quinapoxet River channel will be reconstructed at the dam location to a bankfull channel base width of 80 feet in pool sections and 50 feet in riffle sections. The proposed pool will be approximately 150 feet in length. Proposed riffles will be 220 feet apart and span the channel at varying widths. In order to establish a naturalized channel profile, removal of material upstream of the dam and placement of fill extending 80 feet downstream of the former dam's location are proposed. The proposed means of post restoration bank stabilization consists of a combination of bioengineered and armoring treatments that are appropriately designed for the predicted hydraulic conditions at their respective locations. Natural, bioengineered bank treatments will be implemented in areas where erosive forces are less severe. Approximately 3,950 cubic yards of material will be cut. Approximately 2,530 cubic yards of the material cut will be reused on site. The remaining 860 cubic yards will be disposed of off site. See Appendix B for Plans.

3.1.1 FISH PASSAGE CRITERIA

Consideration must be given to the channel restoration relative to the creation of aquatic habitat for the target species such as trout and landlocked salmon.

The existing dam prevents fish passage from the downstream reservoir into the upper reaches of the Quinapoxet River. This inhibits native species of fish from accessing miles of their natural habitat.

Elements, features, and methods were incorporated into the proposed channel such that the restored conditions are expected to substantially improve fish passage through the site. Referring to a reference reach is a valuable tool when attempting to match the passability of natural conditions in a river restoration project. A pool-riffle reach approximately half of a mile upstream of the project site was assessed and used as a reference reach, where riffle-to-riffle spacing was measured as approximately 150 feet, and slope was measured as approximately 2 percent. The reference geometry, including riffle-to-riffle spacing, slope, and bankfull dimensions, was used to develop the proposed conditions. The United States Fish & Wildlife Service (USFWS) has performed a site assessment of the existing dam, which involved observing the selected reference reach, and was in agreement as to its appropriateness and similarity to target conditions on the subject reach.

Using parameters provided by the USFWS, the hydraulic modeling results of each alternative were assessed relative to its suitability for fish passage for landlocked salmon (see Table 3-1). Hydrology was assessed by compiling flow information from USGS gauge No. 01095375 on the Quinapoxet River at Canada Mills near Holden, Massachusetts. Daily flow data were analyzed, and the May mean flow and August median flow were used to represent the higher and lower flow periods expected during critical periods for fish spawning and survival, respectively. The May mean flow was computed as 88 cfs, and the August median flow was computed as 13 cfs. Modeled flow velocities under these flows, with a 500-cfs discharge from the Quabbin Aqueduct, are presented in Figures 3-1 and 3-2, respectively.

Table 3-1 Summary of Physical Abilities of Landlocked Salmon

Physical	Body length	12		18		in
	% Body Depth	0.2		0.2		
	Body Depth	2.4		3.6		in
	Frontal Area	4.52		10.18		in^2
Swim Speed	Cruising	1.3	2.3	2.0	3.5	ft/s
	Prolonged	4	7	6	10.5	ft/s
	Burst	8	14	12	21	ft/s
Fatigue Time	Cruising					sec
	Prolonged	300	300	300	300	sec
	Burst	5	5	5	5	sec
Fatigue Distance	Cruising	INF	INF	INF	INF	ft
	Prolonged	2,400	4,200	3,600	6,300	ft
	Burst	20	35	30	52.5	ft

The hydraulic modeling indicates that post-dam-removal velocities will be favorable for habitat creation even under low-flow conditions. The proposed pools provide year-round aquatic organism habitat, and the low-flow channel enables fish passage in predicted lower flow conditions based on the criteria in Table 3-2. Under higher springtime flows, modeled flow depths and velocities remain manageable for target freshwater fish species throughout the modified reach. Passage through the restored reach is expected to be dramatically improved, but flow depths may be only marginally improved at certain locations and discharge events. Hence, the proposed deeper pool areas, boulder clusters, and low-flow

channel are intended to provide refugia even during drought conditions. These features will help achieve the project goal of restoring the river to a quasinatural state in terms of both hydraulic performance and aquatic habitat capacity.

Table 3-2 Fish Passage Requirements for Target Species

Parameter	Atlantic Salmon (*Salmo salar*)	Eastern Brook Trout (*Salvelinus fontinalis*)	Brown Trout (*Salmo trutta*)	Rainbow Trout (*Oncorhynchus mykiss*)
Life Stage	Adult	Adult		
Life Strategy	Anadromous	Freshwater		
Thermal Regime	Coldwater	32 - 77°F		
Spawning Temperatures (°F)	36.4 - 42.0°F	38 - 45°F		
Spawning Habitat	Gravel riffle areas	High-elevation lakes and streams		
Major Run	May – mid July	April – July (juvenile)		
Minor Run	September – October	October – December (adult)		
Sustained Swimming Speed (fps)	5.0 - 8.8	2.0 - 7.2		
Minimum Depth (inches)	5.7 - 6.6	5.0 - 6.0		
Time of Migration	Diurnal	---		

fps = feet per second

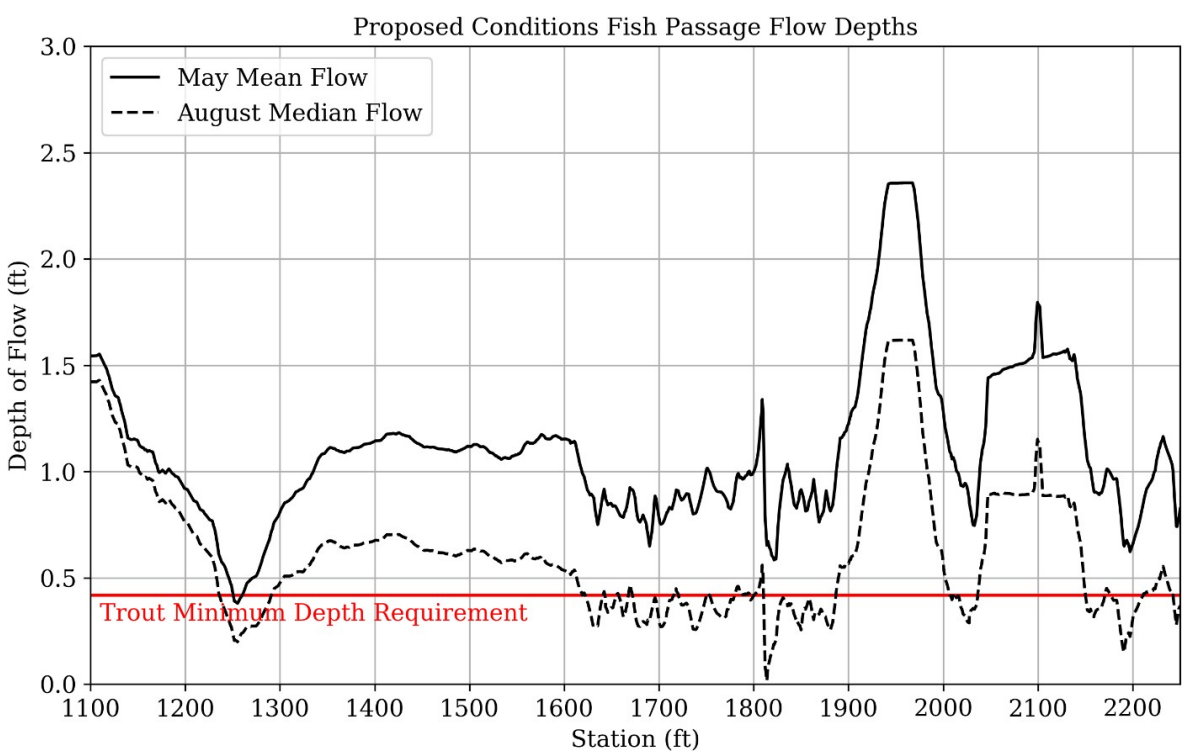

Figure 3-1: Flow Depths Under Projected Springtime Higher Flows and Summertime Lower Flows, Critical Periods for Fish Passage

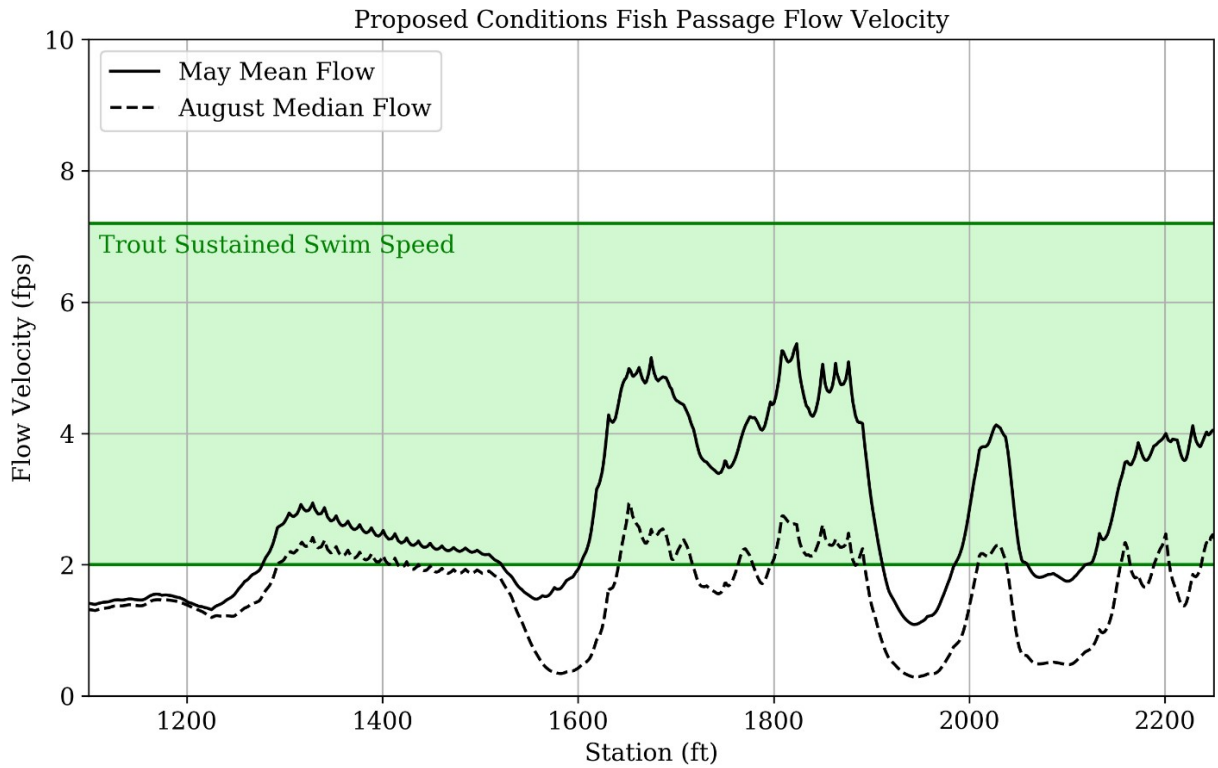

Figure 3-2: Flow Velocities Under Projected Springtime Higher Flows and Summertime Lower Flows

The proposed fish deterrent features and an exit passageway from the tailrace may help keep fish from approaching the powerhouse discharge. Proposed fish deterrents were devised following assessment of existing hydrodynamics so as to avoid additional tailwater influence on the aqueduct. Nominal elevations of these irregular boulder structures were set to the normal water surface elevation of the Wachusett Reservoir (EL 384.0 feet) and located 150 feet and 375 feet downstream of the powerhouse. While flows are necessarily influenced by these features, there are no significant detriments to tailwater conditions. In addition to acting as physical barriers, these features also generate high-flow velocities that may further dissuade fish from entering the tailrace, especially when the Quabbin Aqueduct is discharging during low-flow conditions on the Quinapoxet River.

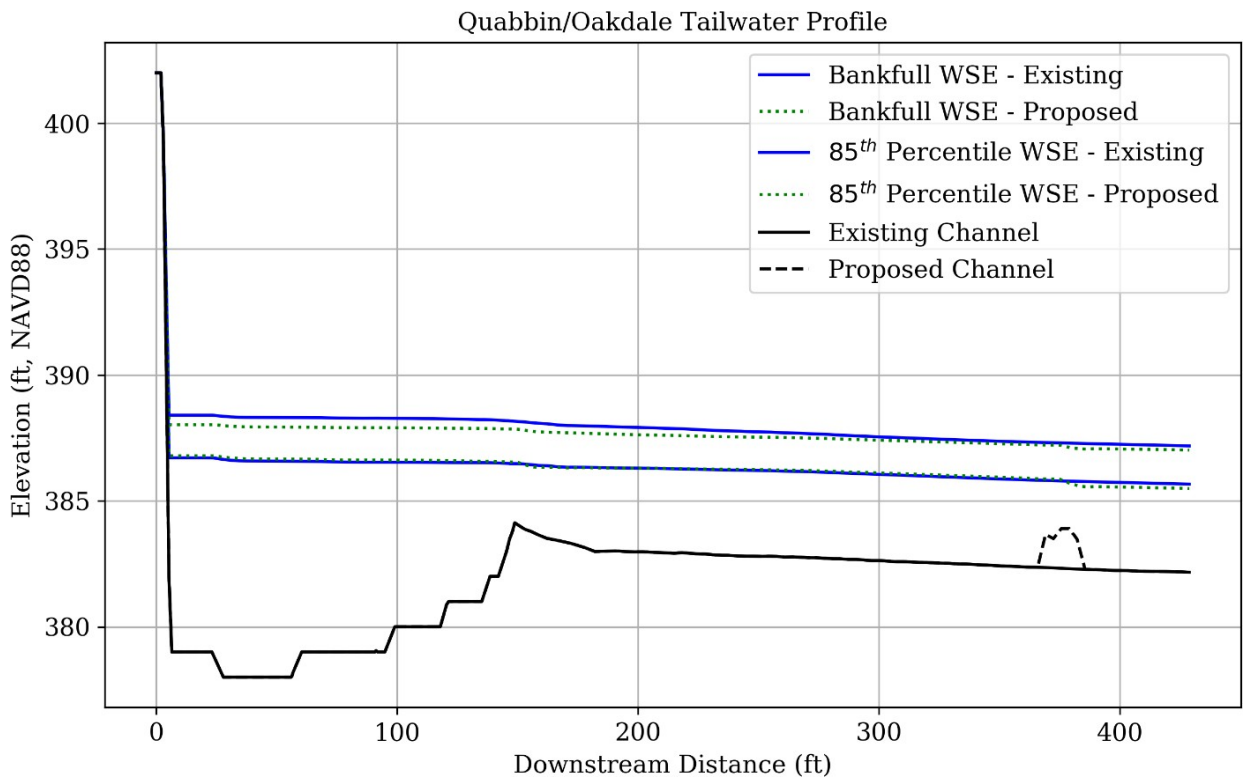

Figure 3-3: Tailwater Profile Downstream of the Oakdale Powerhouse Outlet of the Quabbin Aqueduct. Bankfull flows (830 cfs) and the 85th percentile duration flows (10 cfs) are plotted under existing and proposed conditions, with a 500 cfs discharge from the aqueduct.

3.1.2 BANK STABILITY AND FLOODPLAIN IMPACTS

Modeled flow velocities generally diminish with proximity to the banks but may still exceed 10 feet per second (fps) along the channel margins at the proposed riffle features during a 100-year flood (See Appendix C, Basis of Design). Proposed boulder revetment will consist of 1- to 2-foot-diameter stone keyed into the channel bed a minimum of 4 feet below the finished thalweg elevation. Boulder riffle ribs will key into the bank revetment to provide additional stability to the restored channel. Random boulder clusters and random channel roughness are proposed along the outside of bend to create flow diversity and turbulence, decrease shear stresses during high flow events, and help maintain bank stability by encouraging deeper flows in the center of the channel. Concentrating the highest velocities and shear forces at the two proposed riffles allows for less imposing, naturalized bank treatments elsewhere. These include root wad deflectors, naturalized cobble revetment, hedge brush, and willow fascine plantings. Live-staked boulder revetment and bankfull sills provide robust bank stabilization while effectively diffusing erosive forces. Proposed sills and bankfull benches also enable flows and velocities to be distributed across larger cross-sectional areas, reducing the reliance on hard-armoring treatments.

Hydraulic modeling of the estimated 100-year flood indicates that the proposed dam removal and river restoration will not have adverse impacts on adjacent properties. Slight reductions in inundation extent are expected along with slight reductions in base flood elevations, as shown in Figure 3-4. The hazards associated with a potential dam failure will be eliminated.

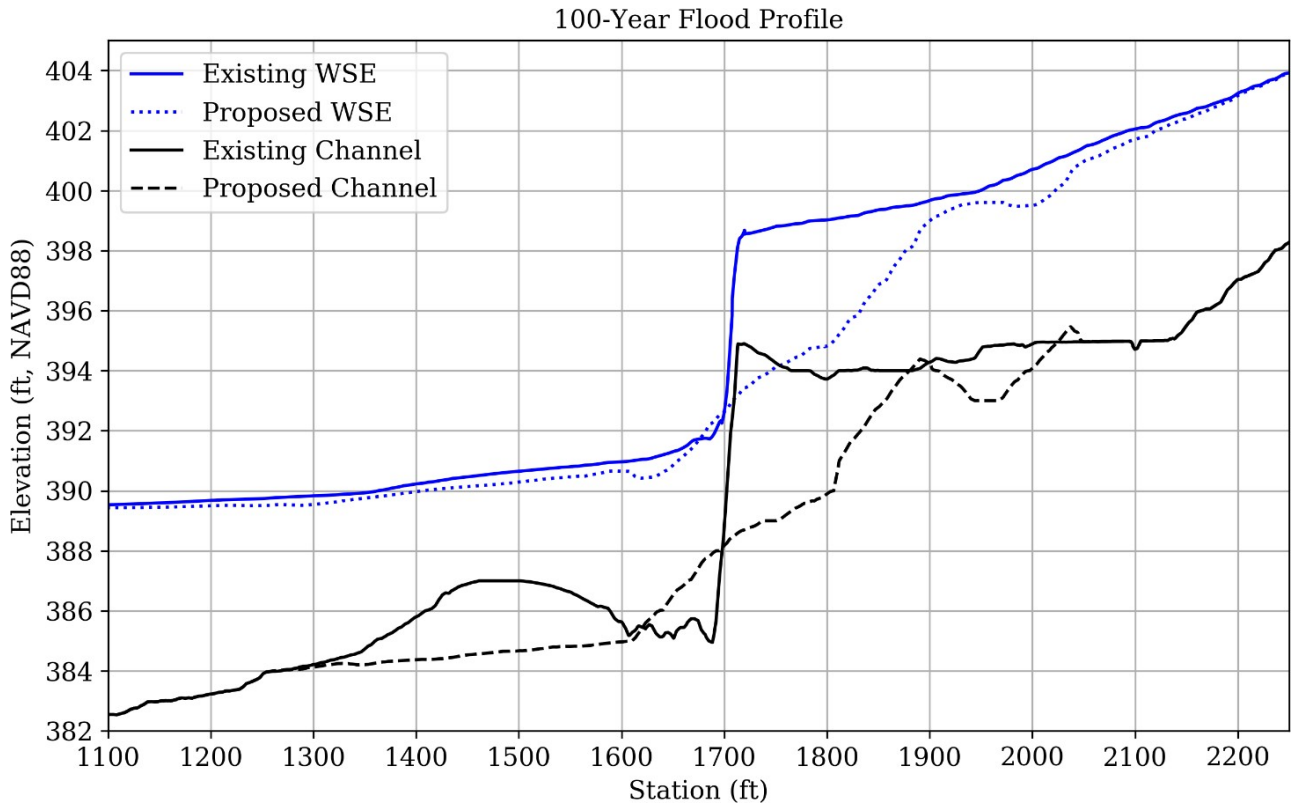

Figure 3-4: Comparison of modeled 100-year flood elevations under existing and proposed conditions. 500 cfs release from the Quabbin Aqueduct is modeled in both cases.

3.1.3 SEDIMENT HANDLING

Based on previous sediment sampling (Section 2.5.2), no additional sediment sampling or testing is necessary. Soil and other materials excavated from the project site should be carefully handled within dry work areas to prevent erosion and downstream sedimentation. Under no circumstances shall excavation, grading, and moving of materials occur in the wet. The dry work area shall be designed to allow the proper transport of soil within the work zone, to designated soil stockpile areas, and off site.

Due to the nature of the dam construction and nearby infrastructure, significant volumes of soil will be excavated upstream of the dam. Approximately 3,950 cubic yards (CY) of material will be excavated over the three project phases, about 2,530 CY of which will be reused on site for proposed design features. The proposed design limits the amount of soil to be reused on site as it would present more sedimentation risk and would be cost prohibitive to stabilize excess soil to be kept on site. Exporting excess earthworks, approximately 860 CY, will prevent erosion and sedimentation after construction is complete, protecting the water quality of the downstream water bodies.

3.1.4 WATER QUALITY PROTECTION AND TURBIDITY MONITORING

Because the Quinapoxet River feeds the Wachusett Reservoir, a drinking water reservoir for the Greater Boston Metropolitan Area, water quality is of the utmost importance. Suspended sediment in a water body is a primary indicator of overall water quality. Furthermore, turbidity is used as a surrogate measurement for quantifying entrained sediment. Turbidity is an optical measurement that indirectly measures the particle density in the water and can be an indication of total suspended solids.

Due to the sensitive nature of the downstream waterbodies, a formal Turbidity Monitoring Plan (TMP) will be implemented during the construction phases of the project (See Appendix H – Sediment Management Plan). Turbidity sampling during construction must consist of both continuous monitoring and discrete grab sampling within the water column, compliant with the Environmental Protection Agency (EPA) and the International Organization for Standardization (ISO) methods, at various points of compliance.

The successful implementation of the TMP will ensure there are no adverse water quality impacts on the downstream drinking water source. Specifically, the contractor must maintain project controls resulting in turbidity no greater than 2 nephelometric turbidmeter units (NTU) as measured by MWRA at its permanent downstream sampling stations. Turbidity monitoring and reporting will be the responsibility of the contractor at all times during construction. It is recommended that the selected contractor employ an experienced and qualified environmental testing agency to ensure the proper implementation of this TMP.

3.1.4.1 Turbidity Continuous Sampling

Continuous monitoring should be performed with a turbidity sensor that is permanently submerged in the body of water. Turbidity sensors allow for the measurement of in-situ, real-time data and most accurately represent surface water conditions. Turbidity sensors should be connected to a buoy-based sonde or a data logger to record and report data in real time. The data logger must be capable of transmitting live data via wireless communication to a web-based or cloud-based platform where the turbidity data can be viewed in real time.

The primary components required for the continuous turbidity monitoring system are as follows:

- Turbidity sensor
    - The selected turbidity sensor must be ISO 7027 compliant and report data at a frequency of 15-minute intervals or more frequently.
    - If the water depth at the sampling location is greater than 3 feet, multiple sensors must be provided for depth sampling. One turbidity sensor must be provided for every 3-foot depth of the water column. (A 3-foot channel depth requires one sensor, a 6-foot channel depth requires two sensors, etc.) Locations that require multiple depth sensors should be daisy-chained from the same buoy.
    - The sonde must contain a wiper to prevent fouling and sediment accumulation on the sensor.

    - Recommended turbidity sensor is the YSI EX02 or approved equal.
- Data Buoy and Data Logger
    - A data buoy, or floating platform, must be provided that supports the real-time monitoring sensor selected.
    - The data buoy must serve to house the monitoring equipment and supply power to the monitoring equipment via solar-powered battery packs.
    - The data buoy and housed data logger must be capable of transmitting sensor data in real time, either via radio, cellular, or satellite based wireless communication.
    - The data buoy must be anchored with a two-point mooring system including a stainless-steel mooring line, bottom chain, and anchor system to ensure that it remains stationary and is capable of handing the anticipated flow rates in the channel.
    - Recommended data buoy is NexSens CB-450 Data Buoy or approved equal.
- Live Data Platform
    - Live turbidity data via a web-based or cloud-based platform must be made available to MWRA, DCR, and SLR at all times during construction.
    - The live data platform must be capable of reporting data in real time at 15-minute intervals for immediate viewing.
    - The data platform and associated software must be password protected, with credentials for login provided as requested by MWRA.
    - The data platform must be capable of providing automated alerts when turbidity levels exceed predefined limits.
    - The data platform must be capable of archiving historic data for future download.
    - Recommended data platform is NexSens WQData Live Web Datacenter or approved equal.

3.1.4.2 Turbidity Grab Sampling

Grab samples will be used as a secondary means of measuring turbidity, with the intent to verify readings from the continuous sampling, provide a backup method of sampling if equipment malfunctions, and provide spot readings at the direction of MWRA or SLR during sensitive work phases.

Turbidimeters are recommended for grab samples with turbidities less than 40 NTU, which is expected for samples from this project. Prior to the start of construction, the contractor shall provide product data as a formal submittal for the selected portable turbidity meter, documenting compliance with EPA Method 180.1.

Grab samples should be retrieved at roughly the middle of the water column, at least 1 foot below the water surface but not within 6 inches of the channel bed. The contractor should avoid stirring the bottom sediments to the maximum extent practicable during sampling. It is of critical importance to have well-trained personnel taking water samples and to minimize sampling personnel changes during a project. To the maximum extent practicable, consistency in sampling personnel should be maintained to reduce result variability. Sampling personnel should receive training in using the equipment prior to the start of sampling.

3.1.4.3 Turbidity Visual Inspections

In addition to measurements taken with the continuous monitoring system and portable turbidity meter, visual monitoring should take place throughout construction. The contractor should visually assess the turbidity downstream of the project site and compare it to the turbidity of the upstream and receiving waters. The contractor should report any visual changes to the water immediately to MWRA and mitigate them as soon as possible.

Should a turbidity plume be observed visually, the contactor should provide photographs of receiving waters at SLR's or MWRA's request and report a turbidity reading from the middle of the plume, which will prompt further action at the direction of MWRA.

3.1.4.4 Turbidity Monitoring Locations and Timeline

Turbidity monitoring locations were selected based on the anticipated construction phasing and water control plan. All monitoring locations are shown on the construction sheets (CP-1 and CP-2) of the design plans in Appendix B. The monitoring locations will be installed for all phases of construction.

One location (WQ-B-1), approximately 100 feet upstream of the project site, will be utilized as a background sample location to establish the baseline for turbidity values at the project site. Two monitoring locations downstream of the project site, known as points of compliance, will serve to measure turbidity downstream of the work area and to compare to the background sampling location. One location (WQ-C-1) will be located approximately 100 feet downstream of the project site, and another location (WQ-C-2) will be approximately 3,000 feet downstream of the project site at the Thomas Street bridge.

3.1.4.5 Turbidity Reporting Frequency

The continuous monitoring system must report turbidity at 15-minute intervals, which are available to be viewed in real time through the live web platform. Turbidity monitoring via the handheld turbidity meters should occur at least once daily to spot check the continuous monitoring equipment and more frequently as requested by MWRA or during sensitive stages of construction.

Table outlines the sampling frequency that the contractor must take turbidity grab samples and the frequency that those turbidity results must be communicated to SLR and MWRA. Grab samples from the upstream and downstream locations should be taken within a maximum period of 30 minutes from each other.

All grab sample turbidity measurements should be reported to MWRA via the Turbidity Monitoring Forms provided in Appendix H – Sediment Management Plan. The "daily" form should be utilized under normal monitoring conditions, and the "increased frequency" form should be used when more frequent testing is required.

Table 3-3 Sampling and Reporting Frequency for Grab Samples

Site Condition	Sampling Frequency	Sample Locations	Reporting Form	Reporting Frequency
Normal Conditions	Daily (Once daily during a typical construction day to spot check continuous monitoring equipment)	Three sampling locations during each sampling 'event': • Upstream Background (WQ-B-1) • Downstream Point of Compliance 1 (WQ-C-1) • Downstream Point of Compliance 2 (WQ-C-2)	Turbidity Monitoring Form – Daily	Email scanned "Daily" forms weekly unless requested daily by MWRA. Report and email forms daily if turbidity reading (NTU) measured with the handheld turbidity meter is NOT within 10 percent of the continuous reading (NTU).
Increased Frequency Conditions	During the circumstances described below, sampling should occur at a minimum of once every hour, or the frequency directed by SLR or MWRA • After visual observation of a turbidity plume • During switching of construction phases and moving of cofferdams • During reintroduction of flow into a dry work area • At the direction of SLR or MWRA	At the direction of MWRA or SLR (sample locations to represent sensitive work areas, turbidity plumes, or any other areas of concern)	Turbidity Monitoring Form – Increased Frequency	Communicate results immediately to SLR or MWRA representative on site. Email scanned "Increased Frequency" forms weekly unless requested daily by MWRA.

3.1.4.6 Turbidity Thresholds and Corrective Actions

The contractor must maintain project erosion and sedimentation (E&S) controls such that the turbidity is no greater than 2 NTU as measured by MWRA at its permanent downstream sampling location at the outlet of Wachusett Reservoir. Increases above background turbidity is defined as the difference in NTU between the background (upstream) turbidity sample (WQ-B-1) and the turbidity at any of the two points of compliance downstream (WQ-C-1 and WQ-C-2). The thresholds at each of the two points of compliance differ based on the expected mixing with Quabbin transfer flows and other hydrodynamic processes occurring just downstream of the project site. The historical turbidity data was used to help inform the selected thresholds above the measured background turbidity.

4. ALTERNATIVES ANALYSIS

The preferred alternative includes the removal of the Quinapoxet Dam and reconstruction of the channel within the Quinapoxet River to support fish passability as described above in Section 3. Alternatives to this approach that were considered are described below. The goals of this project are to restore natural river processes, protect drinking water supply reservoir from excessive sediment mobility, and enable year-round fish passage. Each of these targeted goals was carefully vetted as part of the alternative analysis.

4.1 DAM REMOVAL AND RIVER RESTORATION ALTERNATIVES

The preferred alternative for promoting fish passage at the Quinapoxet Dam is a full dam removal with riffle and pool geometry upstream of the existing dam. Alternatives to the dam removal included: 1) constant channel bed slope and 2) riffle-pool channel grading downstream of the existing dam.

Because the dam was constructed by over excavating and dredging the downstream portion of the channel, the dam removal must be completed without replacing the material removed during construction in order to protect downstream infrastructure. The primary constraint in the evaluated alternatives was the need for a steeper channel while limiting the development of high velocities. The flows needed to also have suitable velocities and depth for fish passage.

4.1.1 NO ACTION

The "do nothing" alternative would leave the Quinapoxet Dam in place. Since this option maintains the status quo and proposes no construction or work, it therefore would not necessitate environmental review or permitting. However, it would result in continued impairment of habitat functionality, such as continued blockage of fish passage, and fragmented river conditions. This action would not satisfy the environmental goals proposed by the project included in Section 1.

If this alternative were selected, it would require the continued maintenance and upkeep of this significant dam, which is in fair condition at the time of the latest inspection performed by GZA in 2007 (Appendix I – 2007 GZA Dam Inspection). According to the inspection report, it is estimated that up to $500,000 would be required for upkeep studies, design, and repair work. This cost estimate would include items such as engineering costs, removal of sediment immediately upstream of the spillway, and repointing the right training wall. It does not include the dredging of the entire impoundment nor a reconstruction of the fish ladder.

4.1.2 CONSTANT CHANNEL BED SLOPE

This alternative involves the removal of the spillway and regrading of the channel at a constant slope of 2.1 percent. The modeled stream had a width of 60 feet and a depth of 2 feet. Most fisheries will be able to survive and migrate in channels near 2 percent slope as long as there is sufficient roughness and resting areas. Natural channels with a 2.1 percent slope fall within the Rosgen Type B with fast run and

riffle profile types. Pools would be rare or absent. A hydraulic jump upstream from a supercritical to subcritical flow would create turbulence. However, the installation of bank armoring such as stones would eliminate any threat of potential headcut associated with this hydrologic jump.

The model results indicate that the restored channel would be subject to high velocities at the upstream end of the project reach. This alternative was not selected because of the high velocities and shear stresses.

4.1.3 RIFFLE-POOL CHANNEL DOWNSTREAM

To mitigate high velocities and shear stresses from the constant channel bed slope alternative, this alternative incorporates riffle-pool types of geomorphology rather than a constant channel bed slope. Incorporation of riffles and channel roughness from boulder clusters reduces predicted velocities through the restored reach. The alternative includes two riffle-pool features spaced 275 feet apart. The pool was modeled to be 190 feet in length with an upstream slope of 3 percent, and the riffle was 100 feet in length with a 4 percent slope. Although the flow through the riffle portions will experience higher velocities, the riffle stone and in-stream features would be appropriately designed to withstand such forces.

While this alternative does reduce flow velocities, it would also include grading that would extend beyond the immediate dam area. This proposed grading would fail to preserve the existing confluence of the Quabbin Aqueduct approximately 145 feet downstream of the dam.

5. CONSTRUCTION SEQUENCE

The proposed project involves three major components:

1) The removal of the Quinapoxet Dam
2) The stabilization and restoration of the Quinapoxet River
3) Installation of an in-channel earthen berm and other fish-deterrent features within the Quabbin Reservoir transfer aqueduct tailrace channel

The design plans have been prepared with three phases of bypass water control to divert the flow of the Quinapoxet River around the active work area. All work will be required to occur in dry conditions, which will limit sedimentation and turbidity levels.

5.1 WATER CONTROL – PHASE I

The first construction phase involves the cofferdamming of low flows around the southern portion of the dam. The removal of a portion of the dam and impoundment excavation shall be completed once the work area is isolated from active flow in the Quinapoxet River and fully dewatered. Removal of this portion will provide space for a passive, gravity bypass of the Quinapoxet River to be installed in Phase II.

5.2 WATER CONTROL – PHASE II

The second phase involves cofferdamming, diverting water through gravity-fed bypass pipe, and if necessary, pumping of low flows around the work area, with smaller sumps and groundwater pumps installed throughout the work site as needed to maintain completely dry conditions. Phase II will also require a culvert crossing under the construction road to allow access to the work area. Disassembling of the remaining dam, fish ladder, and appurtenances; removal of existing islands; and construction of the new channel can be completed in dry conditions during the second phase of construction. Once the main channel is complete, water can be transitioned into the reconstructed riverbed.

5.3 WATER CONTROL – PHASE III

The third phase of water control will require cofferdamming of the exit from the Oakdale Power Station outlet channel with a smaller sump and groundwater pump to maintain completely dry conditions. As soon as the exit channel is fully dewatered, installation of fish-deterrent features on the side channel can be performed. All discharges from temporary bypass pipes shall end in a plunge pool designed to provide a soft landing for out migrating fish. Once the channel is complete, floodplain work outside the wetted portion of the channel can be constructed.

Low-flow (See Table 2-3) control will be of primary importance for Phase II, in which the main portion of the channel will be under construction and the flow bypass will occur via passive, gravity flow around

the work area. Management of low flows during Phases I and III will occur through the main channel, providing access to the majority of the existing or constructed channel and floodplain.

5.4 EROSION, SEDIMENTATION, AND BYPASS WATER CONTROL DURING CONSTRUCTION

The water control plan has been carefully considered prior to construction such that both low-flow and high-flow situations can be controlled without allowing turbidity releases downstream into the Wachusett Reservoir. The MWRA is required to maintain water in the reservoir to the utmost of quality standards to maintain the drinking water supply for 50 communities, including the city of Boston. As such, the contractor will be required to take extra precautions before, during, and after construction to effectively mitigate the risk of untreated sediment-laden stormwater runoff from flowing into the downstream receiving waters or of any turbid waters from the construction site leaving the controlled area and discharging downstream.

All vegetative and structural E&S control practices shall be constructed according to the standards and specifications in the *Massachusetts Erosion and Sediment Control Guidelines*. Construction route locations will be finalized with MWRA prior to start of construction but are preliminarily depicted on the design plans. One construction access is proposed to allow construction equipment to access the area upstream of the dam, which will use existing lawn and paved areas on MWRA property. A second construction access is proposed downstream of the dam, utilizing an existing pedestrian walking path. Temporary construction access roads, staging, and stockpile areas will be limited to DCR-owned property or roadway rights-of-way.

5.4.1 FLOW BYPASS SYSTEM

Under low-flow conditions, it is recommended that two temporary bypass pipes be installed to divert the active flow of the Quinapoxet River around the dewatered construction site, with cofferdams at the upstream and downstream ends of construction to fully isolate the work area. The gravity bypass pipes are shown on the plans schematically, but the final location should be laid out in the contractor's approved E&S Control plan. This setup should be sized to accommodate as much flow as economically feasible up to the bankfull flow but at a minimum should be able to pass 500 cfs.

5.5 HIGH PEAK FLOWS (FLOOD CONTINGENCY PLAN)

The contractor that is selected to perform the work will be required to prepare and submit a Flood Contingency Plan and an Emergency Operations Plan. The project site is located within the 1 percent annual chance floodplain zone and is subject to flooding. Weather reports provided by the National Weather Service shall be monitored. If a significant precipitation event is forecast to occur during the construction period and flows are expected to exceed that which the low-flow water is capable of conveying, the contractor shall stop work, remove equipment from the floodplain, and secure the project site as needed to accommodate the elevated flows.

6. IMPACT ON REGULATED RESOURCE AREAS

The removal of the Quinapoxet Dam will alter wetland resources while reestablishing the natural river and riparian corridor. Dam removal is a proactive habitat restoration approach that seeks to restore and improve the natural capacity of resource areas that have been degraded by human influences. As a result, the ecosystem functions and quality of these resource areas will be improved.

6.1 WETLANDS AND WATERWAYS

6.1.1 JURISDICTIONAL APPLICABILITY

Construction activities associated with dam removal are subject to the Massachusetts WPA and its implementing regulations (310 CMR 10.00) (Figure 6-1, appended). The project team will also coordinate with the West Boylston Conservation Commission to establish the appropriate permitting mechanism for the work.

The project meets the definition of an Ecological Restoration Project as defined in 310 CMR 10.04 and as further clarified in subsequent sections of the WPA regulations. It is understood that such projects "may result in the temporary or permanent loss of Resource Areas and/or the conversion of one Resource Area to another where such loss is necessary to the achievement of the project's ecological restoration goals" [(310 CMR10.53(4)(b)].

Estimates of direct impacts are addressed in Section 6.1.2, pertain only to the limits of the 2.85-acre project site itself, and do not reflect changes to wetlands upstream of the limits of work. Note that permanent impacts will generally result in an increase in the functional benefits of the overall wetland system and that temporary impacts on jurisdictional wetlands upgradient of the dam are necessary to achieve the restoration goals of the project.

The activities associated with the dam removal and channel modification are expected to be permitted entirely under the WPA (310 CMR 10.00). Of note, riffle grade control features will be located entirely below the existing channel bed and below the high water mark, as defined at 310 CMR 9.02 High Water Mark, of the Quinapoxet River.

6.1.2 DIRECT IMPACTS ON WETLAND RESOURCES

Direct impacts on wetland resources as defined under the Massachusetts WPA in the immediate vicinity of project activities are quantified in Table 6-1 below and shown in appended Figure 6-2.

Table 6-1 Impacts on Resource Areas Under WPA

Regulated Area (unit)	Quinapoxet Dam Removal Direct Impacts	Quinapoxet Dam Removal Temporary Impacts	Quinapoxet Dam Removal Permanent Impacts
Inland Bank (linear feet)	1,490 LF	650 LF	1,490 LF
Land Under Water (acres)	1.81 AC	1.17 AC	0.40 AC
Bordering Land Subject to Flooding (acres)	0.62 AC	0.95 AC	1.18 AC
200-Foot Riverfront Area (acres)	0.62 AC	0.84 AC	1.18 AC
Bordering Vegetated Wetlands (square feet)	0 SF	0 SF	0 SF

Approximately 1.81 acres (79,060 square feet) of LUW will be directly impacted by the proposed project. Reconstruction of the river channel upstream and downstream of the Quinapoxet Dam, including the dredging of the downstream islands, will also directly impact 1,490 linear feet of Inland Bank. The modification of the channel will also directly affect 0.62 acres of BLSF and Riverfront Area. No direct impacts are anticipated for BVWs; however, the conversion of LUW to BVW will lead to a net gain of BVW during the project.

Permanent impacts on Inland Bank are due to new bank treatments, loss of existing bank, and grading/earthwork. The temporary impacts on the bank are banks that will be affected by the construction activities but will remain Inland Bank upon completion of the project. Permanent impacts on LUW include channel restoration, grading/earthwork, and the conversion of LUW to BVW. BLSF and Riverfront Area (RFA) will be permanently impacted by activities such as bank treatments, grading/earthwork, fish ladder removal, and walkway. Temporary impacts on BLSF include construction use within the regulated resource. No direct construction is occurring within BVW; however, 0.79 acres of LUW will be converted into BVW. See Table 6-2 for more details.

Table 6-2 presents the existing and proposed wetland resources and evaluates the total change in resource areas.

Table 6-2 Proposed Changes to Resource Areas Under WPA

Regulated Area (unit)	Existing Conditions	Proposed Conditions	Total Change
Inland Bank (linear feet)	2,140 LF	2,020 LF	- 120 LF
Land Under Water (acres)	1.86 AC	1.75 AC	- 0.11 AC
Bordering Land Subject to Flooding (acres)	16.74 AC	17.36 AC	+ 0.62 AC
200-Foot Riverfront Area (acres)	9.51 AC	10.13 AC	+ 0.62 AC
Bordering Vegetated Wetlands (acres)	0.84 AC	1.63 AC	+ 0.79 AC

The direct loss of Inland Bank and LUW will be offset by the anticipated "creation" of 0.79 acres of BVW within the former Quinapoxet Dam area. Formerly impounded LUW will be exposed to the surface and is expected to transition into BVW communities. Appended Figure 7 illustrates the proposed wetland resource areas. As noted previously, provisions under 310 CMR 10.53(4)(b) expressly anticipate significant alterations of jurisdictional resources where necessary to achieve the intended restoration goals.

6.1.3 INDIRECT IMPACTS ON WETLAND RESOURCES

It is unlikely that existing wetland resource areas will lose wetland hydrology due to the nature of the area's poorly draining soils and subsurface and perennial stream hydrology. Following removal of the dam, the relative percentages of various wetland types within the impoundment will change. It should be noted that permanent impacts will generally result in an increase in the functional benefits of the overall wetland system and that temporary impacts on jurisdictional wetlands upgradient of the dam are necessary to achieve the restoration goals of the project. The most significant change that is anticipated is conversion of LUW, which is expected to transition into BVW. Reduction in LUW is anticipated to be approximately 0.11 acres.

6.2 HISTORICAL AND ARCHAEOLOGICAL RESOURCES

Correspondence with the Massachusetts Historical Commission regarding historic and archaeological resources is underway.

The "Quinepoxet River Circular Control Dam" (WBY.905) is listed on the State Register of Historic Places. Other surrounding structures such as the Quabbin Aqueduct (WBY.C), Quabbin Aqueduct Outlet Works (WBY.G), and the Quabbin Aqueduct Outlet Chamber (Shaft #1) (WBY.907) are also listed on the State Register of Historic Places. A Public Notification Form (PNF) regarding the project was filed with MHC in October 2020 by MWRA. In addition, Archaeological & Historical Services, Inc. (AHS) Cultural Resource

Management filed an application for archaeological investigation with MHC due to the potential archaeological sensitivity of the area.

6.3 GREENHOUSE GAS EMISSIONS

Because removal of the dam triggers a mandatory EIR threshold [CMR 11.03 (3)(a)(4)] and is presumed to be funded, in part, with public monies and is therefore subject to broad scope jurisdiction, the project is subject to the Greenhouse Gas (GHG) Emissions Policy. With that said, GHG emissions associated with the project are anticipated to be minimal. Such emissions are only anticipated to occur in association with operation of construction equipment during dam removal activities and bridge construction, including ancillary activities.

The project is consistent with the types of activities cited as examples of projects that may qualify for a de minimis exemption in the May 5, 2010, version of the MEPA GHG Policy.

7. MITIGATION MEASURES

7.1 SEDIMENT AND EROSION CONTROL

Erosion control on site will be managed through the use of approved Best Management Practices (BMPs) from the Massachusetts *Erosion and Sediment Control Guidelines*. Work in the channel will be completed under dry conditions, and the watercourse will be protected using silt fence and straw bales, as appropriate. Any dewatering pumps that are necessary to provide dry conditions during excavation will be discharged to a designated settling basin to eliminate turbidity in the water before it is discharged back into the watercourse.

During construction, measures will be undertaken to minimize erosion on site to the maximum extent practicable. Prior to the commencement of construction, the contractor will prepare and submit a Stormwater Pollution Prevention Plan (SWPPP). Work on the dam removal will be completed predominantly "in the dry." Upland bare soil areas exposed during construction at any one time shall be minimized to the maximum extent practicable. When grading is complete, topsoil shall be spread over exposed upland areas in order to facilitate reestablishment of vegetation. Vegetative cover shall be reestablished in subsequent growing seasons. S&E control BMPs, including the stabilization of construction entrances, turbidity settling basins, erosion control blankets, straw bales, and silt fences, will be installed during construction to the specifications required by regulatory authorities through the permitting process.

7.2 TIME-OF-YEAR RESTRICTION

Deconstruction and removal of the dam and restoration of the channel are anticipated to take approximately 4 months. Typically, the construction window for riverine projects is limited between the months of June to September because of lower flows and fish migration concerns. However, in the case of this project, the MWRA operational needs including the outflow from Quabbin Inflow Shaft No. 1 will dictate the construction window. Due to water supply reasons, the Quabbin Aqueduct is open from May to October. This period, from May to October, is a firm operational period for MWRA when no construction activities may take place. Flows at the downstream end of the project will be elevated, and water quality will be a primary concern. Therefore, construction is aimed to occur between October 2022 and May 2023.

If a serious operational concern or drought conditions occur, a contingency plan will be required to allow for the transfer of water outside of the 6-month transfer period. Should a transfer be required during active construction, extra care must be given to ensure that transfers from Quabbin Reservoir are unimpeded.

7.3 CULTURAL RESOURCES

Correspondence with the MHC is underway. MWRA submitted a PNF on October 6, 2020. In addition, AHS filed an application for archeological investigation with MHC due to the potential archaeological sensitivity of the area.

7.4 INVASIVE PLANT SPECIES

Invasive species within the project limits include multiflora rose (*Rosa multiflora*). This invasive shrub is predominantly located in upland areas and outside of the primary disturbance areas. If it is encountered in the construction zone, this shrub will be mechanically removed, and actions will be taken to ensure growth is limited in the future. At the conclusion of the project, the substrate conditions will not be conducive to colonization of invasive plants in this location. Limited areas of sediment exposure from dam removal are expected. It is anticipated that these areas will be colonized by existing native vegetation. Therefore, no invasive species removal is anticipated to be necessary for this project.

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APPENDIX A

SUPPORTING FIGURES

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

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Date Saved: 1/19/2021

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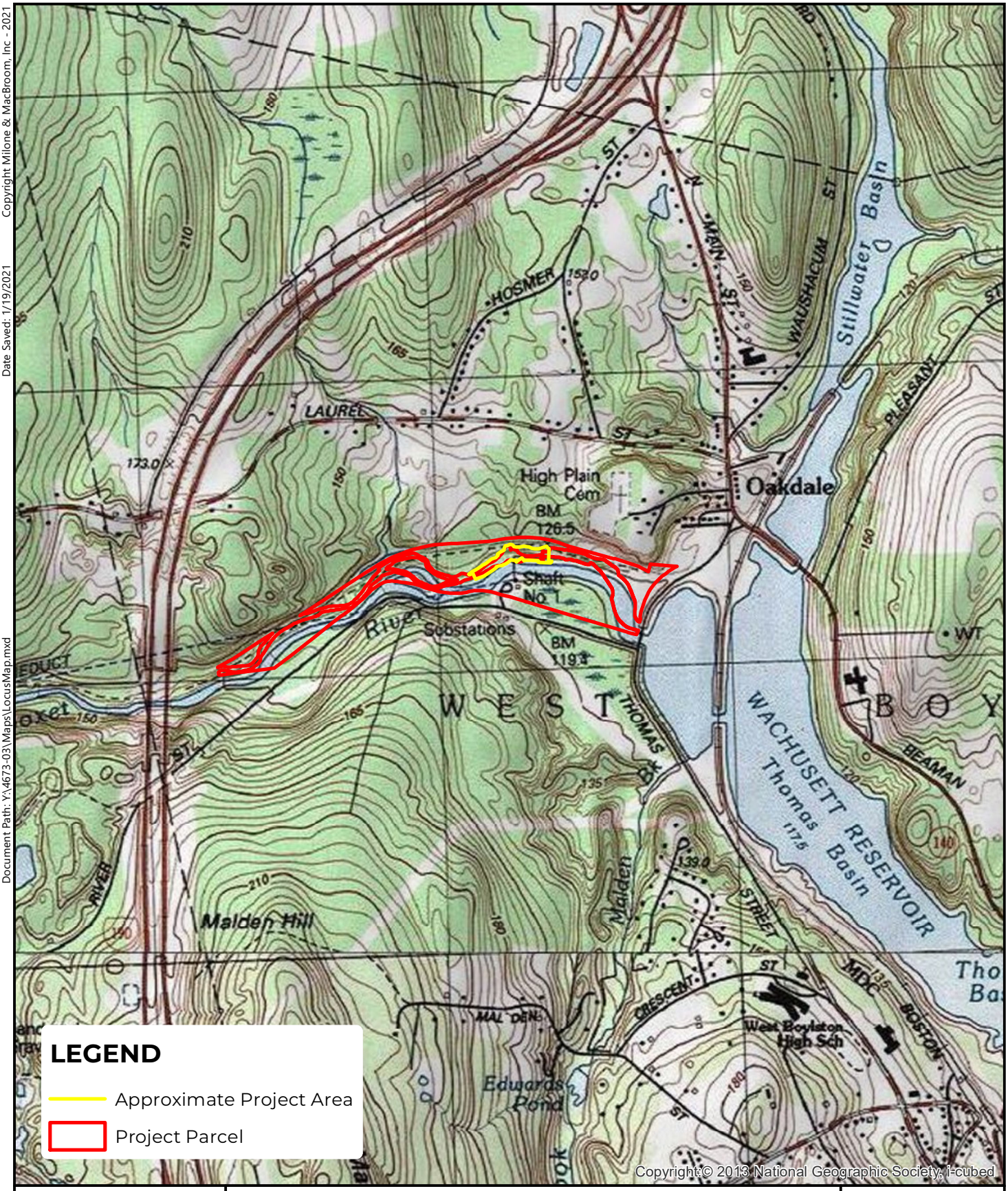

SLR

99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

USGS LOCUS MAP

QUINAPOXET DAM REMOVAL

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

N

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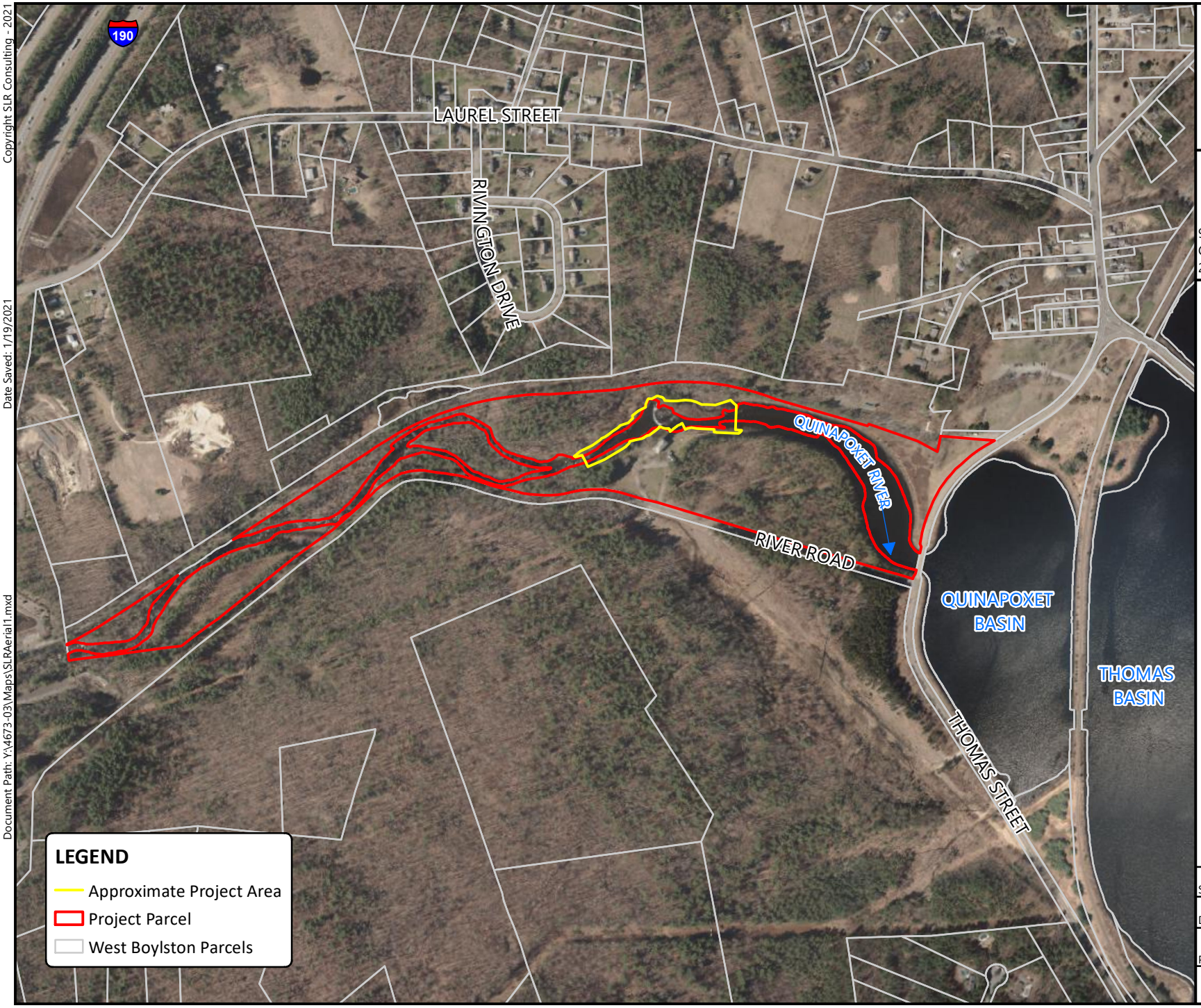
Feet

SCALE	1 " = 2,000 '
DATE	1/19/2021
PROJ. NO.	141.14673.00003

FIG. 2-1



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99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

AERIAL MAP
QUINAPOXET DAM REMOVAL
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

SCALE 1 " = 1,000 '

DATE 1/19/2021

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PROJ. NO.

FIG. 2-2

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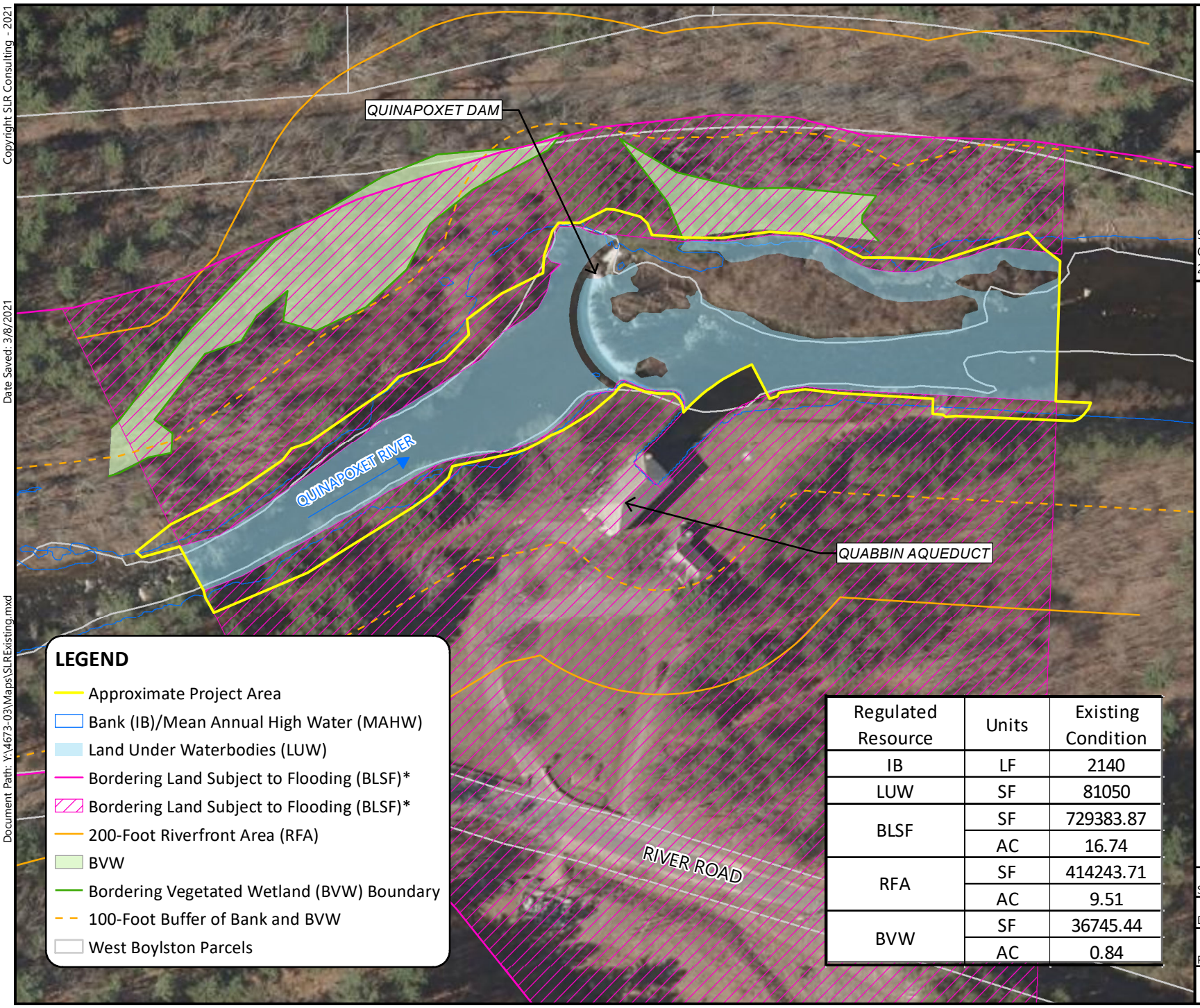

Regulated Resource	Units	Existing Condition
IB	LF	2140
LUW	SF	81050
BLSF	SF	729383.87
	AC	16.74
RFA	SF	414243.71
	AC	9.51
BVW	SF	36745.44
	AC	0.84

N

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Feet

SLR

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CHESHIRE, CT 06410
203.271.1773

LIMITS OF EXISTING WETLAND RESOURCE AREAS

QUINAPOXET DAM REMOVAL

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS
*BLSF BASED ON MAPPED FEMA 100-YEAR FLOOD ELEVATION

SCALE 1 " = 175 '

DATE 3/8/2021

141.14673.00003
PROJ. NO.

FIG. 2-3

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Massachusetts State Plane Mainland Zone (FIPS zone 2001). The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was derived from digital orthophotography. Base map files were provided in digital format by Massachusetts Geographic Information Systems (MassGIS). Ortho imagery was produced at a scale of 1:5,000. Aerial photography is dated April 2005.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

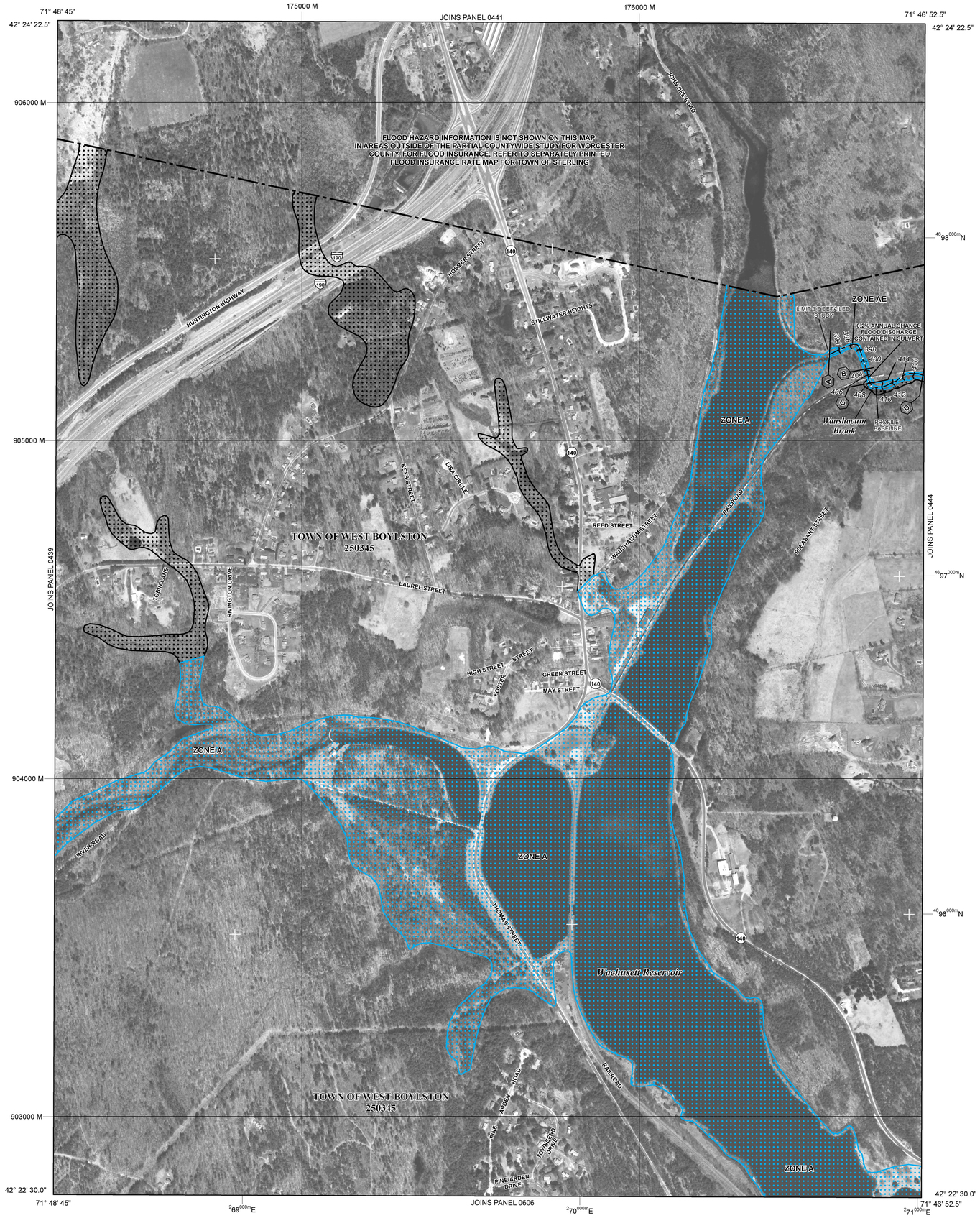
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

FIG. 2-4



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary

0.2% Annual Chance Floodplain Boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.

513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A	Cross section line
23 - - - 23	Transect line
	Culvert
	Bridge
45° 02' 08", 93° 02' 12"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
4989000 M	1000-meter ticks: Massachusetts State Plane Mainland Zone (FIPS Zone 2001), Lambert Conformal Conic projection
49 89 000m N	1000-meter Universal Transverse Mercator grid values, zone 19N
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
July 4, 2011

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0443E

FIRM

FLOOD INSURANCE RATE MAP

WORCESTER COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 443 OF 1075

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
STERLING, TOWN OF	250336	0443	E
WEST BOYLSTON, TOWN OF	250345	0443	E

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

MAP NUMBER
25027C0443E

EFFECTIVE DATE
JULY 4, 2011

Federal Emergency Management Agency

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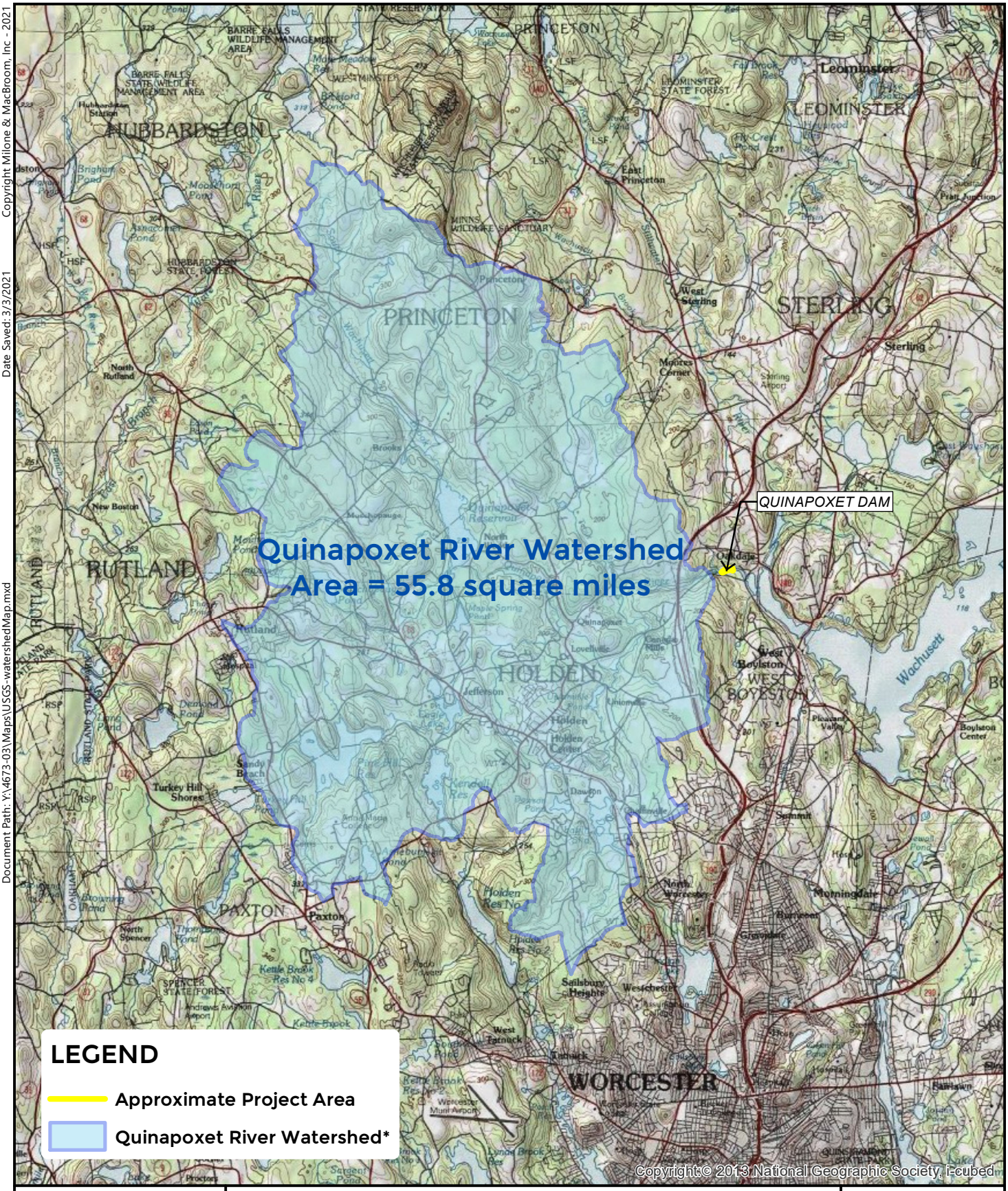
Date Saved: 3/3/2021

Document Path: Y:\4673-03\Maps\USGS-watershedMap.mxd



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WATERSHED MAP -
QUINAPOXET RIVER AT QUINAPOXET DAM
QUINAPOXET DAM REMOVAL
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

*Watershed delineated by the USGS StreamStats program

N

0 6,500 13,000
Feet

SCALE	1 " = 14,325 '
DATE	3/3/2021
PROJ. NO.	141.14673.00003

FIG. 2-5

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Date Saved: 3/8/2021

Document Path: Y:\4673-03\Maps\SLRProposed.mxd

N

0 175
Feet

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LIMITS OF PROPOSED WETLAND RESOURCE AREAS

QUINAPOXET DAM REMOVAL

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS
*BLSF BASED ON MAPPED FEMA 100-YEAR FLOOD ELEVATION

SCALE 1 " = 175 '

DATE 3/8/2021

141.14673.00003
PROJ. NO.

FIG. 2-4

N

0 175
Feet

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WETLAND RESOURCE AREAS DIRECT IMPACTS

QUINAPOXET DAM REMOVAL

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS
*BLSF BASED ON MAPPED FEMA 100-YEAR FLOOD ELEVATION

SCALE 1 " = 175 '

DATE 1/19/2021

141.14673.00003
PROJ. NO.

FIG. 6-2

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Document Path: Y:\4673-03\Maps\SLRDirect.mxd

APPENDIX B

PROJECT PLANS

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

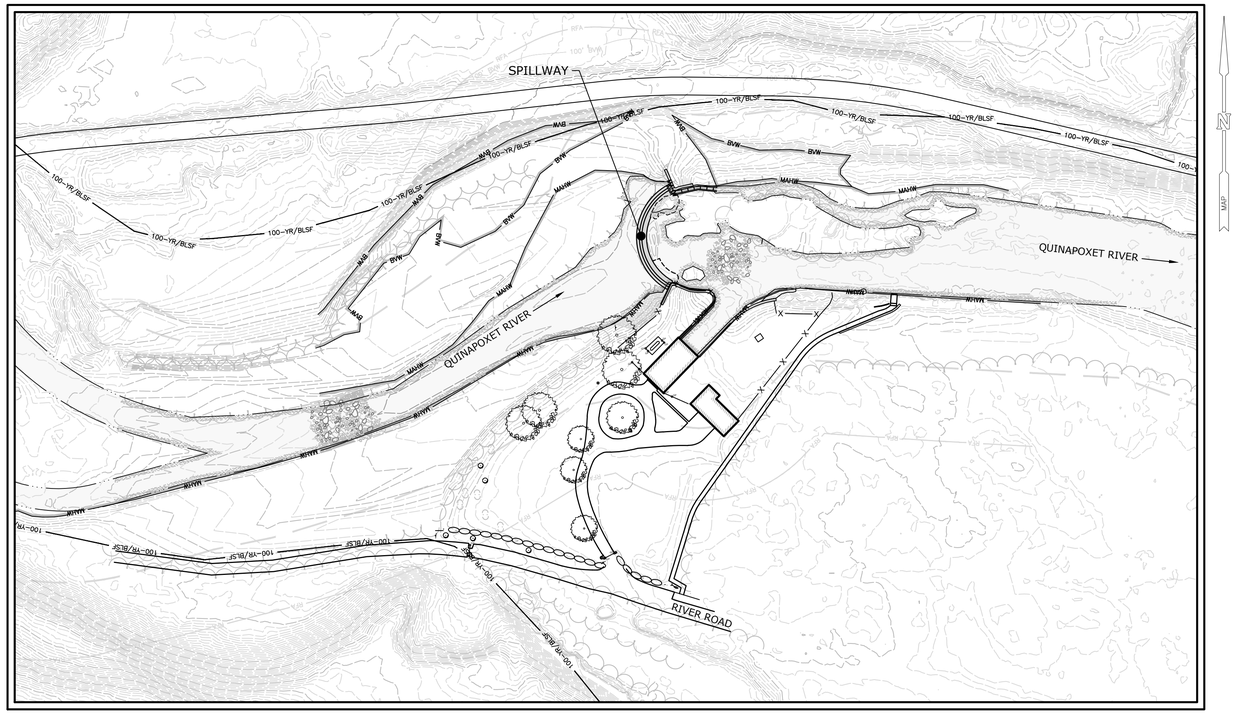
Boston, Massachusetts 02129

May 2021

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

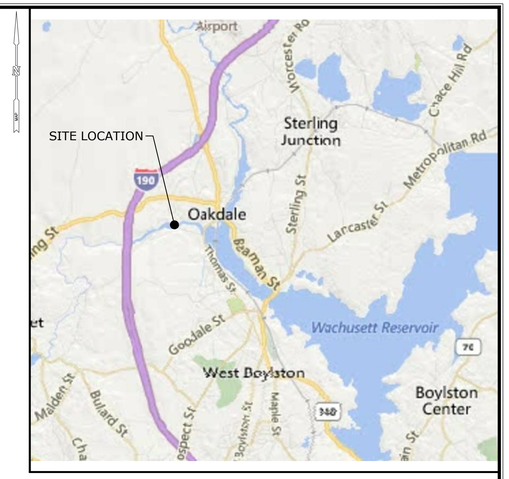
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

60% PRELIMINARY DESIGN DRAWINGS
MAY 26, 2021



PROJECT SITE VICINITY MAP:

0' 50' 100'
0 1/2" 1"
SCALE 1" = 100'



LOCATION MAP:

0' 2500' 5000'
0 1/2" 1"
SCALE 1" = 5000'

PREPARED FOR:

MASSACHUSETTS WATER RESOURCES AUTHORITY
CHARLESTOWN NAVY YARD
100 FIRST AVENUE, BUILDING 39
BOSTON, MA 02129

IN ASSOCIATION WITH:

THE COMMONWEALTH OF MASSACHUSETTS
DIVISION OF ECOLOGICAL RESTORATION
251 CAUSEWAY STREET, SUITE 400
BOSTON, MA 02114

LIST OF DRAWINGS

NO.	NAME	TITLE
01	--	TITLE SHEET
02	IN-1	INDEX PLAN
03	SP-1	SITE PLAN - EXISTING CONDITIONS
04	SP-2	SITE PLAN - EXISTING QUINAPOXET DAM AERIAL
05	SP-3	SITE PLAN - EXISTING QUINAPOXET DAM
06	SP-4	SITE PLAN - REMOVALS
07	SP-5	SITE PLAN - GRADING AND UTILITIES
08	SP-6	SITE PLAN - LAYOUT
09	CP-1	CONSTRUCTION PLAN - WATER CONTROL
10	CP-2	CONSTRUCTION PLAN - WATER CONTROL
11	EL-1	ELEVATION - EXISTING DAM
12	PR-1	PROFILE - QUINAPOXET RIVER
13-20	CS-1 - CS-8	CROSS SECTIONS - QUINAPOXET RIVER
21-24	D-1 - D-4	DETAILS
25	RR-1	REGULATED RESOURCES

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Massachusetts Department of Fish and Game
Division of Ecological Restoration
Invested in Nature and Community

W. Andrew Greene

COMMONWEALTH OF MASSACHUSETTS
W. ANDREW GREENE
NO. 49355
REGISTERED PROFESSIONAL ENGINEER

P.E. MA# 49355

SLR NO.: 44673-03
SUBMITTED: MAY XX, 2020

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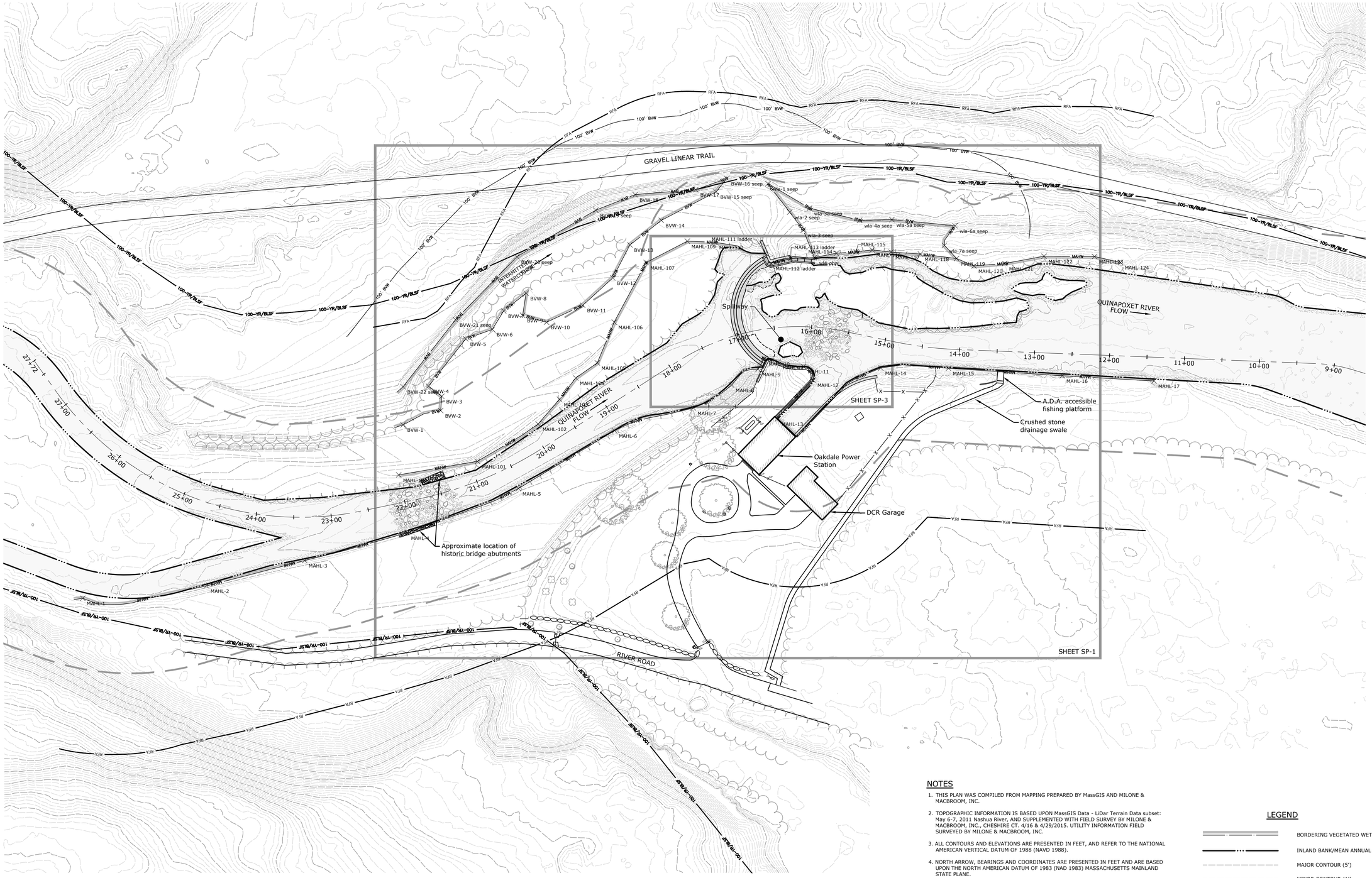

NOTES

1. THIS PLAN WAS COMPILED FROM MAPPING PREPARED BY MassGIS AND MILONE & MACBROOM, INC.
2. TOPOGRAPHIC INFORMATION IS BASED UPON MassGIS Data - LiDar Terrain Data subset: May 6-7, 2011 Nashua River, AND SUPPLEMENTED WITH FIELD SURVEY BY MILONE & MACBROOM, INC., CHESHIRE CT. 4/16 & 4/29/2015. UTILITY INFORMATION FIELD SURVEYED BY MILONE & MACBROOM, INC.
3. ALL CONTOURS AND ELEVATIONS ARE PRESENTED IN FEET, AND REFER TO THE NATIONAL AMERICAN VERTICAL DATUM OF 1988 (NAVD 1988).
4. NORTH ARROW, BEARINGS AND COORDINATES ARE PRESENTED IN FEET AND ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD 1983) MASSACHUSETTS MAINLAND STATE PLANE.
5. INFORMATION REGARDING THE LOCATION OF EXISTING UTILITIES HAS BEEN BASED UPON AVAILABLE INFORMATION AND MAY BE INCOMPLETE, AND WHERE SHOWN SHOULD BE CONSIDERED APPROXIMATE. THE LOCATION OF ALL EXISTING UTILITIES SHOULD BE CONFIRMED PRIOR TO BEGINNING CONSTRUCTION. CALL "DIG SAFE", 1-888-344-7233. ALL UTILITY LOCATIONS THAT DO NOT MATCH THE VERTICAL OR HORIZONTAL CONTROL SHOWN ON THE PLANS SHALL IMMEDIATELY BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR RESOLUTION.
6. SLR INTERNATIONAL CORPORATION ACCEPTS NO RESPONSIBILITY FOR THE ACCURACY OF MAPS AND DATA WHICH HAVE BEEN SUPPLIED BY OTHERS.

LEGEND

- BORDERING VEGETATED WETLAND
- INLAND BANK/MEAN ANNUAL HIGH WATER
- MAJOR CONTOUR (5')
- MINOR CONTOUR (1')
- EDGE OF PAVEMENT
- STONE WALL
- FENCE
- TREELINE

N
W E
S

0' 30' 60'
0 1/2" 1"

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DESCRIPTION	DATE	BY

INDEX PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=60'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 02 OF 25

SHEET NAME: IN-1

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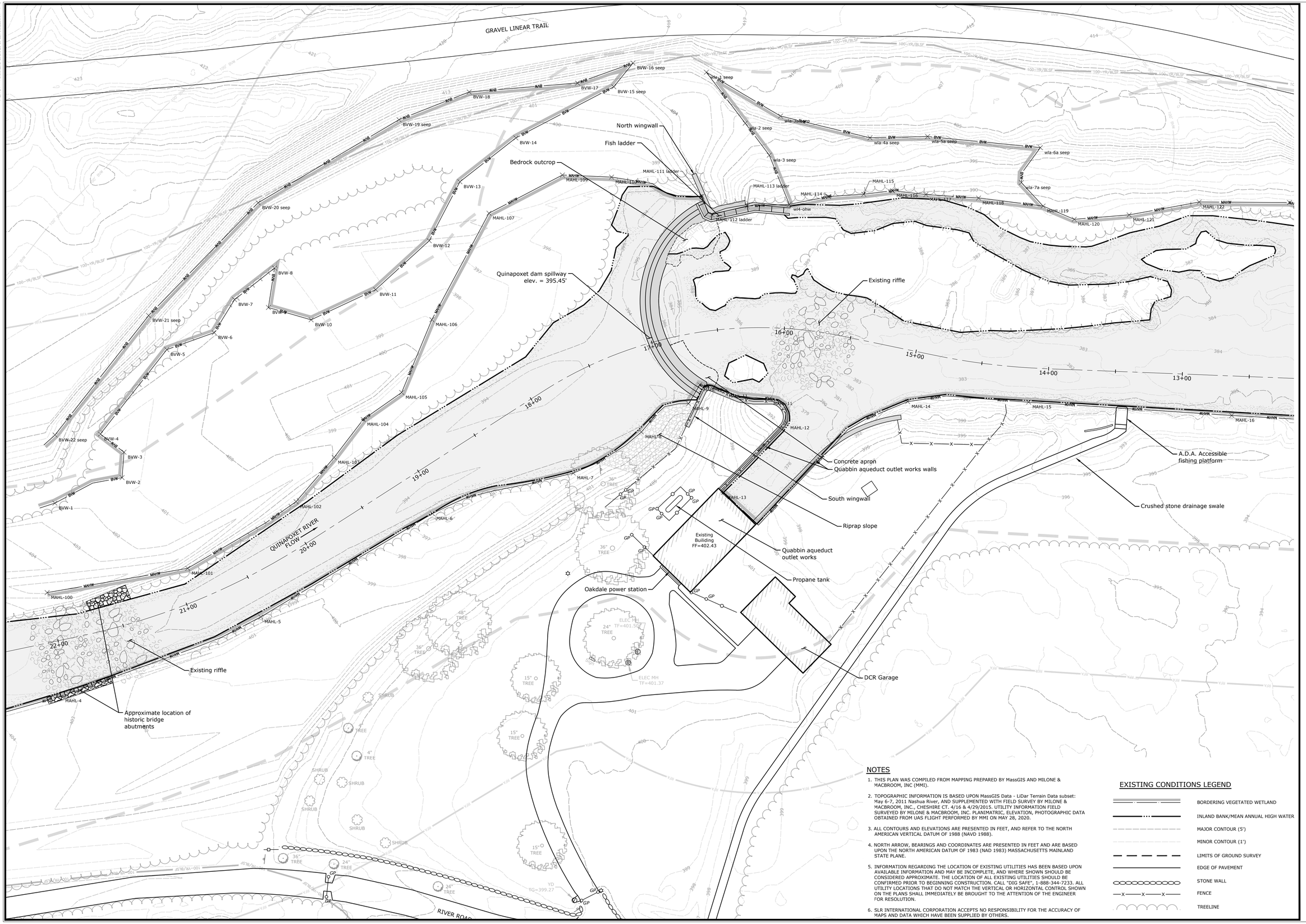

NOTES

1. THIS PLAN WAS COMPILED FROM MAPPING PREPARED BY MassGIS AND MILONE & MACBROOM, INC (MMI).
2. TOPOGRAPHIC INFORMATION IS BASED UPON MassGIS Data - LiDar Terrain Data subset: May 6-7, 2011 Nashua River, AND SUPPLEMENTED WITH FIELD SURVEY BY MILONE & MACBROOM, INC., CHESHIRE CT. 4/16 & 4/29/2015. UTILITY INFORMATION FIELD SURVEYED BY MILONE & MACBROOM, INC. PLAN(MATRIC, ELEVATION, PHOTOGRAPHIC DATA OBTAINED FROM UAS FLIGHT PERFORMED BY MMI ON MAY 28, 2020.
3. ALL CONTOURS AND ELEVATIONS ARE PRESENTED IN FEET, AND REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 1988).
4. NORTH ARROW, BEARINGS AND COORDINATES ARE PRESENTED IN FEET AND ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD 1983) MASSACHUSETTS MAINLAND STATE PLANE.
5. INFORMATION REGARDING THE LOCATION OF EXISTING UTILITIES HAS BEEN BASED UPON AVAILABLE INFORMATION AND MAY BE INCOMPLETE, AND WHERE SHOWN SHOULD BE CONSIDERED APPROXIMATE. THE LOCATION OF ALL EXISTING UTILITIES SHOULD BE CONFIRMED PRIOR TO BEGINNING CONSTRUCTION. CALL "DIG SAFE", 1-888-344-7233. ALL UTILITY LOCATIONS THAT DO NOT MATCH THE VERTICAL OR HORIZONTAL CONTROL SHOWN ON THE PLANS SHALL IMMEDIATELY BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR RESOLUTION.
6. SLR INTERNATIONAL CORPORATION ACCEPTS NO RESPONSIBILITY FOR THE ACCURACY OF MAPS AND DATA WHICH HAVE BEEN SUPPLIED BY OTHERS.

EXISTING CONDITIONS LEGEND

- BORDERING VEGETATED WETLAND
- INLAND BANK/MEAN ANNUAL HIGH WATER
- MAJOR CONTOUR (5')
- MINOR CONTOUR (1')
- LIMITS OF GROUND SURVEY
- EDGE OF PAVEMENT
- STONE WALL
- FENCE
- TREELINE

DESCRIPTION	DATE	BY

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SITE PLAN - EXISTING CONDITIONS

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=30'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 03 OF 25

SHEET NAME: SP-1

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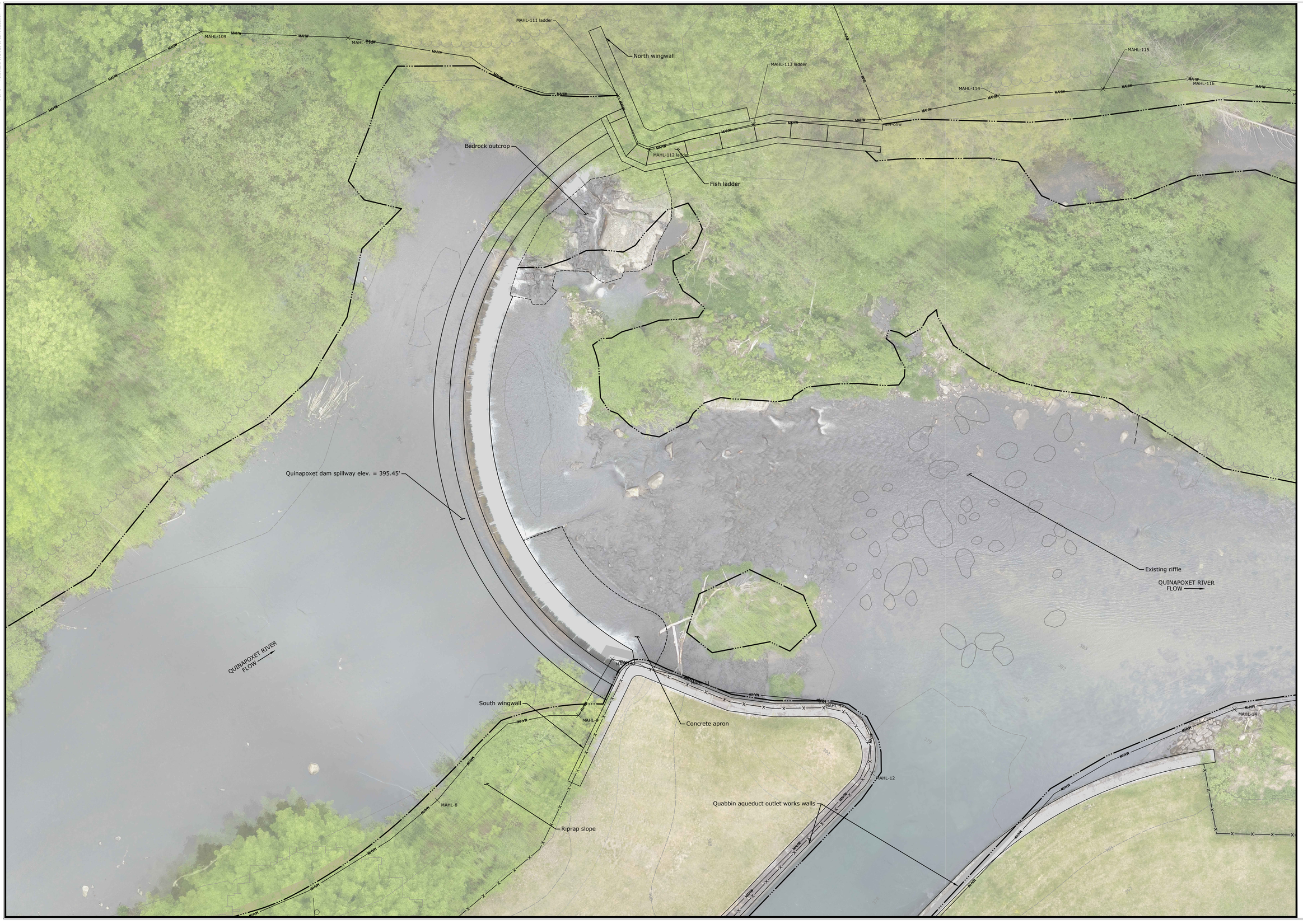

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SITE PLAN - EXISTING QUINAPOXET DAM AERIAL

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=10'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 04 OF 25

SHEET NAME: SP-2

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DESCRIPTION	DATE	BY

SITE PLAN - EXISTING QUINAPOXET DAM

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=10'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 05 OF 25

SHEET NAME: SP-3

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DAM REMOVAL NOTES:

1. SAND AND GRAVEL EXCAVATED FROM UPSTREAM OF THE DAM MAY BE REUSED AS FILL. CONTRACTOR TO RECEIVE APPROVAL OF MATERIAL TO BE REUSED FROM ENGINEER.
2. ONLY NATIVE OR ROUNDED COBBLES SHALL BE ALLOWED FOR THE UPPER LAYER OF RIVER BED ARMORING. NO SHOT OR CRUSHED ANGULAR ROCK WILL BE ALLOWED ON THE RIVERBED SURFACE.
3. THE CONCRETE FISH LADDERS, DAMS, AND WALLS ARE TO BE REMOVED BY MECHANICAL MEANS. NO BLASTING SHALL BE ALLOWED.
4. ALL REINFORCED CONCRETE IS TO BE REMOVED AND DISPOSED OF OFF-SITE AT THE CONTRACTOR'S EXPENSE.
5. STORAGE AREA AND DEWATERING BASINS ARE TO BE REMOVED AND RESTORED TO ORIGINAL CONDITION.
6. REMOVE VERTICAL EXTENT OF CONCRETE FISH LADDER, RETAINING WALLS, STONE WALLS, AND HEAD WALLS AS DEPICTED ON THE PLANS AND SECTIONS.
7. THE CONTRACTOR SHALL MAINTAIN STREAM FLOW AT ALL TIMES WITH USE OF TEMPORARY CHANNELS, PIPES, AND/OR COFFERDAMS, AS NECESSARY.

DEMOLITION AND REMOVALS NOTES:

1. ALL DIMENSIONS AND ELEVATIONS SHALL BE VERIFIED IN THE FIELD PRIOR TO CONSTRUCTION. ANY DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE PROJECT ENGINEER FOR DETERMINATION. THE CONTRACTOR IS EXPECTED TO PROVIDE FIELD ENGINEERING SERVICES DURING CONSTRUCTION TO ESTABLISH AND RECORD GRADES, LINES, AND ELEVATIONS. EXACT ELEVATIONS, SLOPES, AND CHANNEL SHAPES WILL BE APPROVED IN FIELD BY PROJECT ENGINEER.
2. THE CONTRACTOR SHALL DESIGNATE A SUPERINTENDENT AT THE START OF CONSTRUCTION AND THE CONTRACTOR'S SUPERINTENDENT SHALL BE ON-SITE AT ALL TIMES DURING CONSTRUCTION. THE CONTRACTOR AND HIS/HER JOB SUPERINTENDENT SHALL BE RESPONSIBLE FOR COMPLYING WITH THE JOB SPECIFICATIONS AND PERMIT REQUIREMENTS.
3. ALL STORAGE AND ACCESS ROUTES, PEDESTRIAN FENCES/BARRIERS, WORKING HOURS, AND LIMITS OF CLEARING SHALL BE APPROVED BY THE MWRA AND DER AND THE PROJECT ENGINEER.
4. ALL MATERIAL EXCAVATED FROM PROPOSED CHANNEL AREA NOT TO BE REUSED ON SITE TO BE IMMEDIATELY HAULED OFF-SITE AND DISPOSED.
5. RETAIN ALL EXCAVATED ROUNDED ROCK GREATER THAN 8" FOR USE IN STREAM CHANNEL AND ALONG TOE OF BANK, TO BE APPROVED BY ENGINEER.
6. ALL CONCRETE AND REINFORCING STEEL IS TO BE REMOVED BY MECHANICAL MEANS AND DISPOSED/RECYCLED OF OFF SITE.
7. CONTRACTOR MUST COMPLY WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL PERMITS THROUGHOUT DURATION OF PROJECT.
8. NO BEDROCK IS TO BE REMOVED.

LEGEND

- CLEARING LIMIT
- REMOVAL OF EXISTING STRUCTURE
- REMOVAL OF VEGETATION

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SITE PLAN - REMOVALS PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=20'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 06 OF 25

SHEET NAME: SP-4

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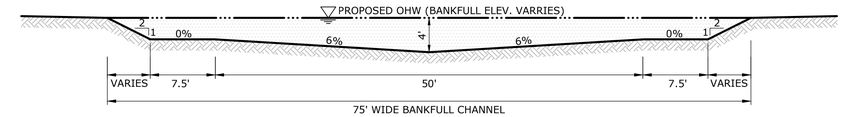
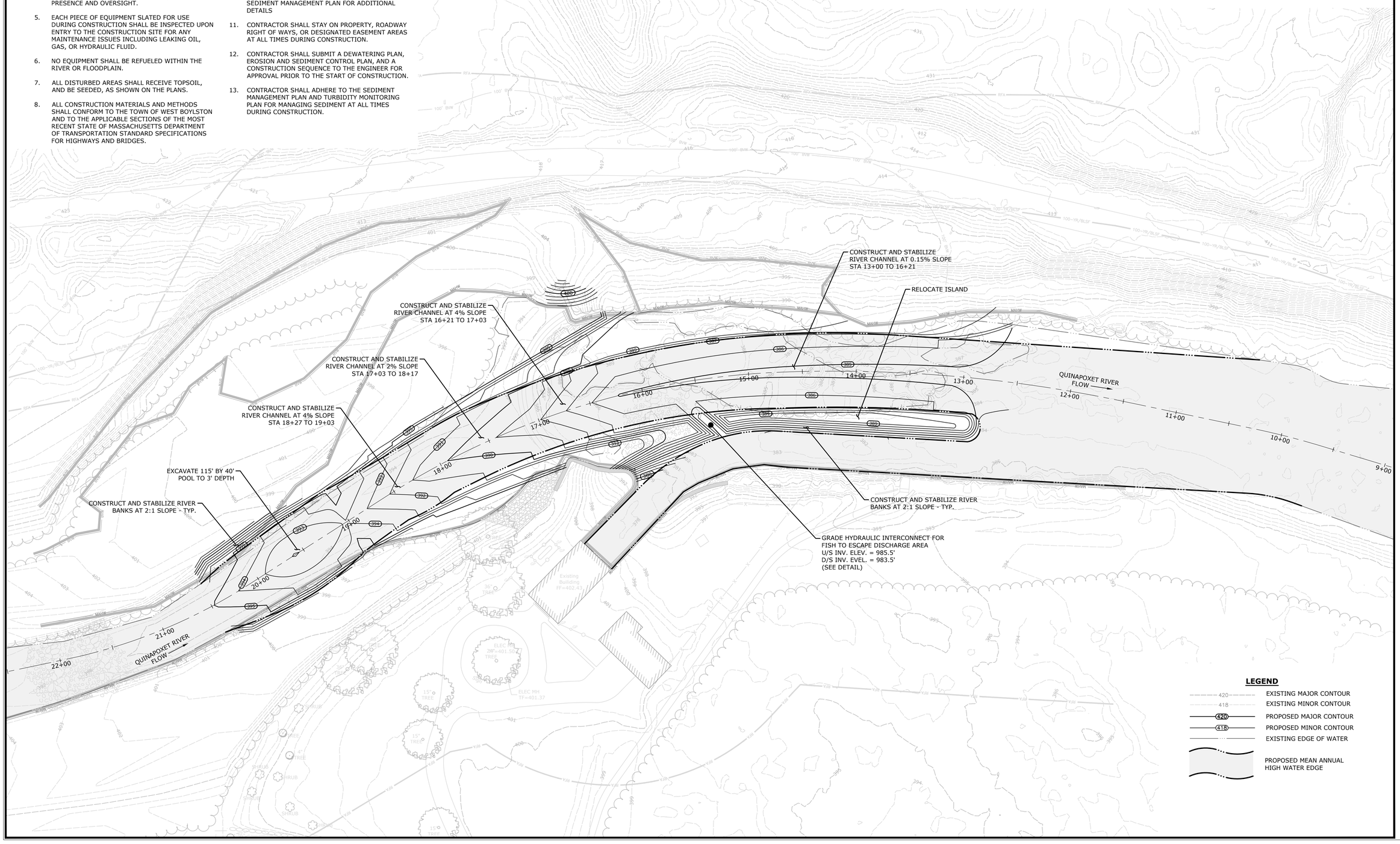
GRADING NOTES:

1. PROPOSED CONTOURS AS PRESENTED ON THIS PLAN INDICATE FINAL GRADE AFTER TOPSOIL, ROCKS, AND OTHER PROPOSED STRUCTURES AND FINISH TREATMENTS ARE COMPLETED.
2. MATERIAL GENERATED DURING CONSTRUCTION THAT IS TO BE REMOVED FROM THE SITE MUST BE HAULED TO AN APPROVED LOCATION.
3. ABIDE BY ALL TIME-OF-YEAR RESTRICTIONS SET FORTH BY THE REGULATORY APPROVALS.
4. CONTRACTOR IS REQUIRED TO COORDINATE THE PLACEMENT OF ROCKS AND HABITAT FEATURES WITH THE OWNER AND/OR ENGINEER, FOR STAFF PRESENCE AND OVERSIGHT.
5. EACH PIECE OF EQUIPMENT SLATED FOR USE DURING CONSTRUCTION SHALL BE INSPECTED UPON ENTRY TO THE CONSTRUCTION SITE FOR ANY MAINTENANCE ISSUES INCLUDING LEAKING OIL, GAS, OR HYDRAULIC FLUID.
6. NO EQUIPMENT SHALL BE REFUELED WITHIN THE RIVER OR FLOODPLAIN.
7. ALL DISTURBED AREAS SHALL RECEIVE TOPSOIL, AND BE SEEDED, AS SHOWN ON THE PLANS.
8. ALL CONSTRUCTION MATERIALS AND METHODS SHALL CONFORM TO THE TOWN OF WEST BOYLSTON AND TO THE APPLICABLE SECTIONS OF THE MOST RECENT STATE OF MASSACHUSETTS DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES.
9. ALL FUEL, OIL, CONSTRUCTION EQUIPMENT, OR OTHER HAZARDOUS MATERIALS SHOULD BE STORED ABOVE THE FEMA DESIGNATED 100-YEAR FLOODPLAIN ELEVATION DURING NON-WORK HOURS.
10. PROJECT SITE IS SUBJECT TO FLOODING. CONTRACTOR SHALL MONITOR WEATHER REPORTS, AND BE PREPARED TO STOP WORK AND STABILIZE SITE IF MORE THAN ONE INCH (1") OF RAINFALL IS PREDICTED BY THE NATIONAL WEATHER SERVICE (70% CHANCE OR HIGHER). WORK SHALL BE HALTED UNTIL PRECIPITATION STOPS, AND CHANCES OF FURTHER RAINFALL FALL BELOW 50%. REFER TO SEDIMENT MANAGEMENT PLAN FOR ADDITIONAL DETAILS
11. CONTRACTOR SHALL STAY ON PROPERTY, ROADWAY RIGHT OF WAYS, OR DESIGNATED EASEMENT AREAS AT ALL TIMES DURING CONSTRUCTION.
12. CONTRACTOR SHALL SUBMIT A DEWATERING PLAN, EROSION AND SEDIMENT CONTROL PLAN, AND A CONSTRUCTION SEQUENCE TO THE ENGINEER FOR APPROVAL PRIOR TO THE START OF CONSTRUCTION.
13. CONTRACTOR SHALL ADHERE TO THE SEDIMENT MANAGEMENT PLAN AND TURBIDITY MONITORING PLAN FOR MANAGING SEDIMENT AT ALL TIMES DURING CONSTRUCTION.



TYPICAL SECTION

NOT TO SCALE



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DESCRIPTION	DATE	BY

SITE PLAN - GRADING AND UTILITIES PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

AWG	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 07 OF 25

SHEET NAME: SP-5

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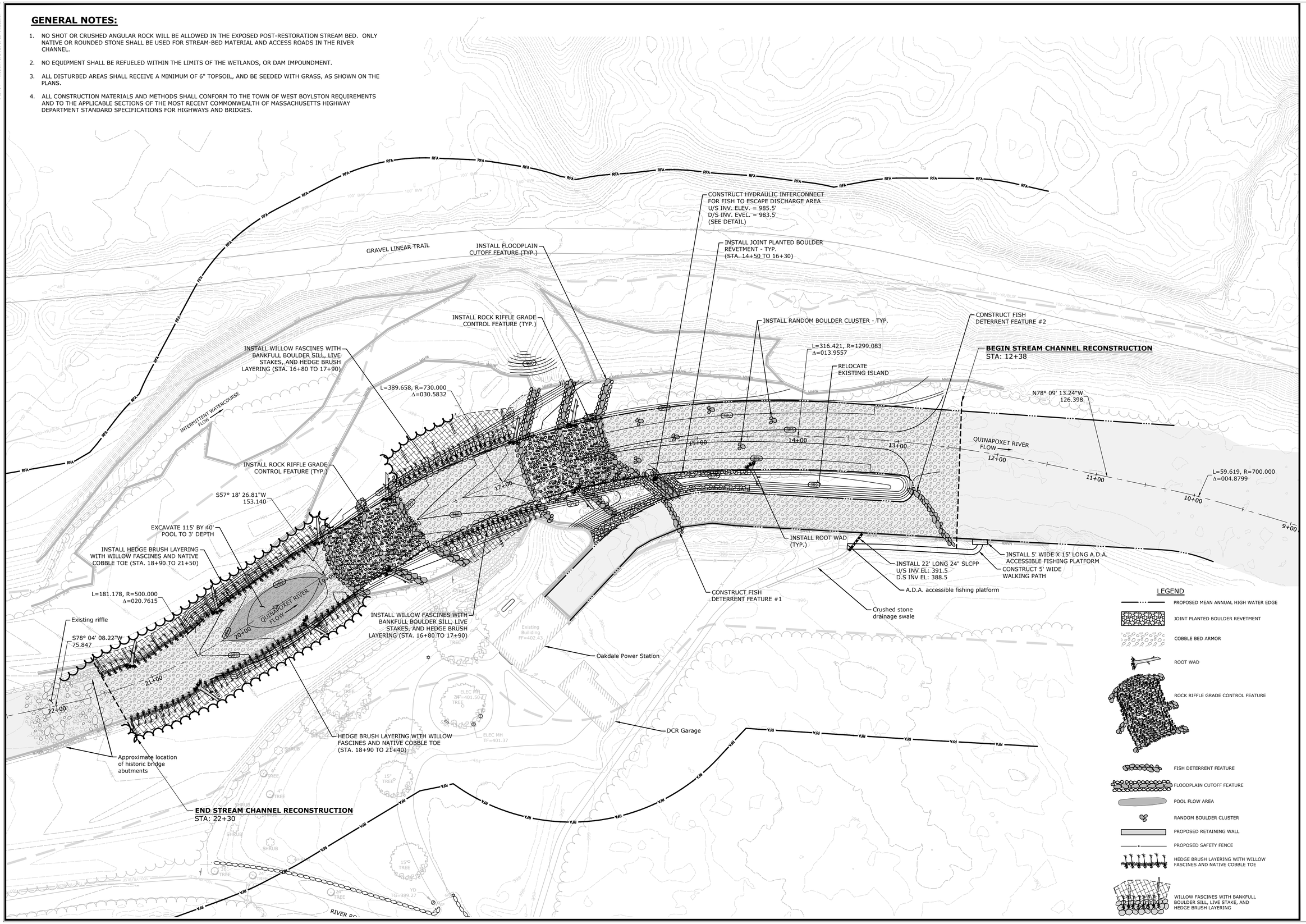
GENERAL NOTES:

1. NO SHOT OR CRUSHED ANGULAR ROCK WILL BE ALLOWED IN THE EXPOSED POST-RESTORATION STREAM BED. ONLY NATIVE OR ROUNDED STONE SHALL BE USED FOR STREAM-BED MATERIAL AND ACCESS ROADS IN THE RIVER CHANNEL.
2. NO EQUIPMENT SHALL BE REFUELED WITHIN THE LIMITS OF THE WETLANDS, OR DAM IMPOUNDMENT.
3. ALL DISTURBED AREAS SHALL RECEIVE A MINIMUM OF 6" TOPSOIL, AND BE SEEDED WITH GRASS, AS SHOWN ON THE PLANS.
4. ALL CONSTRUCTION MATERIALS AND METHODS SHALL CONFORM TO THE TOWN OF WEST BOYLSTON REQUIREMENTS AND TO THE APPLICABLE SECTIONS OF THE MOST RECENT COMMONWEALTH OF MASSACHUSETTS HIGHWAY DEPARTMENT STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES.



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DESCRIPTION	DATE	BY

SITE PLAN - LAYOUT PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	DRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 08 OF 25

SHEET NAME: SP-6

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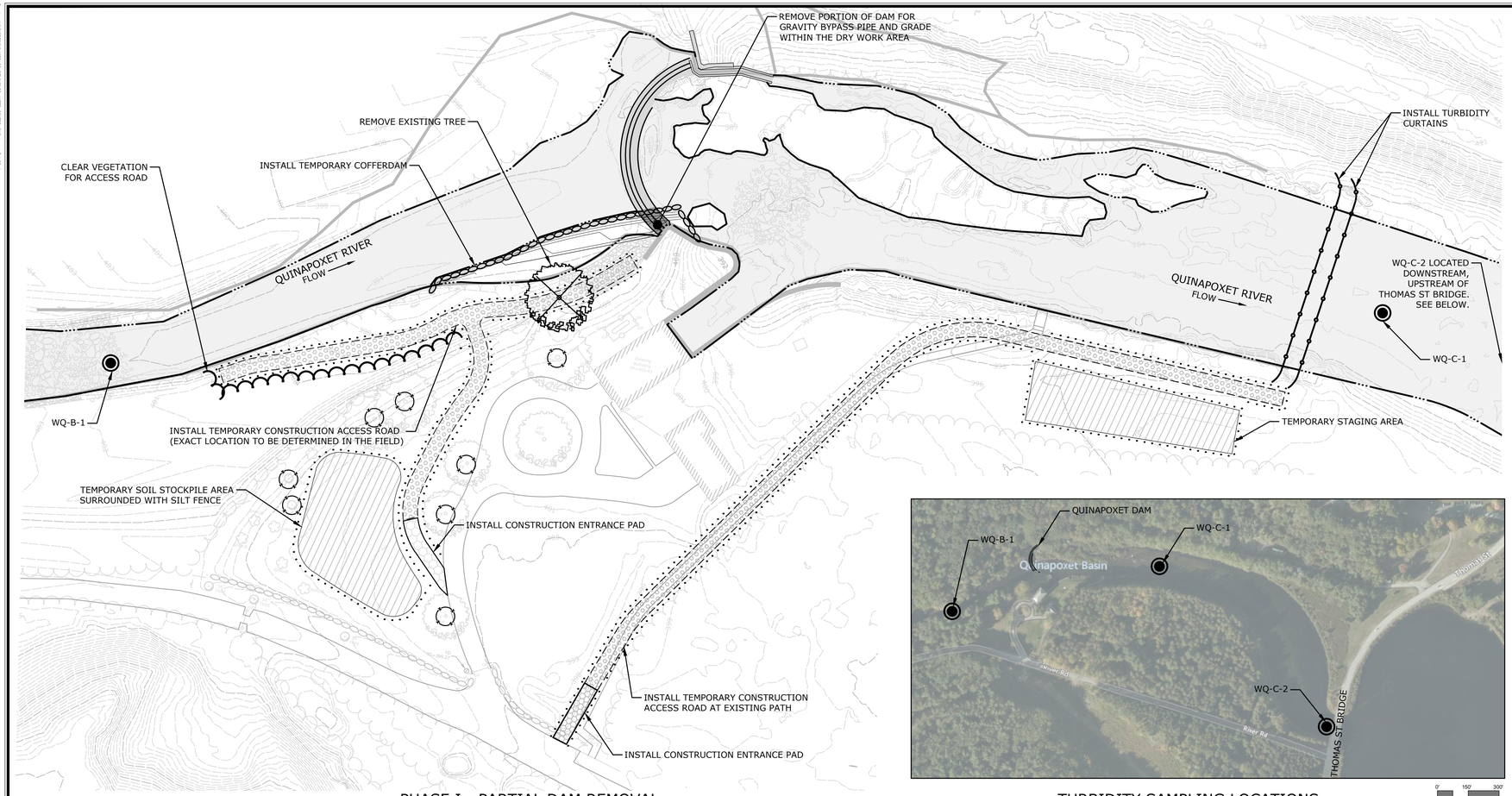

PHASE I - PARTIAL DAM REMOVAL

TURBIDITY SAMPLING LOCATIONS

0' 150' 300'
0 1/2" 1"
SCALE 1" = 300'

Flood Flows				
Recurrence Interval	**Bankfull**	**5-Year**	**10-Year**	**100-Year**
Discharge (CFS)	830	1,500	1,800	3,000

Statistical Flows by Month (CFS)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20th Percentile	28	36	67	82	48	24	9	6	4	7	12	18
Mean Monthly Discharge	84	89	161	189	99	76	30	20	20	37	57	95
80th Percentile	125	127	224	257	134	108	42	26	22	53	88	158

Statistical Flows by Month (GPM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20th Percentile	12,400	16,000	29,900	36,800	21,600	10,600	4,100	2,500	1,800	2,900	5,500	7,900
Mean Monthly Discharge	37,800	39,900	72,400	85,000	44,600	34,100	13,600	8,900	8,900	16,800	25,700	42,500
80th Percentile	56,100	57,100	100,600	115,300	60,200	48,300	18,700	11,800	9,900	23,900	39,400	70,800

LEGEND

- LIMITS OF CLEARING
- PERIMETER CONTROL (SILT FENCE AND STRAW BALES)
- STABILIZED CONSTRUCTION ENTRANCE ANTI-TRACKING PAD
- TEMPORARY CONSTRUCTION ACCESS ROAD
- CONSTRUCTION STAGING AND STOCKPILE AREA
- TREE PROTECTION
- TURBID WATER SUMP
- WATER PUMP
- TURBIDITY SETTLING BASIN
- TEMPORARY COFFERDAM
- GRAVITY DEWATERING PIPE
- WATER FLOW DIRECTION
- STAGING AREA FOR BYPASS PUMP AND POWER PACK
- TEMPORARY CLEAN WATER SPLASH PAD
- TURBIDITY CURTAIN
- TURBIDITY MONITORING POINTS
- TEMPORARY STREAM CROSSING

GENERAL CONSTRUCTION SEQUENCE:

1. PRIOR TO COMMENCEMENT OF WORK A PRE-CONSTRUCTION MEETING SHALL BE HELD WITH REPRESENTATIVES OF THE TOWN OF WEST BOYLSTON, MASSACHUSETTS AND CONTRACTOR. AT THIS MEETING, THE CONTRACTOR SHALL DESIGNATE ONE EMPLOYEE TO BE IN CHARGE OF SEDIMENT AND EROSION CONTROL FOR THE ENTIRE SITE.
2. THE PROPOSED CONSTRUCTION SEQUENCE IS PROVIDED AS A RECOMMENDED APPROACH. THE CONTRACTOR IS RESPONSIBLE FOR SUBMITTING A PROPOSED CONSTRUCTION SEQUENCE TO THE PROJECT ENGINEER FOR APPROVAL PRIOR TO THE START OF CONSTRUCTION.
3. CONTRACTOR TO STAKE OUT LIMITS OF DISTURBANCE AND VEGETATION TO BE RETAINED. NO DISTURBANCE IS TO TAKE PLACE BEYOND THE LIMITS OF WORK SHOWN.
4. PERFORM NECESSARY SITE CLEARING AND ESTABLISH CONSTRUCTION ENTRANCE/TEMPORARY SITE ACCESS ROAD WITH THE ASSOCIATED SEDIMENT AND EROSION CONTROLS.
5. SEE WATER CONTROL SEQUENCES FOR PHASE SPECIFIC CONSTRUCTION WORK.
6. EACH PIECE OF EQUIPMENT SLATED FOR USE DURING CONSTRUCTION SHALL BE ASSESSED BY THE CONSTRUCTION INSPECTOR DAILY FOR ANY MAINTENANCE ISSUES INCLUDING LEAKING OIL, GAS, OR HYDRAULIC FLUID.
7. REFER TO THE PROJECT SPECIFIC SEDIMENT MANAGEMENT PLAN FOR ADDITIONAL INFORMATION ON CONSTRUCTION SEQUENCING AND WATER CONTROL.

CONSTRUCTION ACCESS NOTES:

1. CONSTRUCTION ACCESS ROUTES SHOWN ARE SCHEMATIC IN NATURE - FINAL ROUTES TO BE NEGOTIATED WITH MWRA PRIOR TO START OF CONSTRUCTION.
2. CONSTRUCTION ACCESS ROAD SHALL BE CONSTRUCTED ABOVE GRADE. CONSTRUCTION ACCESS ROADS TO BE RESTORED TO PRE-CONSTRUCTION (OR BETTER) CONDITIONS UPON PROJECT COMPLETION.
3. ALL LAWN, GARDEN, SHRUBS, TREES, FENCING, WALKWAYS, PAVEMENT, AND OTHER SITE FEATURES SHALL BE RESTORED OR REPAIRED AT PROJECT COMPLETION AT THE APPROVAL OF THE MWRA.
4. UNDERGROUND UTILITIES SHALL BE LOCATED AND AVOIDED WHEN PLANNING THE CONSTRUCTION ACCESS ROUTES. ANY DISRUPTION OR DAMAGE TO EXISTING UTILITIES, SHALL BE REPAIRED BY THE CONTRACTOR.
5. CONTRACTOR SHALL STAY ON MWRA OWNED PROPERTY, ROADWAY RIGHT OF WAYS, OR DESIGNATED EASEMENT AREAS AT ALL TIMES DURING CONSTRUCTION.

WATER CONTROL NOTES:

1. THE WATER CONTROL PLAN PRESENTED HEREIN IS PROVIDED AS A RECOMMENDED APPROACH. THE CONTRACTOR IS RESPONSIBLE FOR WATER CONTROL DURING THE PROJECT, AND FOR SUBMITTING A PROPOSED WATER CONTROL PLAN TO THE PROJECT ENGINEER FOR APPROVAL PRIOR TO THE START OF CONSTRUCTION.
2. PROJECT SITE IS SUBJECT TO FLOODING. CONTRACTOR SHALL MONITOR WEATHER REPORTS, AND BE PREPARED TO STOP WORK AND STABILIZE SITE IF MORE THAN ONE INCH (1") OF RAINFALL IS PREDICTED WITHIN ANY 24-HOUR PERIOD BY THE NATIONAL WEATHER SERVICE (SEE FLOOD CONTINGENCY NOTES BELOW.)
3. GRAVITY BYPASS IS THE PREFERRED METHOD OF WATER BYPASS FOR LOW-FLOWS. GRAVITY BYPASS PIPE SHALL BE SIZED TO HANDLE DOUBLE THE 80TH PERCENTILE FLOW DURING THE CONSTRUCTION SEASON. THE HIGHEST POTENTIAL 80TH PERCENTILE FLOW DOUBLED IS APPROXIMATELY 520 CFS (SEE FLOW TABLE BELOW), WHICH CAN BE CONVEYED USING A TWO 5 FT INNER DIAMETER PIPES SLOPED AT A MINIMUM OF 1%.
4. THERE SHALL BE NO EXTRA COMPENSATION DUE TO DELAYS OR DAMAGE ASSOCIATED WITH HIGH WATER LEVELS FROM NATURAL EVENTS SUCH AS HEAVY RAINFALL, FLOODS, SNOW MELT, ETC.
5. THE DISCHARGE FROM THE DEWATERING PIPE AND ANY INCIDENTAL PUMPING SHALL BE CLEAR OF TURBIDITY OR DEBRIS. ANY TURBIDITY SHALL BE ADDRESSED THROUGH THE USE OF A SETTLING BASIN OR FRAC TANK, AS REQUIRED.
6. PROJECT SITE IS PART OF MWRA DRINKING WATER SUPPLY SYSTEM. SEDIMENTS IMPOUNDED BEHIND THE DAM MUST BE KEPT FROM WASHING DOWNSTREAM AT ALL TIMES DURING AND AFTER CONSTRUCTION. PROCEDURES TO CONTROL SEDIMENT EROSION SHALL BE PART OF THE WATER HANDLING PLAN SUBMITTED BY THE CONTRACTOR PRIOR TO CONSTRUCTION. REFER TO THE SEDIMENT MANAGEMENT PLAN FOR MORE INFORMATION.
7. ALL DISCHARGES FROM TEMPORARY BYPASS PIPES SHALL END IN A PLUNGE POOL DESIGNED TO PROVIDE A SOFT LANDING FOR OUT-MIGRATING FISH.

WATER CONTROL SEQUENCE:

PHASE 1:

1. INSTALL TEMPORARY WATER CONTROL COFFERDAM AND DIVERT WATER.
2. ONCE THE PORTION OF THE CHANNEL IS FULLY DEWATERED, PERFORM DAM REMOVAL TO THE LIMITS SHOWN IN THE PHASE 1 PLANS AND IMPOUNDMENT EXCAVATION IN THE DRY AS SHOWN IN THE PLANS.

PHASE 2 AND PHASE 3: (SEE SHEET CP-2)

FLOOD CONTINGENCY PLAN:

1. THE PROJECT SITE IS LOCATED WITHIN THE 1% ANNUAL CHANCE FLOODPLAIN ZONE, AND IS SUBJECT TO FLOODING.
2. CONTRACTOR SHALL MONITOR WEATHER REPORTS, AND BE PREPARED TO STOP WORK AND STABILIZE SITE IF MORE THAN ONE INCH (1") OF RAINFALL IS PREDICTED WITHIN ANY 24-HOUR PERIOD BY THE NATIONAL WEATHER SERVICE (50% CHANCE OR HIGHER). WORK SHALL BE HALTED UNTIL PRECIPITATION STOPS AND CHANCES OF FURTHER RAINFALL FALL BELOW 50%. WORK SHOULD BE PERFORMED DURING LOW WATER AS POSSIBLE. EQUIPMENT AND MATERIALS MUST BE AVAILABLE TO ALLOW A RAPID RESPONSE TO STABILIZE OPEN CONSTRUCTION AREAS, EVACUATE WORKERS, EQUIPMENT, AND ANY STOCKPILED MATERIALS FROM POTENTIALLY IMPACTED AREAS, IF NEEDED.
3. NO EQUIPMENT OR MATERIAL SHALL BE MOVED BACK TO THE SITE UNTIL THE QUINAPOXET RIVER WATER LEVELS RECEDE, AND ARE CONTAINED WITHIN ITS BANKS.
4. CONTRACTOR TO PREPARE AND SUBMIT FORMAL FLOOD CONTINGENCY PLAN PRIOR TO THE START OF CONSTRUCTION.

EROSION CONTROL NOTES:

1. REFER TO THE ASSOCIATED SEDIMENT MANAGEMENT PLAN FOR ADDITIONAL DETAILS AND INSTRUCTIONS OF EROSION AND SEDIMENT CONTROL MEASURES TO BE IMPLEMENTED. SEDIMENT MANAGEMENT PLAN CONTAINS INSPECTION AND MAINTENANCE INSTRUCTIONS FOR ALL E&S MEASURES SHOWNN.
2. ACCESS ROADS TO BE GRADED AND WIDENED AS NEEDED BY CONTRACTOR WITH APPROVAL OF ENGINEER.
3. ACCESS ROAD AND STOCKPILE AREAS SHALL BE BORDERED WITH SEDIMENT AND EROSION CONTROL FENCES AND HAY BALES.
4. TEMPORARY COFFERDAMS TO BE CONSTRUCTED OF CONCRETE BLOCKS, SANDBAGS, SILT SACS OR APPROVED EQUAL, AS GIVEN IN THE TECHNICAL SPECIFICATIONS.
5. ALL DEWATERING PUMPS SHALL DISCHARGE TO A TEMPORARY DEWATERING SEDIMENT BASIN.
6. THE CONTRACTOR SHALL MAINTAIN ALL STREETS, SIDEWALKS, AND WALKWAYS IN THE AREA FREE OF SOIL, MUD AND CONSTRUCTION DEBRIS. CONSTRUCTION ENTRANCES MUST BE MAINTAINED AT EACH RIVER ACCESS POINT.
7. ALL VEGETATIVE AND STRUCTURAL EROSION AND SEDIMENT CONTROL PRACTICES SHALL BE CONSTRUCTED ACCORDING TO THE STANDARDS AND SPECIFICATIONS IN THE MASSACHUSETTS EROSION AND SEDIMENT CONTROL GUIDELINES.
8. A COPY OF THE APPROVED EROSION AND SEDIMENT CONTROL PLAN SHALL BE MAINTAINED ON THE SITE AT ALL TIMES.
9. AN EROSION CONTROL BLANKET SHALL BE PLACED OVER ANY DISTURBED SLOPES STEEPER THAN 3:1 (H:V) TO PREVENT EROSION DURING RAINFALL RUNOFF EVENTS.
10. THE CONTRACTOR IS RESPONSIBLE FOR THE MAINTENANCE OF ALL SOIL EROSION AND SEDIMENT CONTROL MEASURES. THE CONSTRUCTION INSPECTOR WILL VERIFY THE MAINTENANCE WEEKLY AND AFTER RAIN EVENTS.
11. TEMPORARY STOCKPILE AND STAGING AREAS TO BE FLAGGED BY CONTRACTOR PRIOR TO CONSTRUCTION AND APPROVED BY TOWN, MWRA, AND PROJECT ENGINEER.
12. NO CONSTRUCTION VEHICLES SHALL BE STORED, SERVICED, WASHED OR FLUSHED IN A LOCATION WHERE LEAKS, SPILLAGE, WASTE MATERIALS, CLEANERS, OR WATERS WILL BE INTRODUCED OR FLOW INTO WETLANDS OR WATERCOURSES. AN EMERGENCY MANAGEMENT PLAN AND SPILL KIT WILL BE MAINTAINED ON SITE AT ALL TIMES. IN THE EVENT OF AN ACCIDENTAL RELEASE, IMMEDIATELY STOP CONSTRUCTION WORK, CONTAIN THE SPILL, AND NOTIFY THE TOWN, APPROPRIATE AUTHORITIES AND PROJECT ENGINEER.
13. ALL STORAGE AND ACCESS ROUTES, PEDESTRIAN FENCES/BARRIERS, WORKING HOURS, AND LIMITS OF CLEARING SHALL BE APPROVED BY THE TOWN OF WEST BOYLSTON, LANDOWNERS AND THE PROJECT ENGINEER.

13. ALL WETLANDS SHALL BE AVOIDED AND PROTECTED FROM CONSTRUCTION ACTIVITIES WITH SEDIMENT CONTROL MEASURES WHERE NECESSARY AS DETERMINED BY THE PROJECT ENGINEER.

14. CLEARING OF NATIVE VEGETATION FOR CONSTRUCTION ACCESS SHOULD BE MINIMIZED.

TURBIDITY MONITORING PLAN:

1. PROJECT SITE IS LOCATED WITHIN A SENSITIVE BODY OF WATER THAT SUPPLIES DRINKING WATER TO THE CITY OF BOSTON. CONTRACTOR TO IMPLEMENT THE PROJECT SPECIFIC TURBIDITY MONITORING PLAN (TMP) OUTLINED IN THE SEDIMENT MANAGEMENT PLAN.
2. TURBIDITY REPORTED IN NEPHLOMETRIC TURBIDITY UNITS (NTU) SHALL BE MEASURED AT THE DESIGNATED LOCATIONS. MONITORING LOCATIONS SHALL BE FIELD LOCATED AND APPROVED BY MWRA AND THE ENGINEER PRIOR TO INSTALLING MONITORING EQUIPMENT.
3. CONTINUOUS TURBIDITY MONITORING SHALL BE RECORDED AT A MINIMUM OF 15 MINUTE INTERVALS WITH APPROVED EQUIPMENT. CONTRACTOR SHALL PROVIDE ACCESS TO LIVE DATA VIA A WEB DATABASE.
4. AT LEAST ONCE DAILY, AS OUTLINED IN THE TMP, CONTINUOUS TURBIDITY MEASUREMENTS SHALL BE VERIFIED WITH GRAB SAMPLES AND HANDHELD TURBIDITY METERS.
5. TURBIDITY MONITORING EQUIPMENT SHALL BE CALIBRATED AND MAINTAINED ACCORDING TO THE MANUFACTURER'S SPECIFICATIONS.
6. CONTRACTOR IS RESPONSIBLE FOR MAINTAINING E&S CONTROLS SUCH THAT TURBIDITY MEASUREMENTS MEET CERTAIN THRESHOLDS ABOVE THE BACKGROUND TURBIDITY. REFER TO THE TMP FOR ACCEPTABLE THRESHOLDS.
7. IF TURBIDITY THRESHOLDS ARE NOT MET, THE CONTRACTOR WILL BE REQUIRED TO STOP WORK AND SUBMIT A CORRECTIVE ACTION PLAN FOR EROSION AND SEDIMENT CONTROL ACCORDING TO THE TMP.
8. ADDITIONAL DETAILS ON THE TURBIDITY MONITORING PLAN, SAMPLING, AND REPORTING CAN BE FOUND IN THE SEDIMENT MANAGEMENT PLAN.

N W E S

0' 25' 50'
0 1/2" 1"

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DESCRIPTION	DATE	BY

CONSTRUCTION PLAN - WATER CONTROL

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	CME	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=50'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 09 OF 25

SHEET NAME: CP-1

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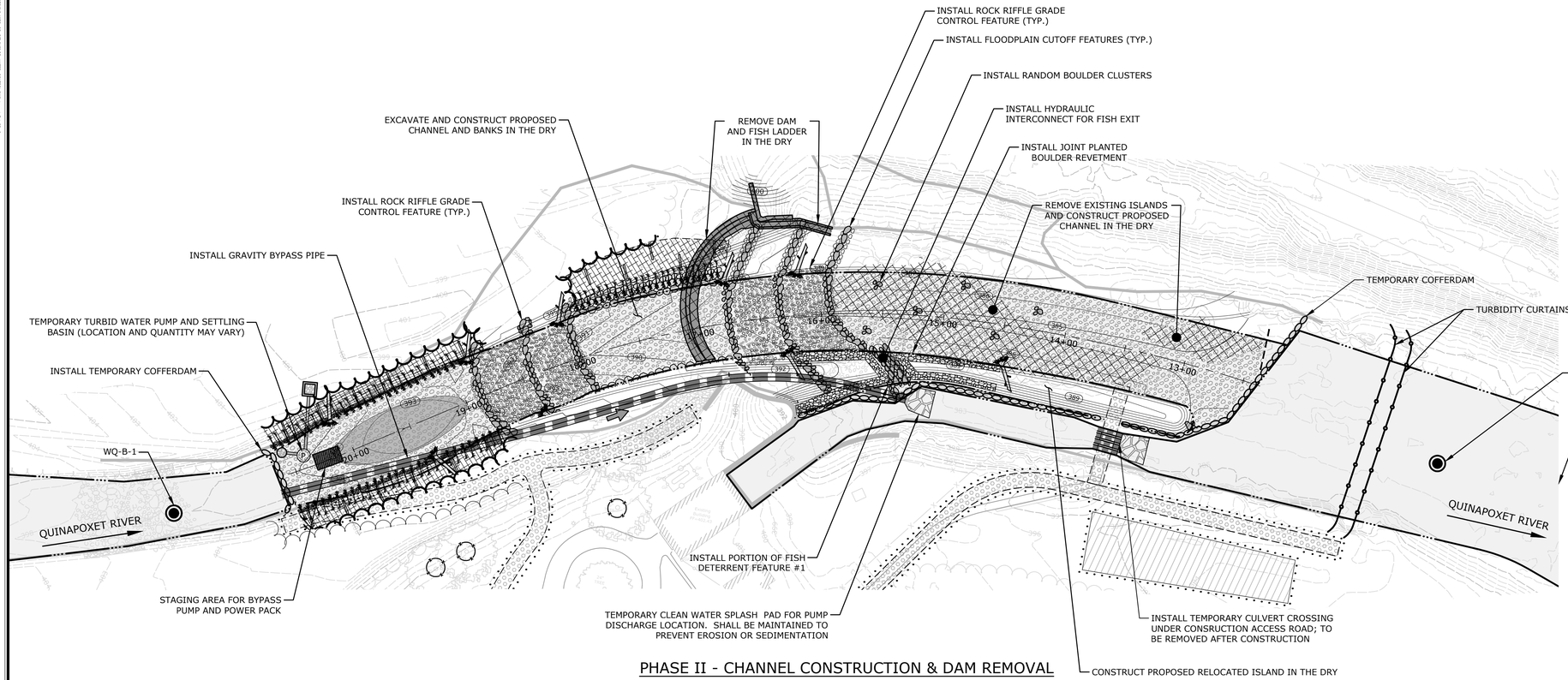
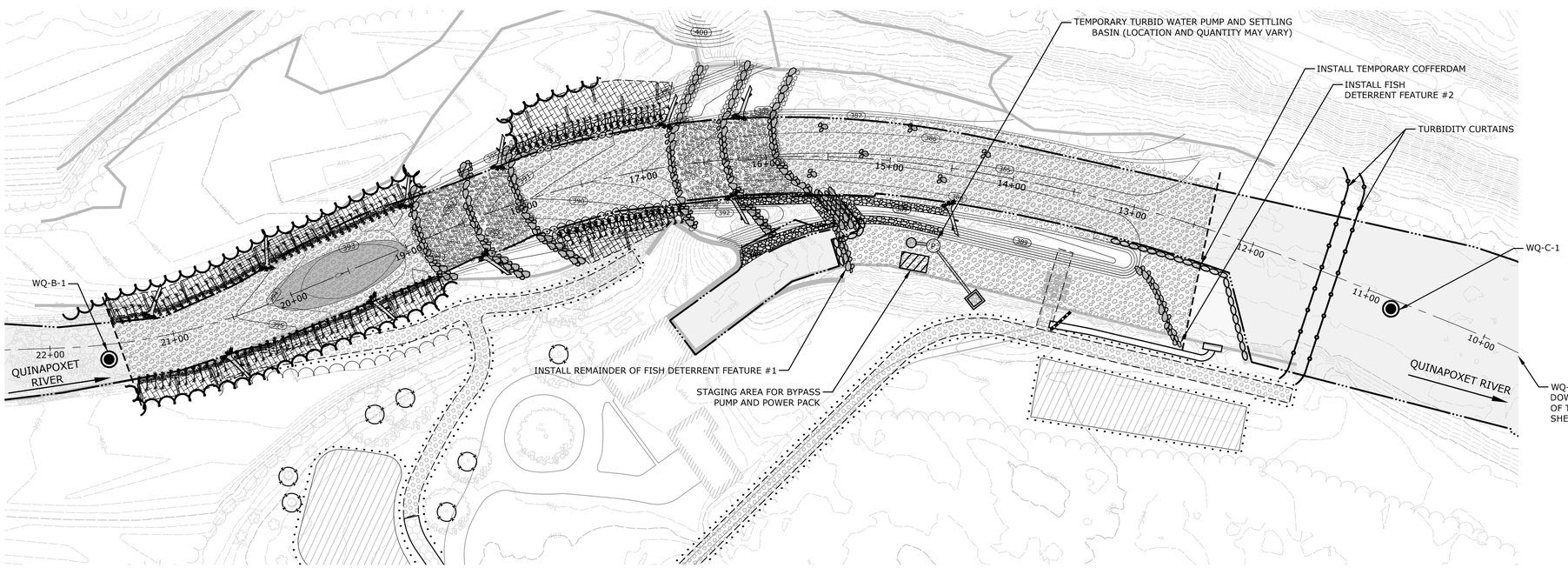


PHASE II - CHANNEL CONSTRUCTION & DAM REMOVAL

LEGEND

- LIMITS OF CLEARING
- PERIMETER CONTROL (SILT FENCE AND STRAW BALES)
- STABILIZED CONSTRUCTION ENTRANCE ANTI-TRACKING PAD
- TEMPORARY CONSTRUCTION ACCESS ROAD
- CONSTRUCTION STAGING AND STOCKPILE AREA
- TREE PROTECTION
- TURBID WATER SUMP
- WATER PUMP
- TURBIDITY SETTLING BASIN
- TEMPORARY COFFERDAM
- GRAVITY DEWATERING PIPE
- WATER FLOW DIRECTION
- STAGING AREA FOR BYPASS PUMP AND POWER PACK
- TEMPORARY CLEAN WATER SPLASH PAD
- TURBIDITY CURTAIN
- TURBIDITY MONITORING POINTS
- TEMPORARY STREAM CROSSING



PHASE III - FINAL CONSTRUCTION & RESTORATION

WATER CONTROL SEQUENCE:

PHASE 1: **(SEE SHEET CP-1)**

PHASE 2:

1. INSTALL TEMPORARY WATER CONTROL COFFERDAMS, DEWATERING PUMP AND ASSOCIATED PIPING, SPLASH PAD, SETTLING BASIN AND TEMPORARY CULVERT CROSSING UNDER CONSTRUCTION ACCESS ROAD.
2. ONCE CHANNEL IS FULLY DEWATERED, BEGIN DISASSEMBLING DAM, FISH LADDER AND APPURTENANCES, AS SHOWN IN THE PROPOSED PLANS.
3. REMOVE EXISTING ISLANDS AND GRADE PROPOSED RELOCATED ISLAND IN THE DRY.
4. PERFORM MAIN CHANNEL GRADING AND INSTALL ROCK RIFFLE GRADE CONTROL FEATURE, FLOODPLAIN CUTOFF FEATURE, POOLS, RANDOM BOULDER CLUSTERS, JOINT PLANTED BOULDER REVETMENT, PORTION OF FISH DETERRENT FEATURE #1, HYDRAULIC INTERCONNECT AND OTHER CHANNEL/BANK TREATMENTS, AS SHOWN IN THE PROPOSED PLANS.

PHASE 3:

1. INSTALL TEMPORARY WATER CONTROL COFFERDAMS, DEWATERING PUMP AND ASSOCIATED PIPING, SPLASH PAD, SETTLING BASIN AND DIVERT WATER AS SHOWN IN PLANS.
2. INSTALL REMAINDER OF FISH DETERRENT FEATURE #1 AND INSTALL FISH DETERRENT FEATURE #2 IN THE DRY.
3. FINALIZE PROPOSED CHANNEL, HYDRAULIC INTERCONNECT, BANK AND CHANNEL TREATMENTS, AND RELOCATED ISLAND.
4. REMOVE ALL TEMPORARY CONSTRUCTION ACCESS ROADS, COFFERDAMS, WATER CONTROL PUMP/PIPING, AND RESTORE DISTURBED AREAS TO EXISTING CONDITIONS, TOP SOIL AND SEED ALL DISTURBED AREAS.

DESCRIPTION	DATE	BY

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CONSTRUCTION PLAN - WATER CONTROL

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	CME	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=50'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 10 OF 25

SHEET NAME: CP-2

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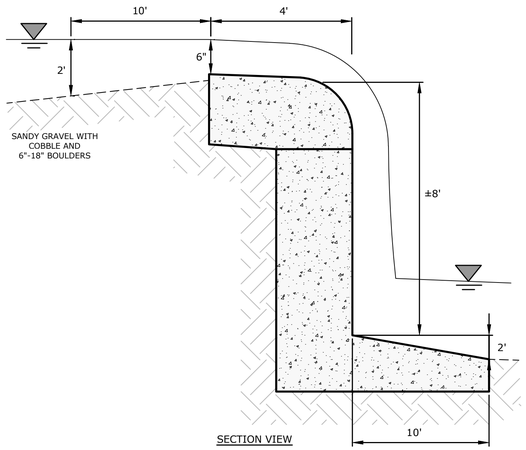
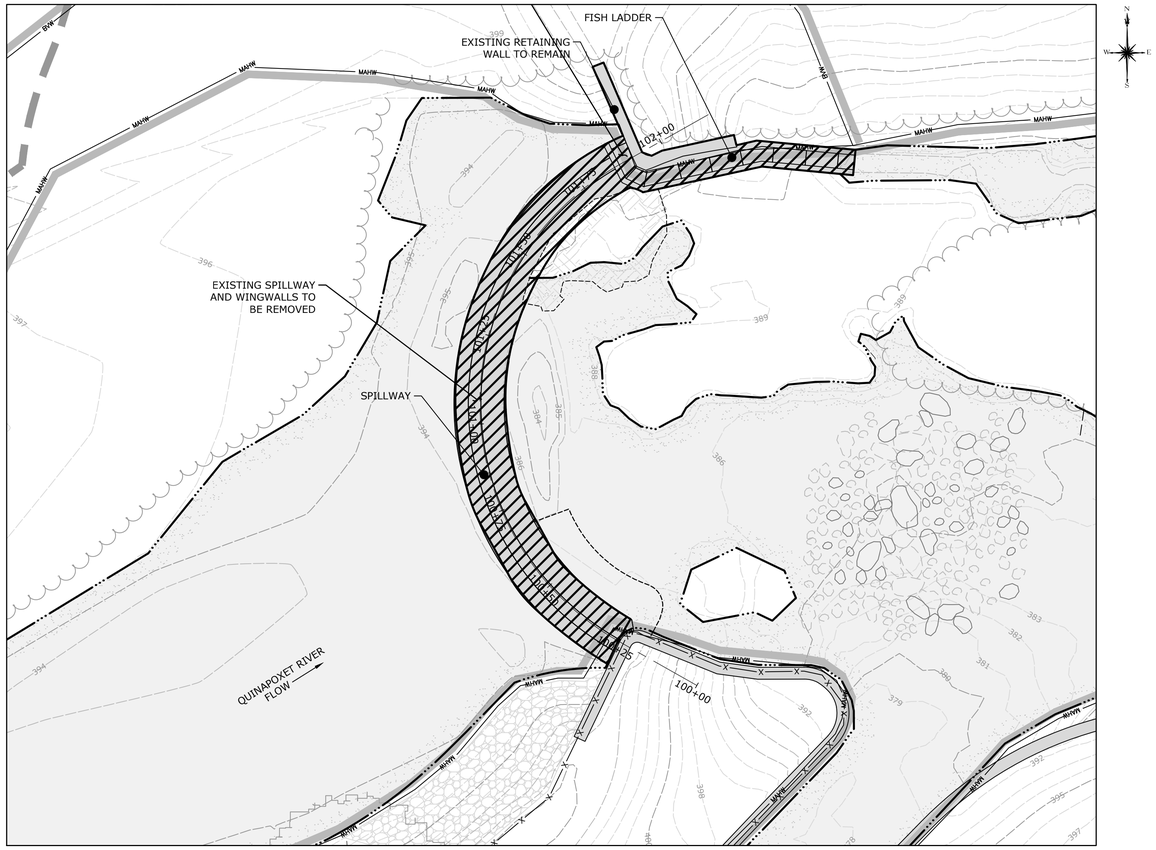


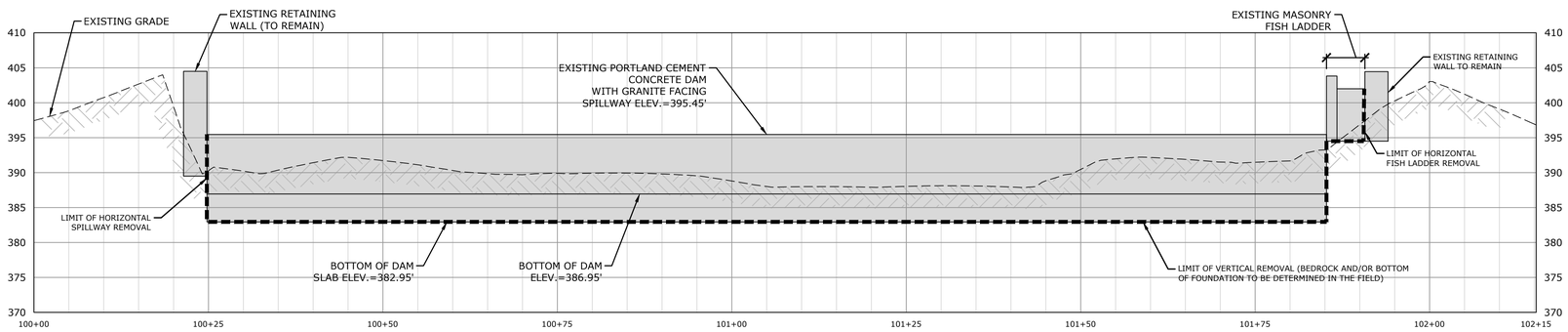
TYPICAL DAM CREST SECTION

NOT TO SCALE



EXISTING DAM - SITE PLAN

(SCALE: 1"=20')



EXISTING DAM - ELEVATION - FACING UPSTREAM

(SCALE: 1"=10' H, 1"=10'V)

LEGEND

- PROPOSED GRADE
- EXISTING GRADE
- LIMITS OF REMOVAL
- EXISTING CONCRETE TO REMAIN

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DESCRIPTION	DATE	BY

ELEVATION - EXISTING DAM

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 11 OF 25

SHEET NAME: EL-1

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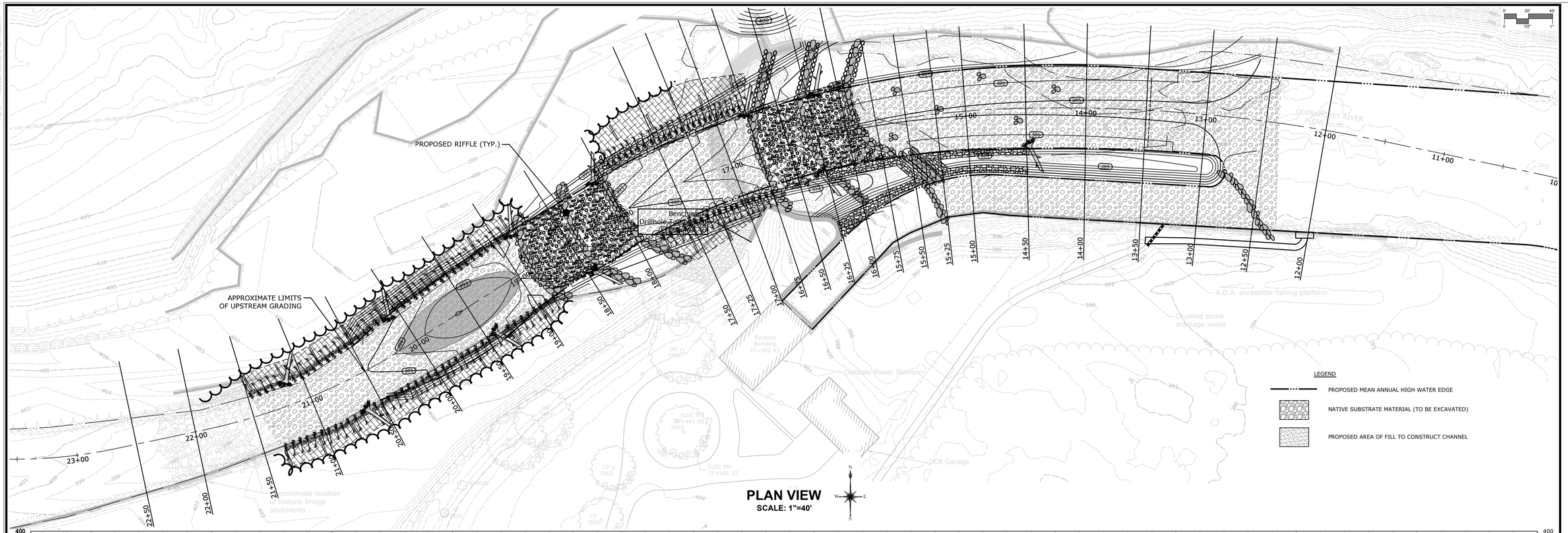
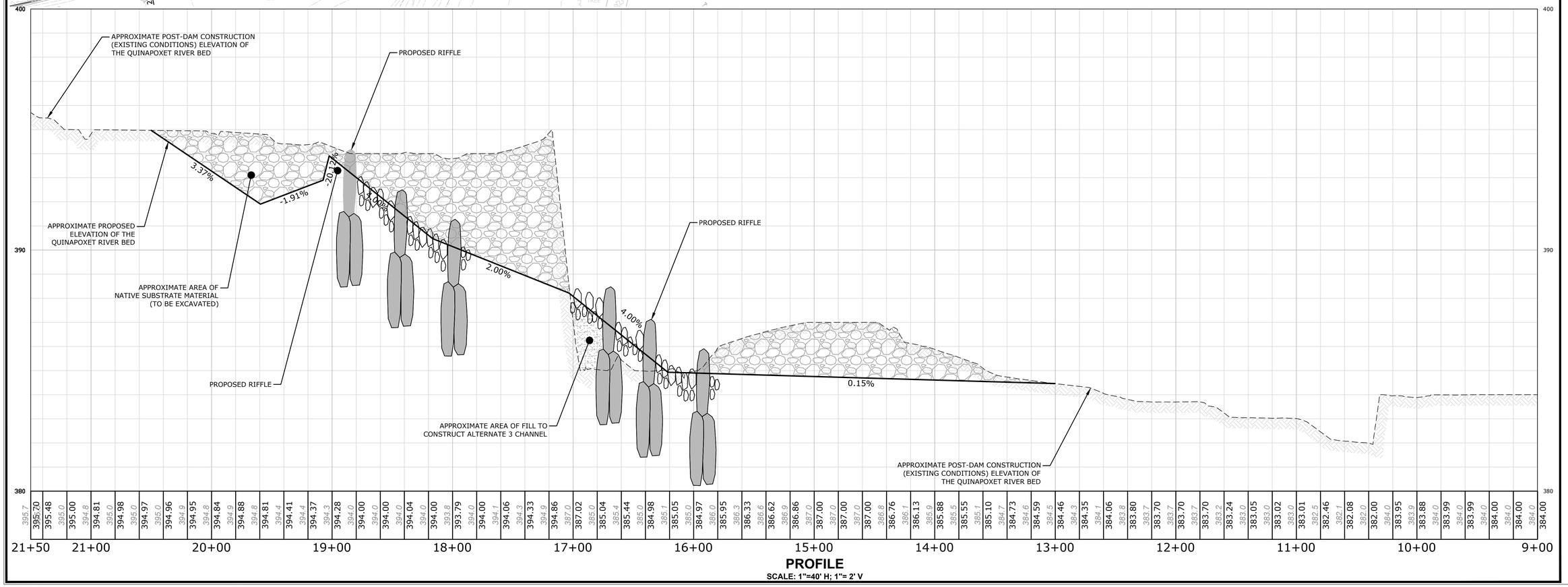


PLAN VIEW
SCALE: 1"=40'



PROFILE
SCALE: 1"=40' H; 1"= 2' V

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DESCRIPTION	DATE	BY

PROFILE - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

WAG	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 12 OF 25

SHEET NAME: **PR-1**

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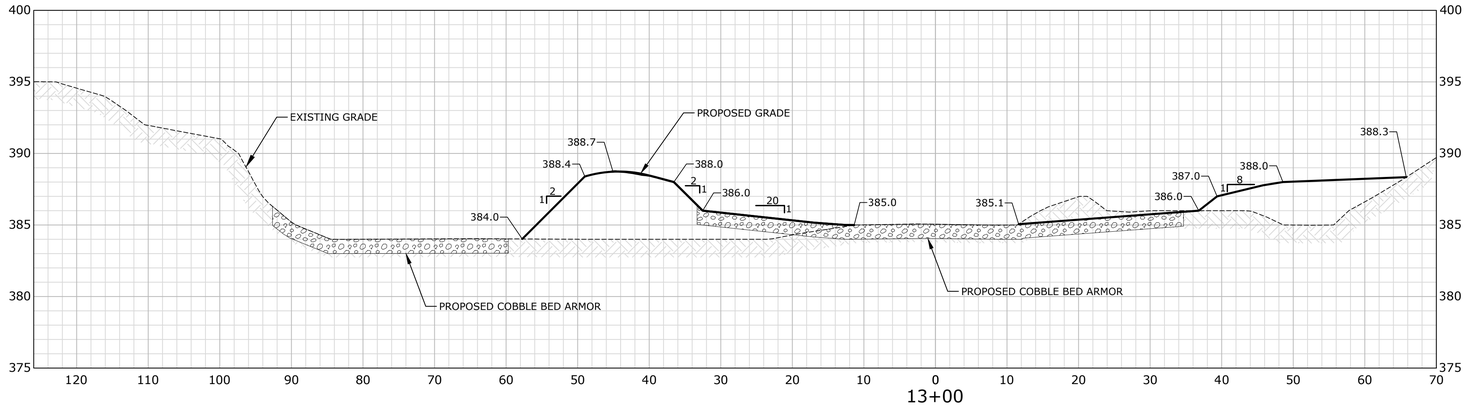

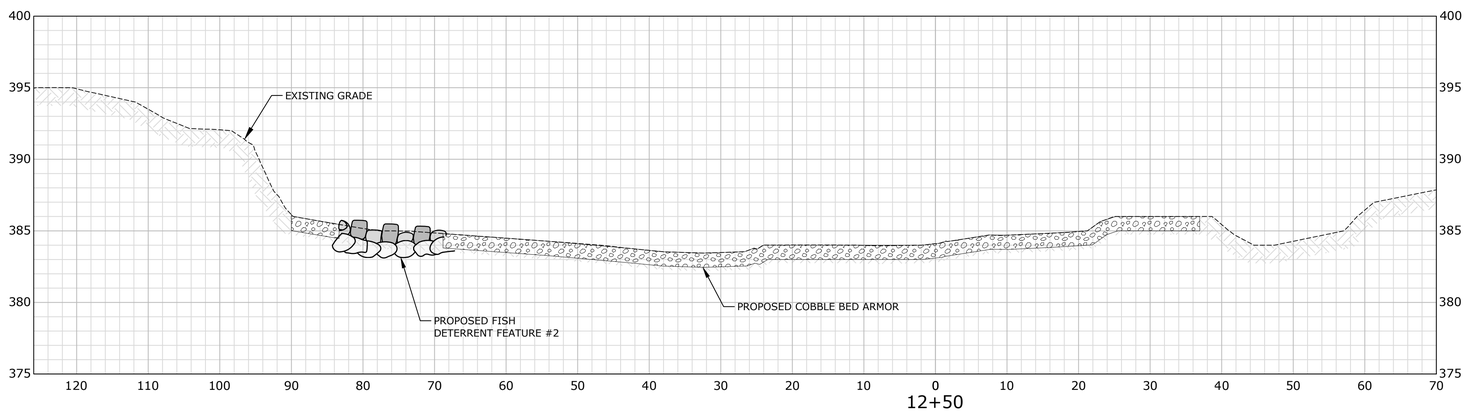

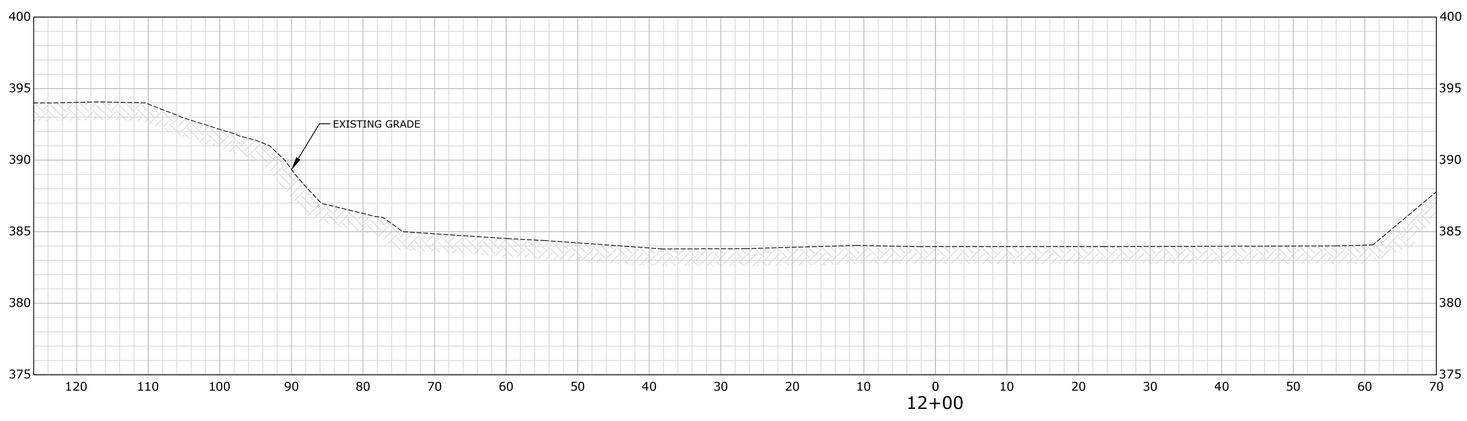

LEGEND

EXISTING GRADE

PROPOSED GRADE

QUINAPOXET RIVER - CROSS SECTIONS

(LOOKING UPSTREAM)

SCALE: 1"=10' H, 1"=5' V

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MBINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 13 OF 25

SHEET NAME: **CS-1**

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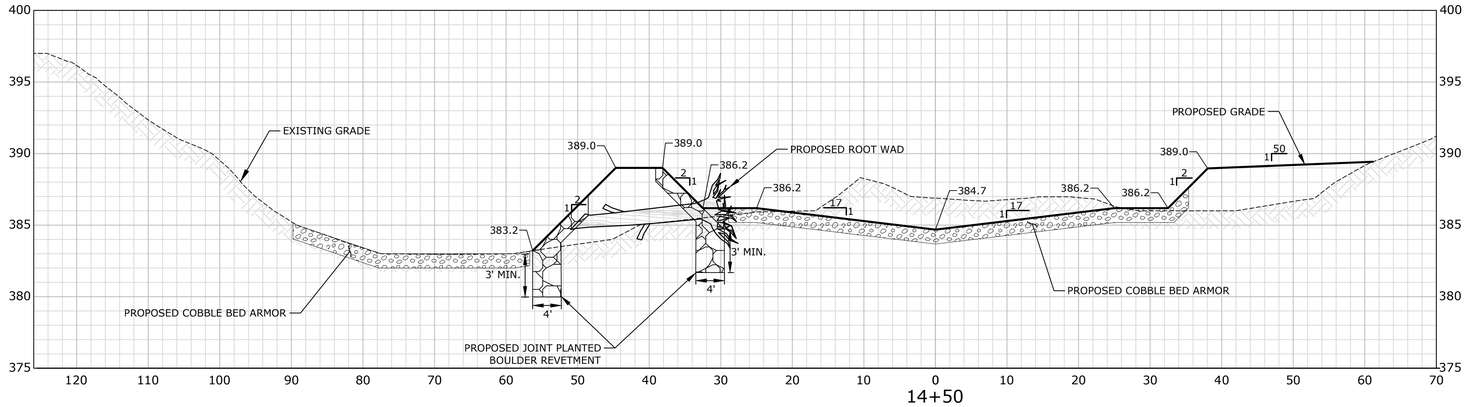

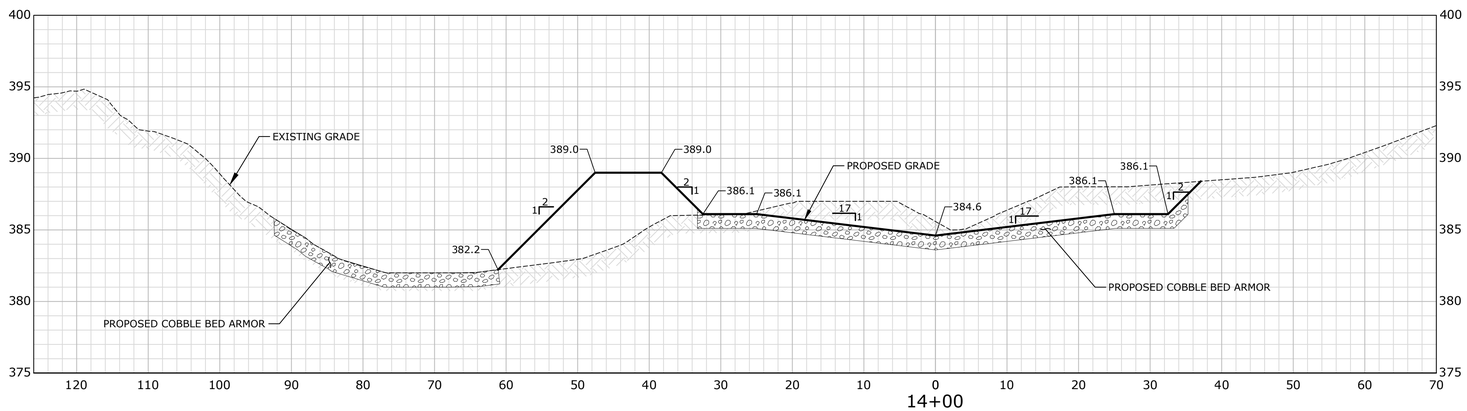

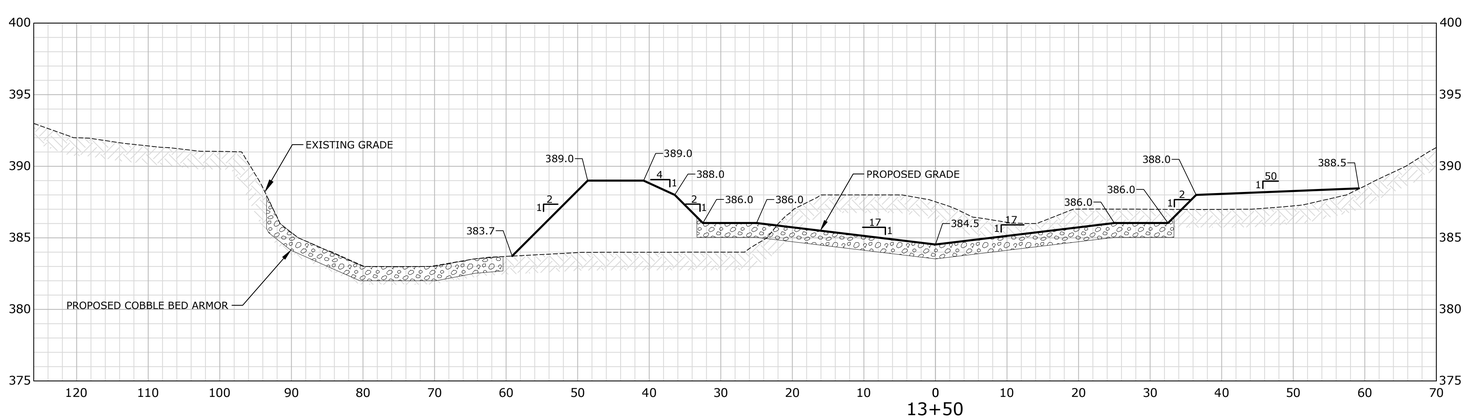

QUINAPOXET RIVER - CROSS SECTIONS
(LOOKING UPSTREAM)
SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE
PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MBINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 14 OF 25
SHEET NAME: CS-2

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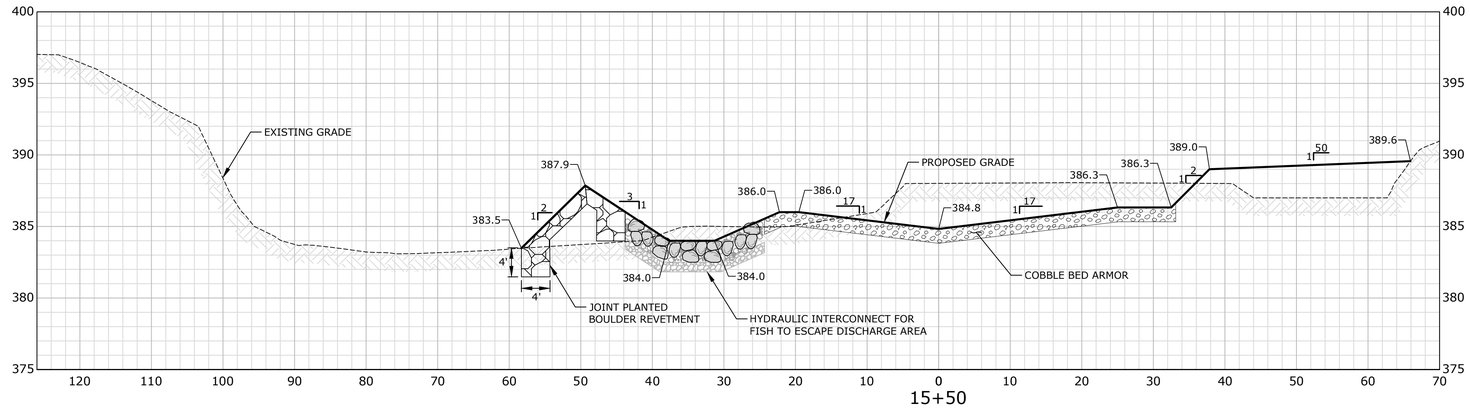

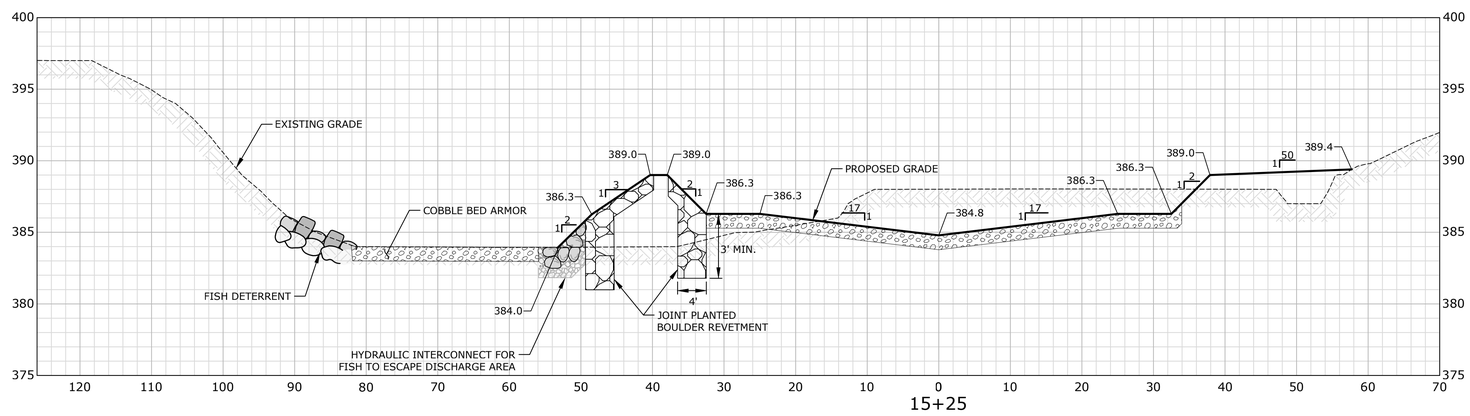

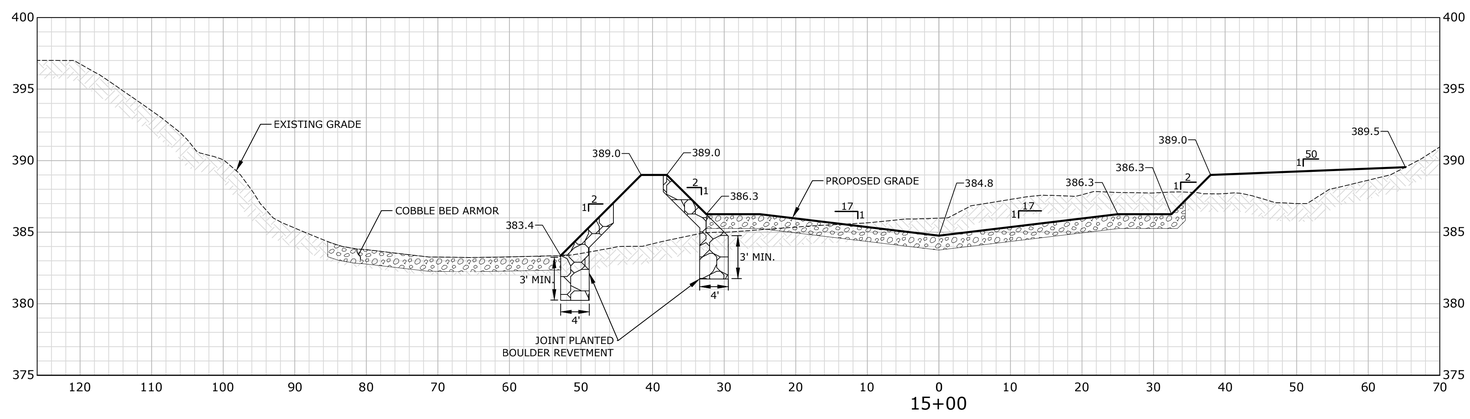

QUINAPOXET RIVER - CROSS SECTIONS

(LOOKING UPSTREAM)

SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE

PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MBINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 15 OF 25

SHEET NAME: CS-3

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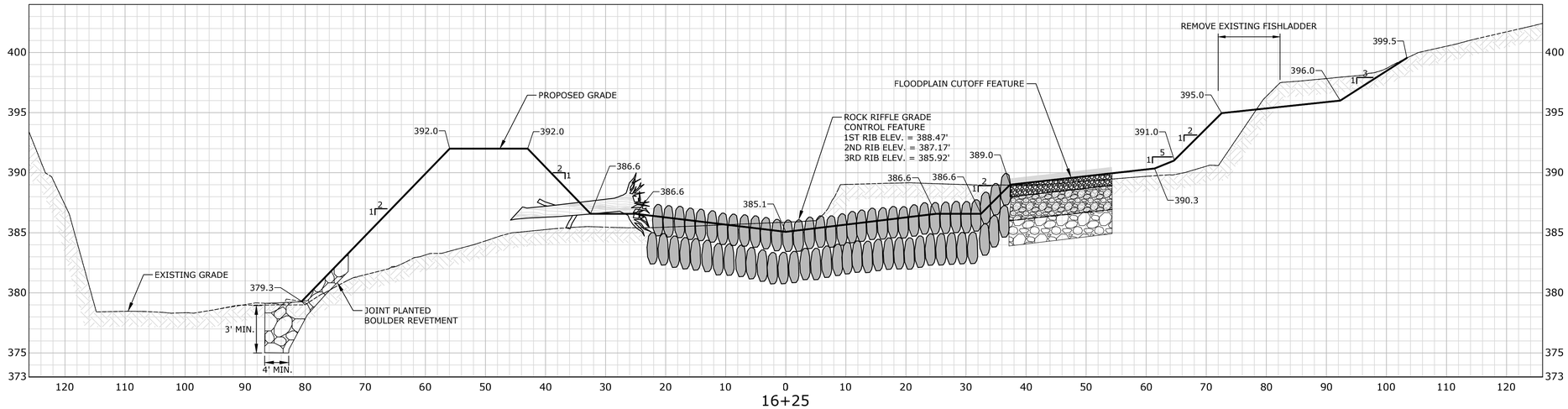

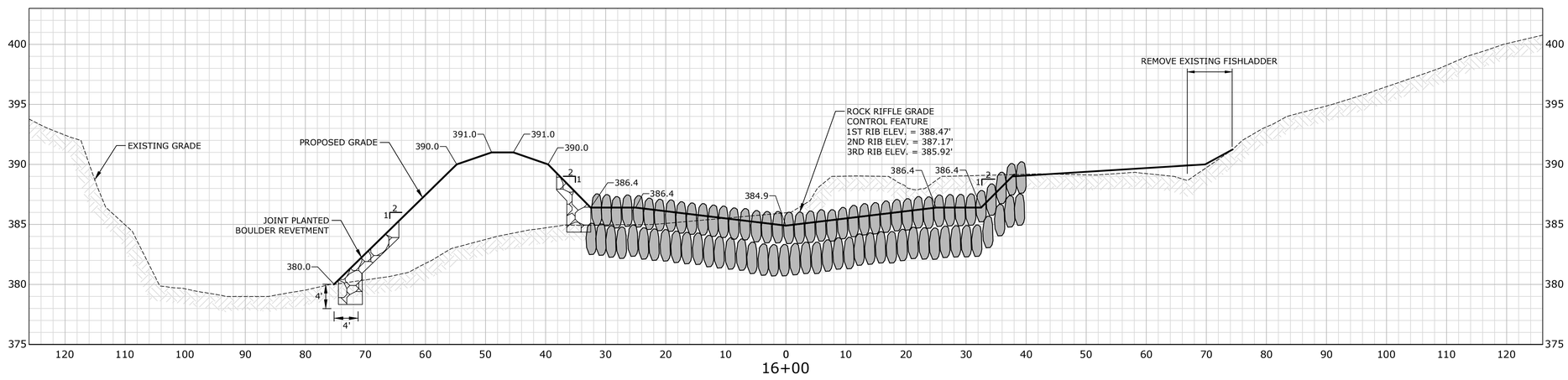

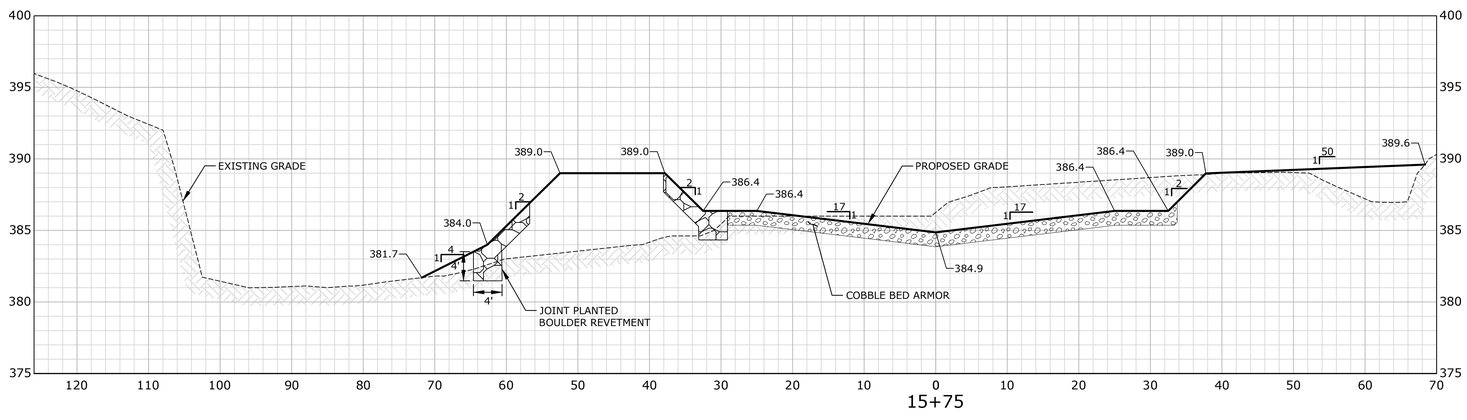

QUINAPOXET RIVER - CROSS SECTIONS

(LOOKING UPSTREAM)

SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE

PROPOSED GRADE

MILONE & MACBROOM

99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
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DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 16 OF 25

SHEET NAME: CS-4

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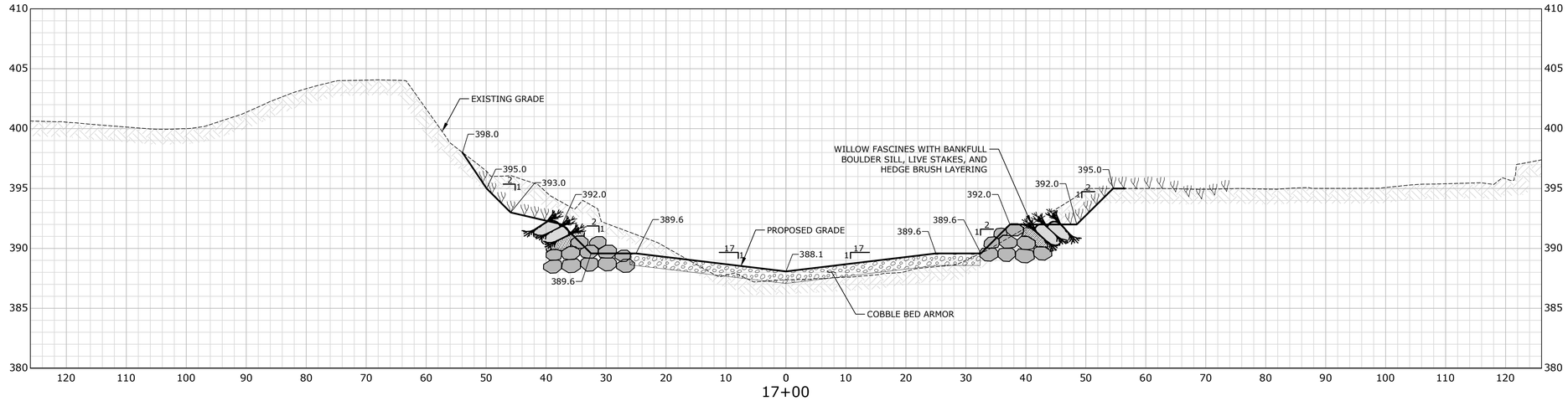

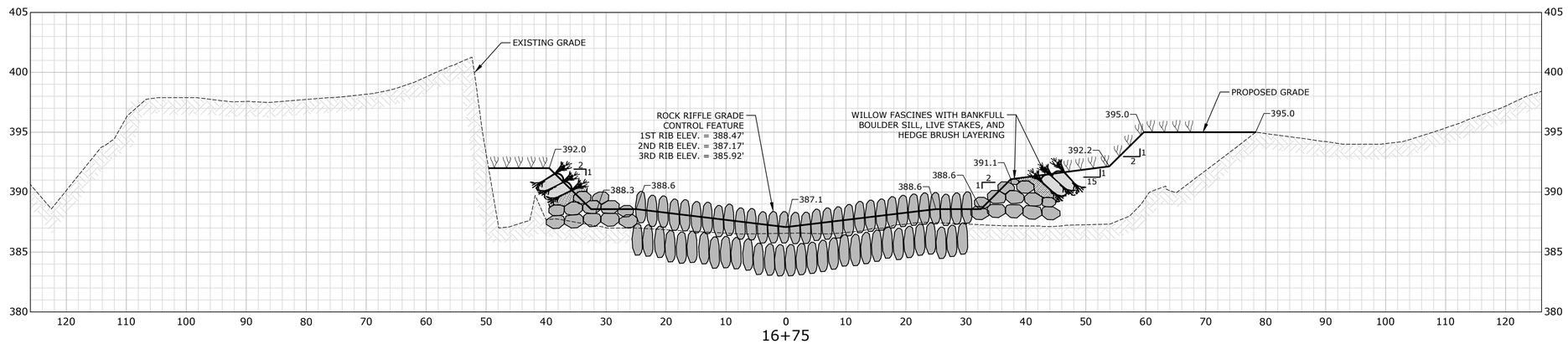

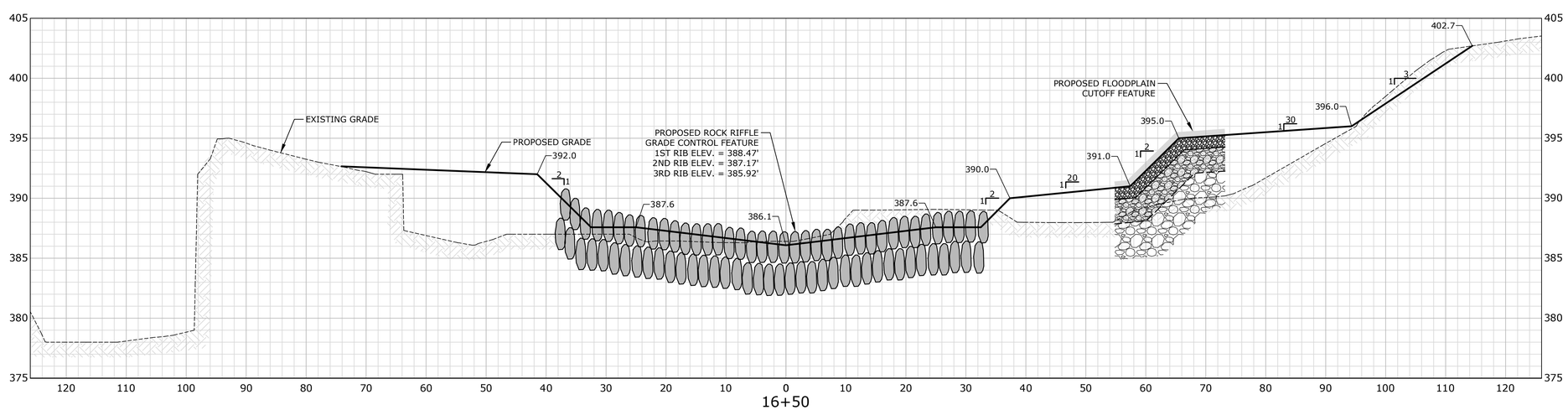

QUINAPOXET RIVER - CROSS SECTIONS
(LOOKING UPSTREAM)
SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE
PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MMINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 17 OF 25
SHEET NAME: CS-5

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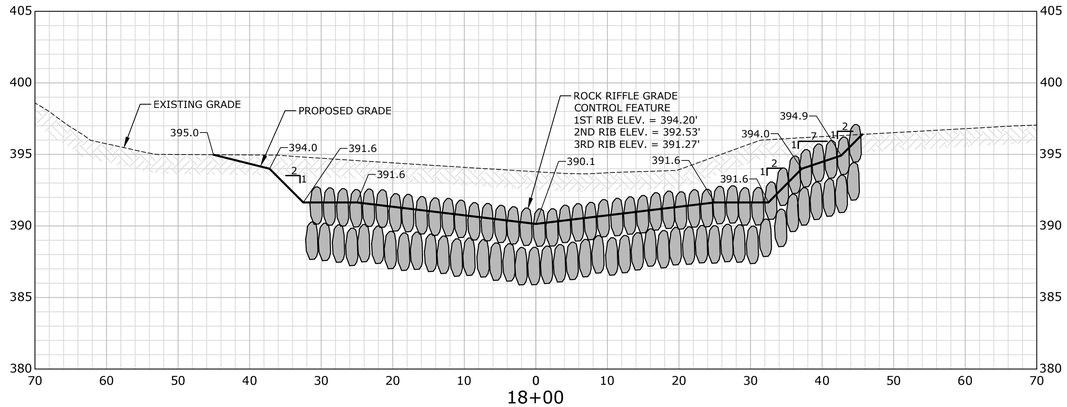

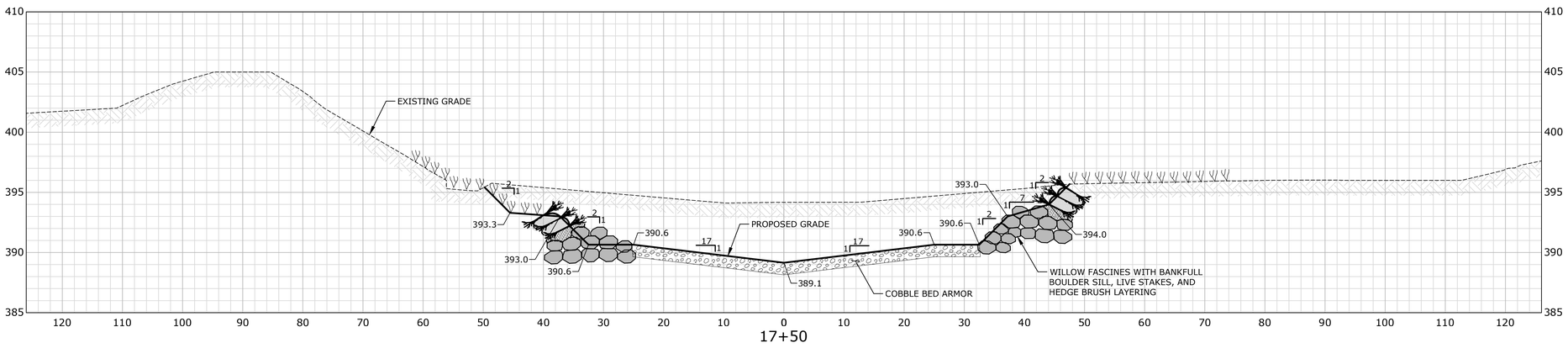

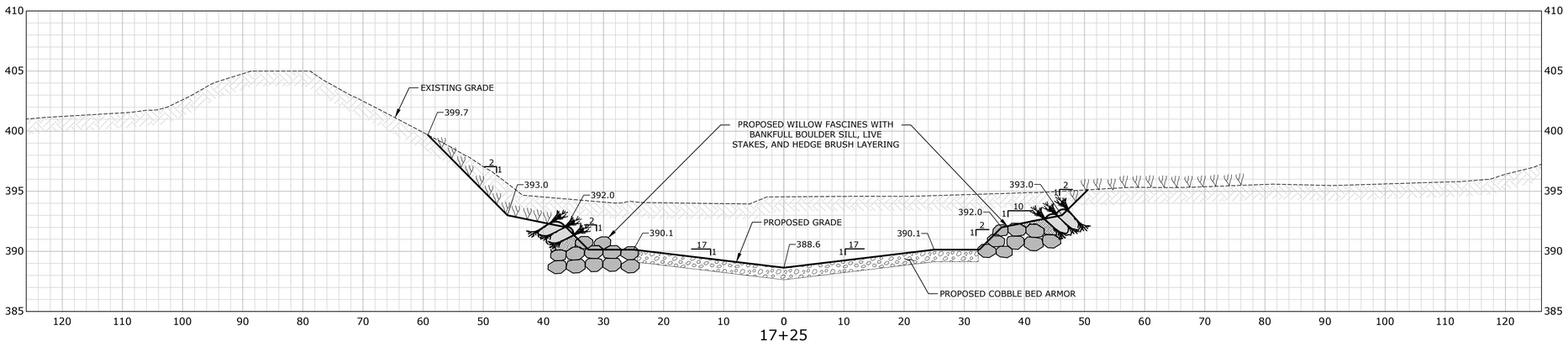

QUINAPOXET RIVER - CROSS SECTIONS
(LOOKING UPSTREAM)
SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE

PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MMINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 18 OF 25

SHEET NAME: CS-6

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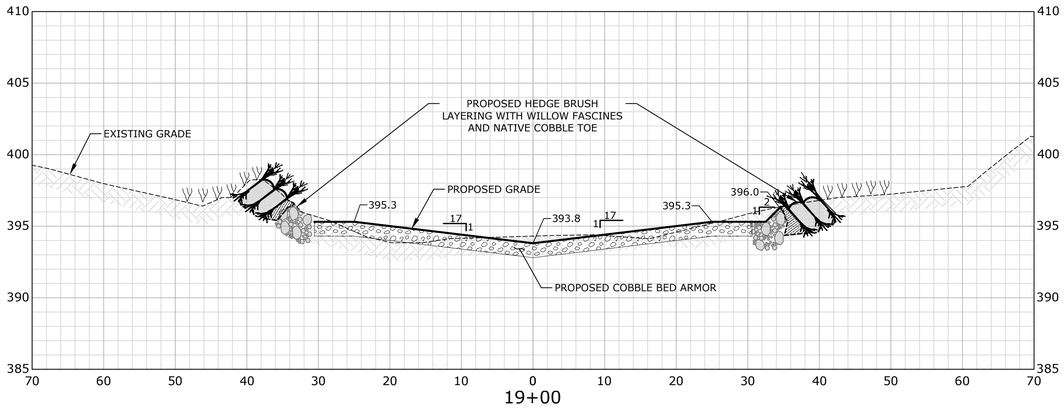

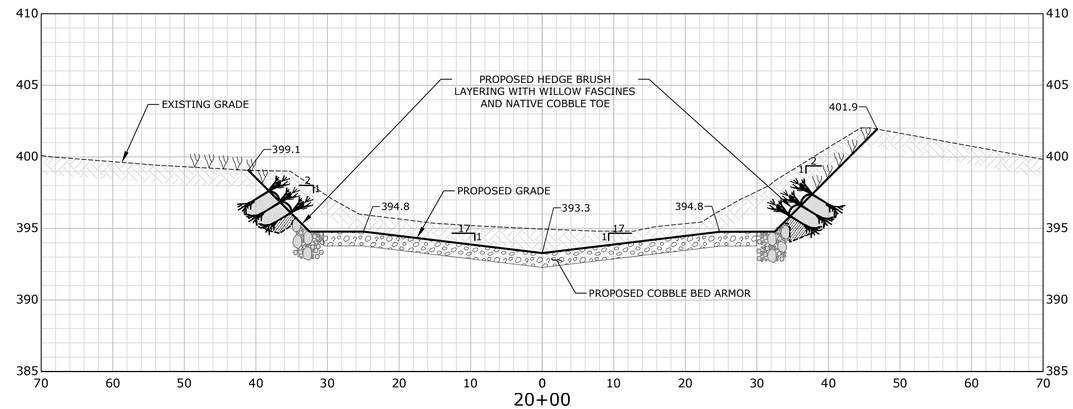

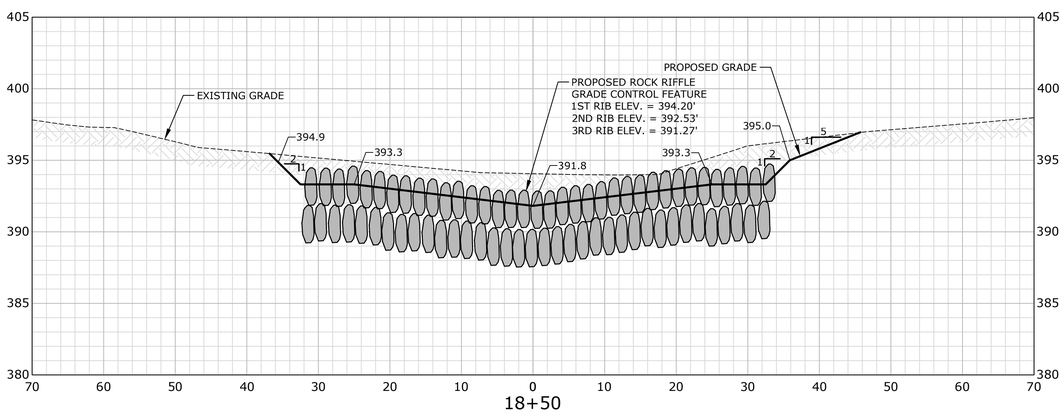

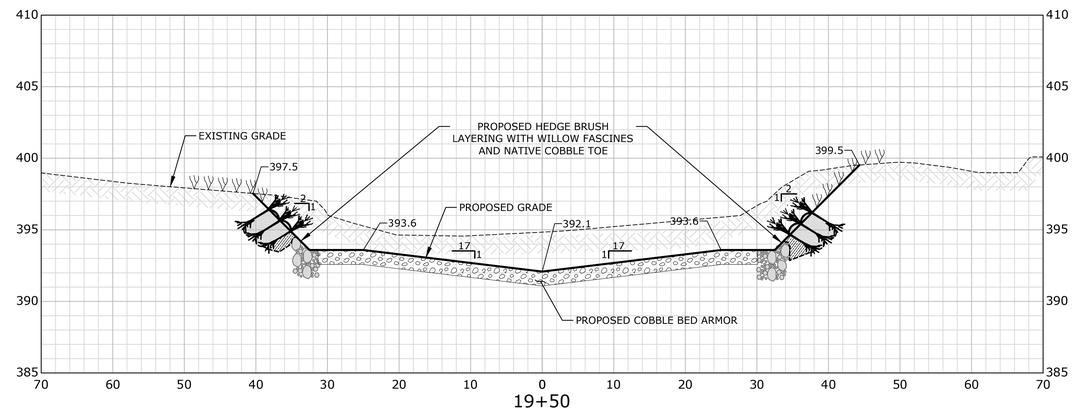

QUINAPOXET RIVER - CROSS SECTIONS
(LOOKING UPSTREAM)
SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE
PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MMINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 19 OF 25
SHEET NAME: CS-7

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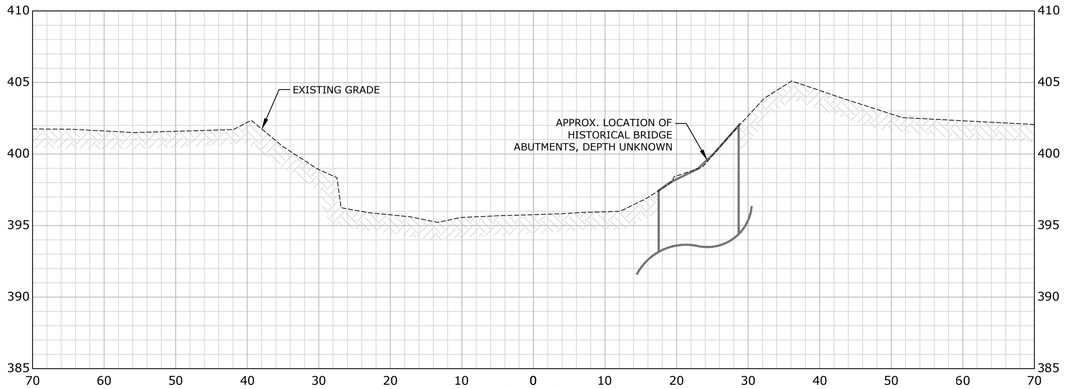

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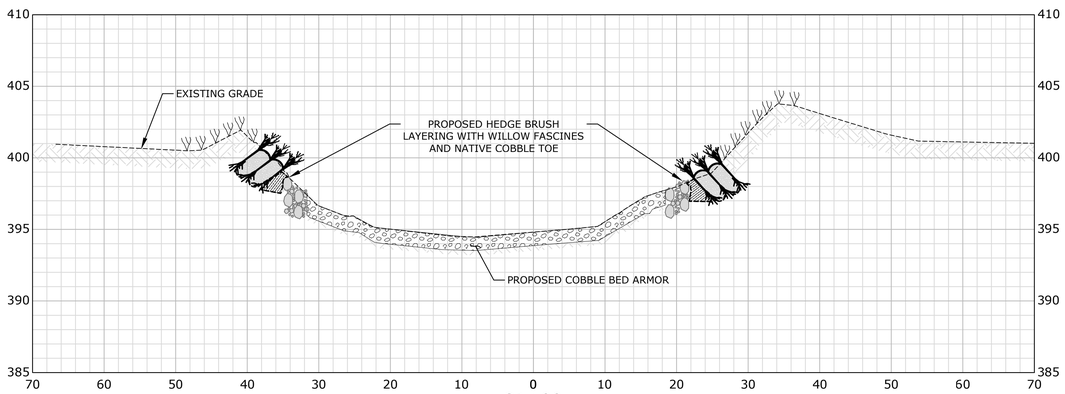

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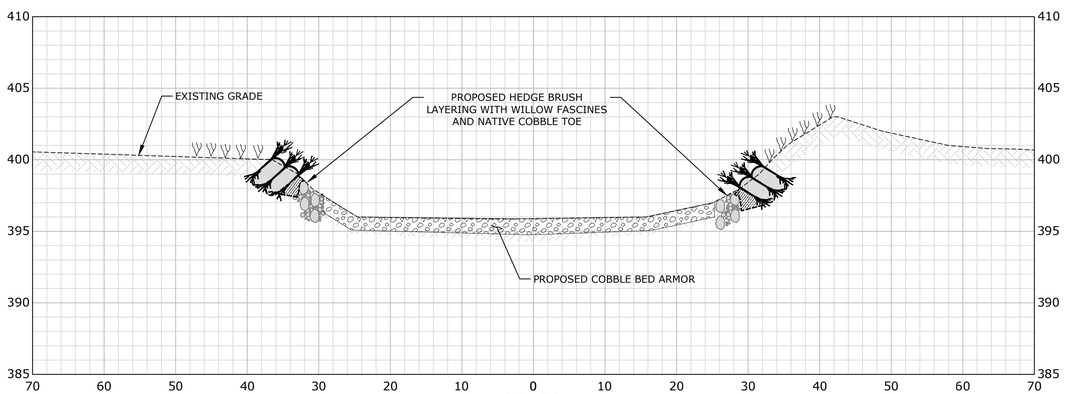

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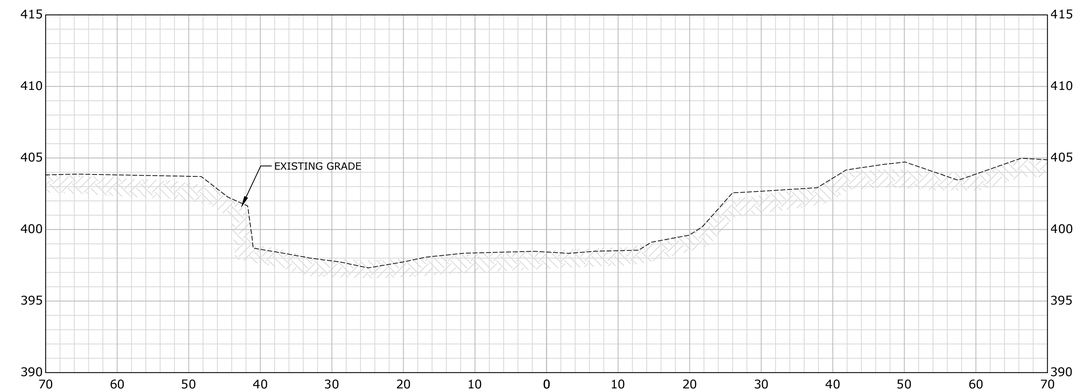

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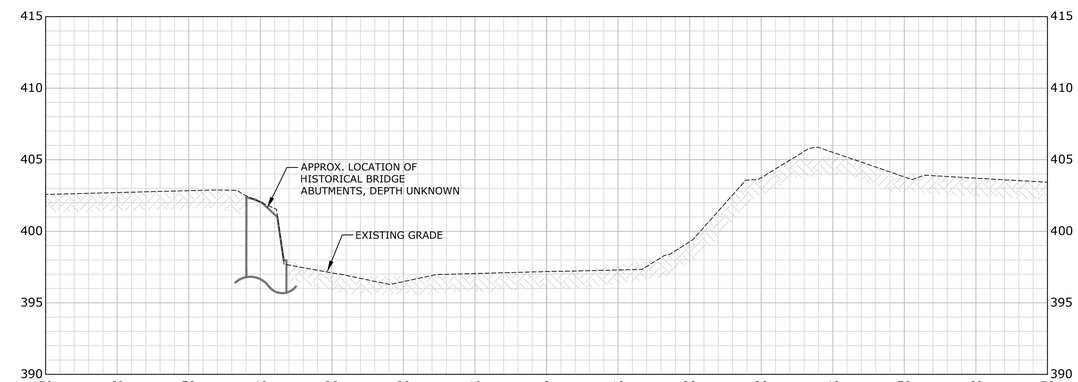

22+00

QUINAPOXET RIVER - CROSS SECTIONS
(LOOKING UPSTREAM)
SCALE: 1"=10' H, 1"=5' V

LEGEND

EXISTING GRADE
PROPOSED GRADE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MMINC.COM

DESCRIPTION	DATE	BY

CROSS SECTIONS - QUINAPOXET RIVER

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

JCM	FRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 20 OF 25
SHEET NAME: CS-8

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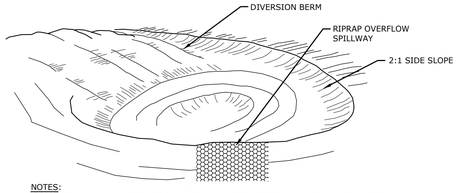
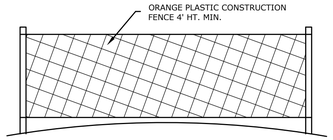


NOTES:
REFER TO SEDIMENT & EROSION CONTROL PLAN FOR APPROXIMATE DIMENSIONS AND REQUIRED VOLUME.

SOURCE: 2002 CT. GUIDELINES
FOR SOIL EROSION AND SEDIMENT CONTROL

TEMPORARY SEDIMENT TRAP

NOT TO SCALE

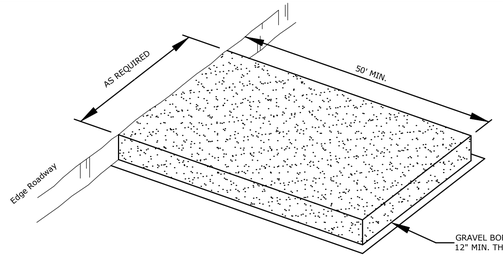


NOTE:
1. CONTRACTOR SHALL COORDINATE TEMPORARY FENCE INSTALLATION WITH OWNERS REPRESENTATIVES.

2. CONTRACTOR SHALL SUBMIT SHOP DRAWINGS TO ENGINEER FOR APPROVALS PRIOR TO CONSTRUCTION.

ORANGE CONSTRUCTION FENCING

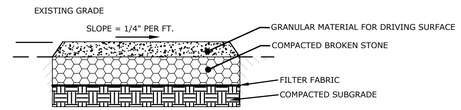
NOT TO SCALE



NOTE: STABILIZED CONSTRUCTION ENTRANCE SHALL BE INSTALLED AND MAINTAINED DURING OPERATIONS WHICH PROMOTE VEHICULAR TRACKING OF MUD

STABILIZED CONSTRUCTION ENTRANCE

NOT TO SCALE

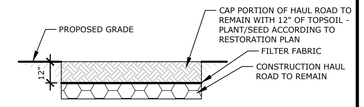


NOTES:
1. GRANULAR MATERIAL FOR DRIVING SURFACE AND COMPACTED BROKEN STONE TO BE REMOVED UPON COMPLETION OF CONSTRUCTION, AND REPLACED WITH TOPSOIL. DISTURBED AREAS TO BE SEEDED AND MULCHED ACCORDING TO THE RESTORATION PLAN.

TEMPORARY CONSTRUCTION ACCESS ROAD

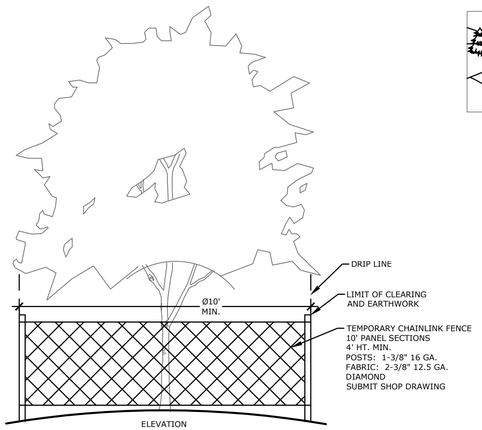
NOT TO SCALE

NOTE: CONTRACTOR HAS THE OPTION TO REMOVE THE STONE USED FOR THE CONSTRUCTION HAUL ROAD AND DISPOSE OF OFFSITE



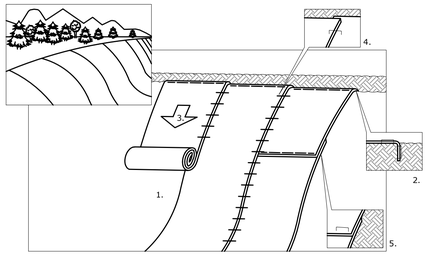
ACCESS ROAD RESTORATION

NOT TO SCALE



TREE PROTECTION

NOT TO SCALE

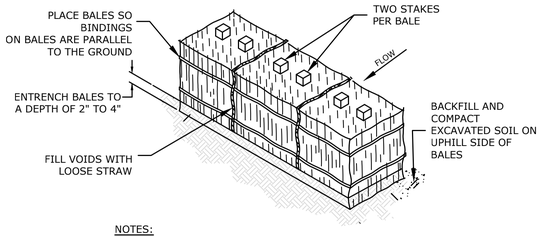


1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING SCC225, DO NOT SEED PREPARED AREA. SCC225 MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN A 6" DEEP BY 6" WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
3. ROLL THE BLANKETS DOWN THE SLOPE IN THE DIRECTION OF THE WATER FLOW.
4. THE EDGES OF PARALLEL BLANKETS MUST BE STAPLED WITH APPROXIMATELY 2" OVERLAP.
5. WHEN BLANKETS MUST BE SPLICED DOWN THE SLOPE, PLACE BLANKETS END OVER END (SHINGLE STYLE) WITH APPROXIMATELY 6" OVERLAP. STAPLE THROUGH OVERLAP AREA, APPROXIMATELY 12" APART.

REFER TO GENERAL STAPLE PATTERN GUIDE IN NORTH AMERICAN GREEN CATALOG FOR CORRECT STAPLE PATTERN RECOMMENDATIONS FOR SLOPE INSTALLATIONS.

EROSION CONTROL BLANKET ON SLOPES

NOT TO SCALE



NOTES:

1. IDEALLY, BALES SHOULD BE ENTRENCHED 2 TO 4 INCHES AND TIGHTLY BUTTED TOGETHER. BALES CAN BE SUCCESSFULLY PLACED WITHOUT A TRENCH IF GOOD GROUND CONTACT IS MADE. REMOVE HEAVY BRUSH AND FILL ALL VOIDS WITH LOOSE STRAW.

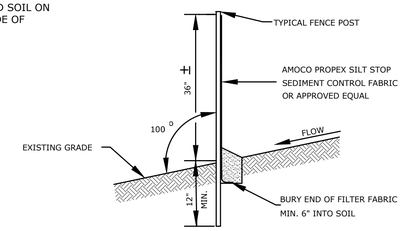
2. BALES SHALL BE ONLY USED AS A TEMPORARY BARRIER AND FOR NO LONGER THAN 60 DAYS.

3. WHEN SEDIMENTATION DEPOSITS REACH WITHIN 3" OF THE TOP OF BALES, REMOVE SEDIMENTATION OR ADD ADDITIONAL BALES ON SEDIMENTATION DIRECTLY BEHIND FIRST ROW OF BALES AS DIRECTED BY THE ENGINEER.

4. UPON ESTABLISHMENT OF GROUND COVER ON DISTURBED AREAS AND WHEN DIRECTED BY THE ENGINEER, HAY BALES WILL BE REMOVED AND USED AS MULCH. ANY SEDIMENTATION WILL BE THINLY SPREAD UPON ESTABLISHED GROUND COVER.

STRAW BALE BARRIER PROTECTION

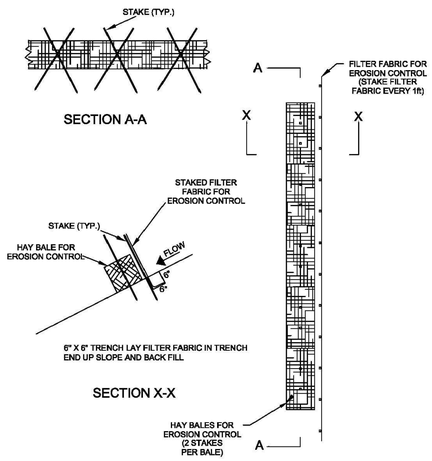
NOT TO SCALE



NOTE:
1. CONTRACTOR SHALL HAVE AVAILABLE ON-SITE A MIN. OF 300 LINEAR FEET OF SILT FENCE FOR USE IF REQUIRED BY FIELD CONDITIONS.

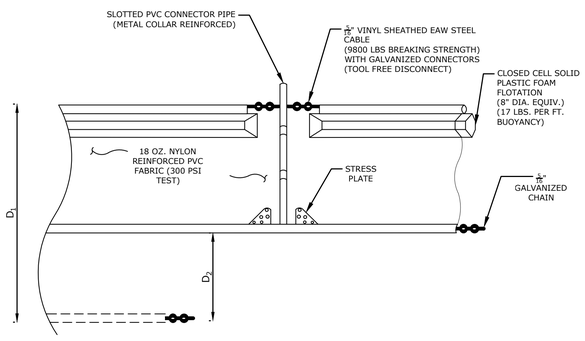
SILT FENCE

NOT TO SCALE



PERMITER CONTROL LAYOUT

NOT TO SCALE



TEMPORARY TURBIDITY CURTAIN NOTES:

1. D_1 5' STD. (SINGLE PANEL FOR DEPTHS 5' OR LESS).
2. D_2 5' STD. (ADDITIONAL PANEL FOR DEPTHS GREATER THAN 5').
3. CURTAIN TO REACH BOTTOM UP TO DEPTHS OF 10 FEET.
4. TWO (2) PANELS TO BE USED FOR DEPTHS GREATER THAN 10 FEET UNLESS SPECIAL DEPTH CURTAINS SPECIFICALLY CALL FOR IN THE PLANS OR AS DETERMINED BY THE ENGINEER.

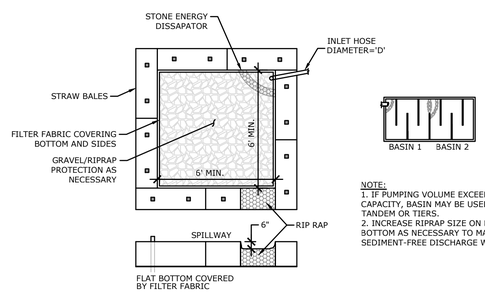
NOTICE: COMPONENTS OF TYPES I AND II MAY BE SIMILAR OR IDENTICAL TO PROPRIETARY DESIGNS. ANY INFRINGEMENT ON THE PROPRIETARY RIGHTS OF THE DESIGNER SHALL BE THE SOLE RESPONSIBILITY OF THE USER. SUBSTITUTIONS FOR TYPES I AND II SHALL BE AS APPROVED BY THE ENGINEER.

TEMPORARY TURBIDITY CURTAIN APPLICATIONS NOTES:

1. TURBIDITY BARRIERS ARE TO BE USED IN ALL PERMANENT BODIES OF WATER REGARDLESS OF WATER DEPTH.
2. NUMBER AND SPACING OF ANCHORS DEPENDENT ON CURRENT VELOCITIES
3. DEPLOYMENT OF BARRIER AROUND PILE LOCATIONS MAY VARY TO ACCOMMODATE CONSTRUCTION OPERATIONS.
4. NAVIGATION MAY REQUIRE SEGMENTING BARRIER DURING CONSTRUCTION OPERATIONS.
5. TURBIDITY BARRIERS FOR FLOWING STREAMS AND TIDAL CREEKS MAY BE EITHER FLOATING OR STAKED TYPES OR ANY COMBINATIONS OF TYPES THAT WILL SUIT SITE CONDITIONS AND MEET EROSION CONTROL AND WATER QUALITY REQUIREMENTS. THE BARRIER TYPE(S) WILL BE AT THE CONTRACTOR'S OPTION UNLESS OTHERWISE SPECIFIED IN THE PLANS, HOWEVER PAYMENT WILL BE UNDER THE PAY ITEM(S) ESTABLISHED IN THE PLANS FOR FLOATING TURBIDITY BARRIER AND/OR STAKED TURBIDITY BARRIER. POSTS IN STAKED TURBIDITY BARRIERS TO BE INSTALLED IN VERTICAL POSITION UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

TEMPORARY TURBIDITY CURTAINS

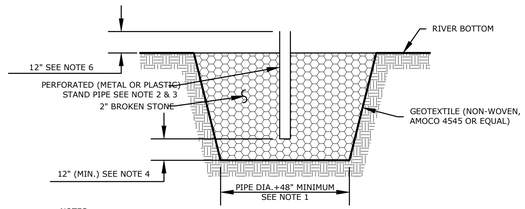
NOT TO SCALE



NOTE:
1. IF PUMPING VOLUME EXCEEDS BASIN CAPACITY, BASIN MAY BE USED IN TANDEM OR TIERS.
2. INCREASE RIPRAP SIZE ON BASIN BOTTOM AS NECESSARY TO MAINTAIN SEDIMENT-FREE DISCHARGE WATERS

TURBIDITY SETTLING BASIN

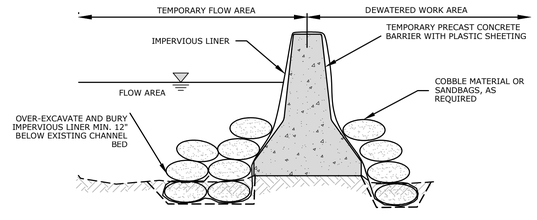
NOT TO SCALE



NOTES:
1. OVERALL SUMP PIT DIMENSIONS TO BE COMPATIBLE WITH ANTICIPATED SEEPAGE RATES AND PUMP TO BE USED.
2. THE STAND PIPE DIAMETER AND NUMBER OF PERFORATIONS TO BE COMPATIBLE WITH THE PUMP SIZE BEING USED.
3. PERFORATIONS IN THE STANDPIPE TO BE EITHER CIRCULAR OR SLOTS, PERFORATION SIZE SHALL NOT EXCEED 1/2" DIAMETER.
4. 2" BROKEN STONE SHALL EXTEND A MINIMUM OF 12" BELOW THE BOTTOM OF THE STANDPIPE.
5. A PROPERLY DESIGNED GEOTEXTILE TO BE PLACED BETWEEN THE EXISTING SOILS AND THE CRUSHED STONE BACKFILL.
6. THE STANDPIPE SHALL EXTEND A MINIMUM OF 12" ABOVE THE SURROUNDING GROUND.

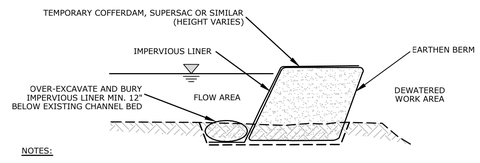
TURBID WATER SUMP FOR PUMPING

NOT TO SCALE



TEMPORARY COFFERDAM - ALT. A

NOT TO SCALE



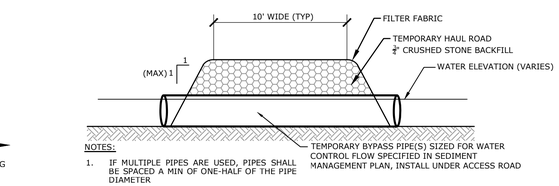
NOTES:

1. COFFERDAM AND TO BE SIZED FOR NORMAL FLOW CONDITIONS. TOP ELEVATION OF COFFERDAM TO ISOLATE LAGOON FROM TIDAL INFLUENCE AND STREAM FLOWS.

2. COFFERDAM TO BE CONSTRUCTED OF SUPERSAC OR SIMILAR PRODUCT.

TEMPORARY COFFERDAM - ALT. B

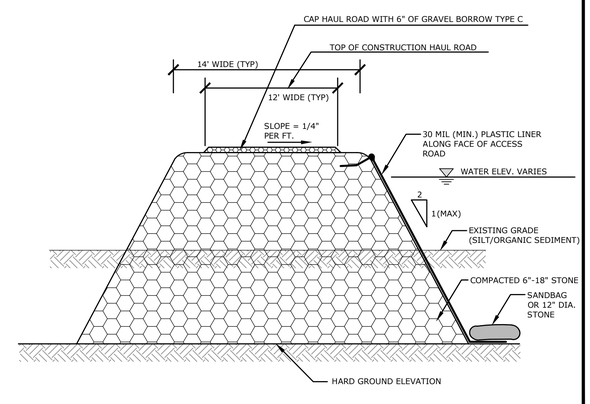
NOT TO SCALE



NOTES:
1. IF MULTIPLE PIPES ARE USED, PIPES SHALL BE SPACED A MIN OF ONE-HALF OF THE PIPE DIAMETER

TEMPORARY STREAM CROSSING

NOT TO SCALE



TEMPORARY ACCESS ROAD NEAR WATER

NOT TO SCALE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
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DESCRIPTION	DATE	BY

DETAILS

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 21 OF 25
SHEET NAME: D-1

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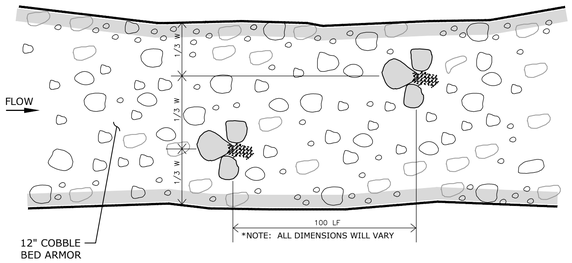
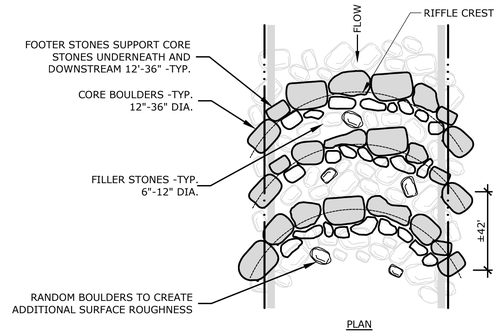


COBBLE BED ARMOR

NOT TO SCALE

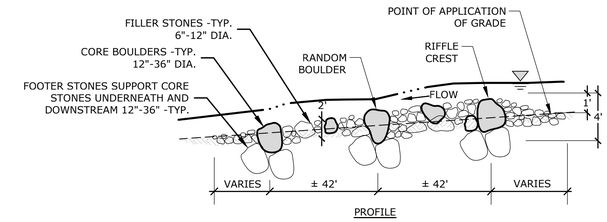
COBBLE BED ARMOR NOTES:

1. PLACE 6" TO 9" DIAMETER STONES TO DEPTH SHOWN ON PLAN.
2. PLACE 6" DEPTH EXCAVATED CHANNEL MATERIAL OVER COBBLES AND MECHANICALLY WORK SMALLER MATERIAL IN TO COBBLE.
3. STONES MAY EXTEND ABOVE NOMINAL CHANNEL GRADE TO CREATE SURFACE ROUGHNESS. STONES SHOULD NOT BLOCK MORE THAN ½ OF TOTAL CROSS SECTION.



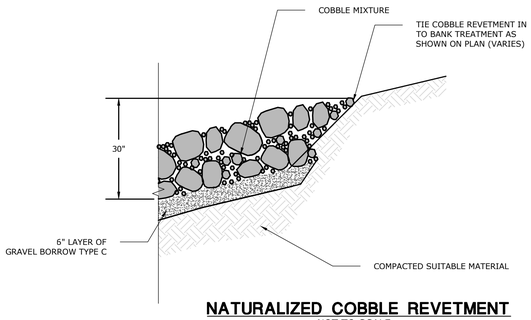
ROCK RIFFLE NOTES:

1. SELECTED CORE BOULDERS SHOULD EXTEND ABOVE PROPOSED GRADE. CORE BOULDERS TO BE BURIED BY MINIMUM ½ TOTAL ROCK HEIGHT.
2. PLACE RANDOM BOULDERS OVER FACE OF RIFFLE TO CREATE CHANNEL ROUGHNESS. DO NOT BLOCK MORE THAN ½ OF TOTAL CROSS SECTION WITH RANDOM BOULDERS.
3. USE 10-12 SINGLE RANDOM BOULDERS PER RIFFLE.
4. SINGLE RANDOM BOULDERS TO BE 12"-36" ROUNDED STONE, AS FOR RANDOM BOULDER CLUSTERS.
5. ROOTWADS INSTALLED WITH RIFFLES SHOULD BE INSTALLED AT THE BANK ADJACENT THE FURTHEST UPSTREAM CREST.



ROCK RIFFLE GRADE CONTROL FEATURE

NOT TO SCALE



NATURALIZED COBBLE REVETMENT

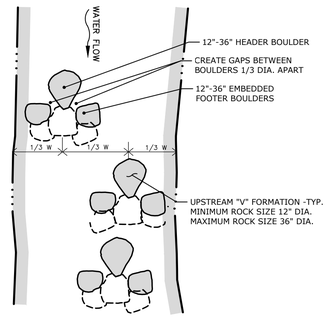
NOT TO SCALE

NOTE:

1. COBBLE MIXTURE SHALL CONFORM TO THE FOLLOWING GRADATION:

SIEVE DESIGNATION	PERCENT PASSING
9"	100%
6"	75%
3"	50%
NO. 50	10%
NO. 200	5%

2. REVETMENT SHALL BE INSTALLED TO EXTEND VERTICALLY 30" ABOVE CHANNEL INVERT ELEVATION. INSTALL TO LIMITS SHOWN ON PLANS.

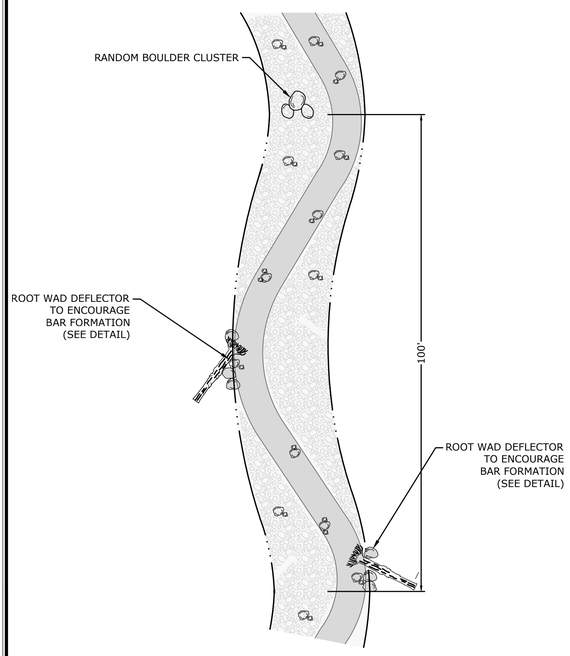


RANDOM BOULDER CLUSTER

NOT TO SCALE

RANDOM BOULDER CLUSTER NOTES:

1. CLUSTERS SHOULD NOT BE EVENLY SPACED FROM EACH OTHER.
2. PLACE ½ OF ALL BOULDER CLUSTERS AT TOE OF BANK .
3. POSITION BOULDER GROUPS IN AN UPSTREAM OR DOWNSTREAM "V" FORMATION.
4. BOULDERS SHOULD BE 12" TO 36" IN DIAMETER.
5. POSITION BOULDERS WITH THEIR LONG AXIS PARALLEL TO THE STREAM FLOW.
6. INSTALL FOOTER BOULDER TO WEDGE HEADER BOULDER IN PLACE FROM DOWNSTREAM.
7. INSTALL HEADER BOULDERS AT A LOW PROFILE SUCH THAT THEY ARE PARTIALLY SUBMERGED DURING NORMAL LOW FLOW. INSTALL SUCH THAT ½ OF ROCK DIAMETER IS BURIED IN STREAM CHANNEL.
8. FINISHED ELEVATION OF THE BOULDERS WILL BE DETERMINED IN THE FIELD BY THE ENGINEER.
9. PROVIDE A GAP BETWEEN BOULDERS A MINIMUM OF 1/3 THE ROCK DIAMETER.

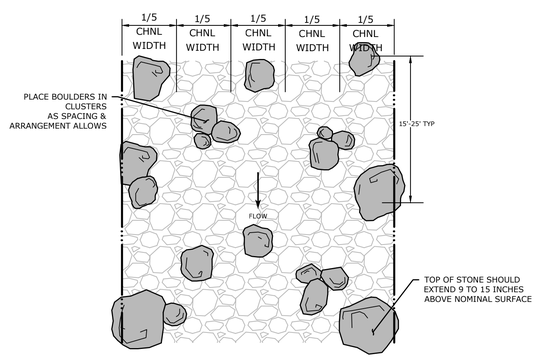


INSTREAM FEATURES - PLACEMENT OF RANDOM BOULDER CLUSTERS, ROOT WADS, AND RANDOM COBBLE

NOT TO SCALE

NOTES:

1. PURPOSE OF INSTREAM FEATURES IS TO MAINTAIN IRREGULARITY IN LOW FLOW CHANNEL.
2. FINAL FEATURES PLACEMENT TO BE AT DIRECTION OF ENGINEER IN FIELD.
3. 4 BOULDER CLUSTERS AND 2 ROOT WAD DEFLECTORS EVERY 100 FEET OF INDIVIDUAL QUANTITIES, MAY BE MODIFIED AS APPROVED BY ENGINEER. 5-6 TOTAL FEATURES EVERY 100 FEET.
4. ROOT WADS SHALL BE 6" MIN. DIA., X 10' LENGTH, ANCHORED MIN. 6' INTO BANK. FINAL PLACEMENT OF LOG TO BE DIRECTED IN FIELD BY ENGINEER.

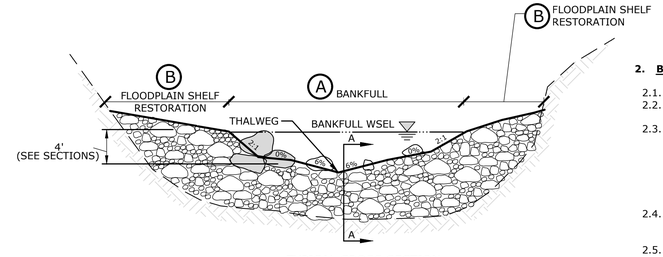


SURFACE BOULDERS

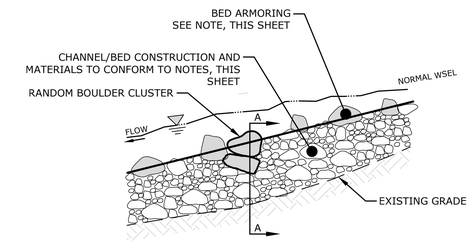
NOT TO SCALE

NOTES:

1 USE 18" TO 30" INCH DIAMETER ROUNDED BOULDERS.
2. BURY BOULDERS IN THE CHANNEL BED MATERIAL ¼ TO ⅓ THEIR TOTAL HEIGHT.
3. PLACE BOULDERS IN EACH OF THE FIVE SECTIONS OF THE RAPIDS. POSITION BOULDERS WITH THE LONG AXIS OF EACH BOULDER PARALLEL TO THE CHANNEL FLOW DIRECTION. THE FINISHED ELEVATION OF THE BOULDERS SHALL BE DETERMINED IN THE FIELD BY THE ENGINEER.
4. PLACE BOULDERS APPROXIMATELY THREE TO FIVE FEET APART IN THE DOWNSTREAM DIRECTION.
5. PLACE 24"-36" ROUNDED BOULDERS ALONG CHANNEL EDGE EVERY 15' TO 25'. EMBED EDGE BOULDERS A MINIMUM 1/2 DIA.



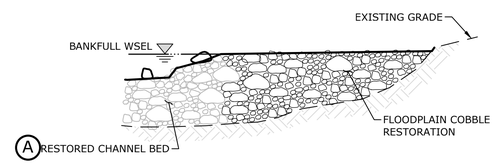
TYPICAL CROSS SECTION



TYPICAL PROFILE VIEW

A RESTORED BANKFULL CHANNEL BED

NOT TO SCALE



B FLOODPLAIN SHELF RESTORATION

NOT TO SCALE

RESTORED BANKFULL CHANNEL BED NOTES:

1. REMOVAL OF EXISTING BED ARMORING:

1.1. REMOVE AND STOCKPILE ALL EXISTING SAND, GRAVEL, COBBLE, AND BOULDER TO MINIMUM 12" DEPTH WITHIN EXISTING BANKFULL CHANNEL. COLLECT MORE ARMORING FROM COBBLE BARS, WHERE POSSIBLE. REUSE MATERIAL ON TOP 12" OF FINAL CHANNEL BED. ALL BOULDERS OVER 12" IN SIZE LOCATED PARTIALLY OR FULLY WITHIN THE 12" SHALL BE REMOVED FOR REUSE.

2. BANKFULL CHANNEL FORMATION:

2.1. PERFORM ROUGH GRADING OF CHANNEL.
2.2. DO NOT REUSE FINE-GRAINED SILTS, CLAYS, OR ORGANIC MATERIAL WITHIN THE BANKFULL CHANNEL.
2.3. TO ESTABLISH NEW CHANNEL IN FILL SITUATION: FILL TO WITHIN 12" OF FINAL GRADE WITH NATURAL SAND & GRAVEL/COBBLE/BOULDER RE-USED FROM ON-SITE EXCAVATION. DO NOT USE SILTS, CLAYS, OR ORGANICS. DO NOT USE STOCKPILED BED ARMORING AS GENERAL FILL TO RAISE BED. PLACE FINAL 12" OF MATERIAL FROM STOCKPILED MATERIAL, AND SUPPLEMENT WITH BED ARMORING AS DESCRIBED BELOW.
2.4. TO ESTABLISH NEW CHANNEL IN CUT SITUATION, IN SUITABLE SOIL: PLACE FINAL 12" OF MATERIAL FROM STOCKPILED MATERIAL, AND SUPPLEMENT WITH BED ARMORING AS DESCRIBED BELOW.
2.5. TO ESTABLISH NEW CHANNEL IN CUT SITUATION, IN UNSUITABLE SOIL: REMOVE MATERIAL TO 24" BELOW FINAL GRADE. PLACE 12" OF SUITABLE SAND/GRAVEL FILL. PLACE FINAL 12" OF MATERIAL FROM STOCKPILED MATERIAL, AND SUPPLEMENT WITH BED ARMORING AS DESCRIBED BELOW.

3. LOW-FLOW CHANNEL:

3.1 SHALL BE A V-SHAPED CHANNEL WITH 10% SLOPE FROM DEEPEST POINT TO BANKS, 15' WIDE AND 0.75'-1.0' DEEP.

4. BED ARMORING:

4.1 REPLACEMENT OF THE SAND, GRAVEL, AND COBBLE STOCKPILED BEFORE CONSTRUCTION BEGAN SHALL BE DONE IN SUCH A MANNER AS TO SIMULATE THE NATURAL CREEK BED BEFORE CONSTRUCTION.
4.2 LARGE BOULDERS OVER 12" - 36" IN DIAMETER SHALL BE PLACED AT A RANDOM APPLICATION RATE OF 10 ROCKS PER TEN LINEAR FEET OF CREAK CHANNEL.
4.3 ON-SITE BOULDERS MAY BE USED FOR FINAL BED ARMORING. IF INSUFFICIENT SUPPLY EXISTS ON-SITE, WEATHERED/ROUNDED BOULDERS (TYPE 1, SEE SPECIFICATIONS) SHALL BE IMPORTED.

FLOODPLAIN SHELF RESTORATION NOTES:

1. GRADE FLOODPLAIN BENCH AT 2% TOWARD THE STREAM
2. PROVIDE IMPORTED OR NATIVE TOPSOIL AND SPREAD TO SIX INCHES (6") DEPTH
3. HYDROSEED WITH MIXTURE ACCORDING TO THE PROJECT SPECIFICATIONS.
4. WATER UNTIL SEEDING IS ESTABLISHED.
5. FLOODPLAIN SHELF RESTORATION MATERIAL SHALL BE REUSED EXISTING COBBLE MATERIAL FOUND ON SITE
6. FINISHED ELEVATION OF THE FLOODPLAIN SHELF RESTORATION SHALL MATCH GRADES FOUND ON THE GRADING PLAN.
7. ANY MATERIAL OTHER THAN EXISTING COBBLE MATERIAL FOUND ON SITE SHALL BE CONSIDERED UNSUITABLE FOR USE UNLESS APPROVED BY THE ENGINEER ON SITE.
8. ANY MATERIAL THAT IS PLACED AS FLOODPLAIN SHELF RESTORATION SHALL BE COMPACTED WITH EITHER AN EXCAVATOR AS IT IS PLACED OR WITH A ROLLER COMPACTOR. LIFTS SHALL NOT EXCEED 2 FEET IN HEIGHT.

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
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DESCRIPTION	DATE	BY

DETAILS

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 22 OF 25

SHEET NAME: D-2

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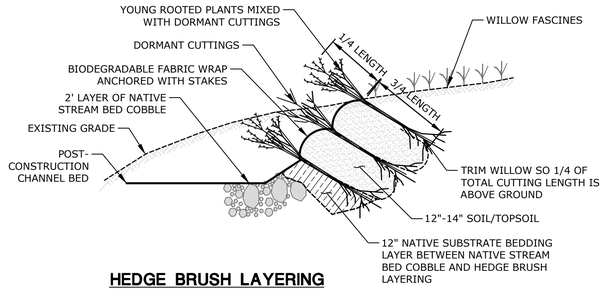
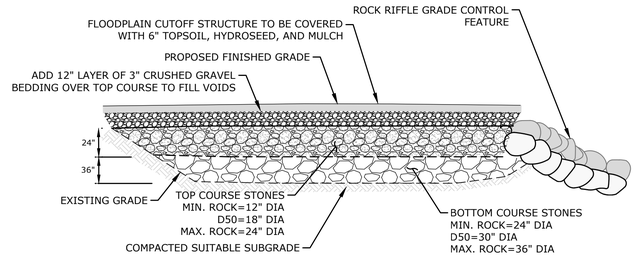


HEDGE BRUSH LAYERING

NOT TO SCALE

NOTES:

1. MIX TOPSOIL WITH BACKFILL TO ENHANCE GROWTH MEDIUM



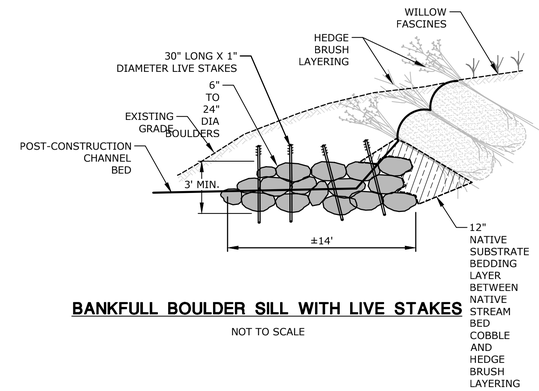
SECTION VIEW

NOTES:

1. SEE SHEET LA-2 FOR LAYOUT VIEW.
2. IF CLAY IS ENCOUNTERED DURING THE EXCAVATION OF THE FOOTING OF THE STRUCTURE, THE CLAY SHALL BE OVER-EXCAVATED AND DISPOSED OF OFF-SITE, AND A LAYER OF 3" CRUSHED GRAVEL BEDDING SHALL BE INSTALLED TO A DEPTH OF 12" PRIOR TO THE NORMAL CONSTRUCTION OF THE STRUCTURE.

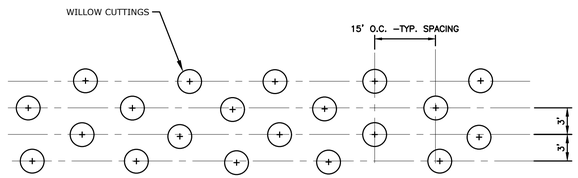
FLOODPLAIN CUTOFF FEATURE

NOT TO SCALE

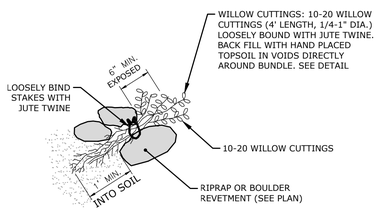


BANKFULL BOULDER SILL WITH LIVE STAKES

NOT TO SCALE



PLAN VIEW

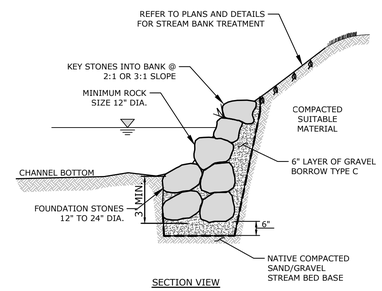


WILLOW CUTTINGS

NOTES:
1. WILLOW STAKES SHALL BE A SINGULAR WILLOW CUTTING

LIVE WILLOW CUTTING/STAKES

NOT TO SCALE

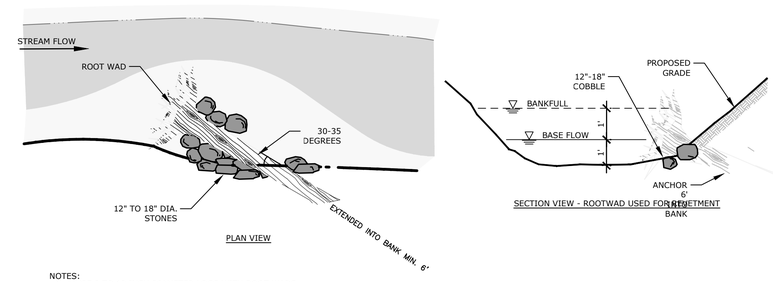


SECTION VIEW

NOTES:
1. USE 12" TO 24" DIAMETER WEATHERED ROUNDED STONES.
2. EMBED THE STONE SEVERAL INCHES INTO THE STREAM BANK TO KEY INTO THE BANK.
3. FINISHED ELEVATION OF THE STONES WILL BE DETERMINED IN THE FIELD.
4. STONES SHALL BE PLACED TO CREATE AN IRREGULAR EDGE.
5. PLACE BOULDERS TO IRREGULAR HEIGHT AND HORIZONTAL EXTENT INTO THE CHANNEL. REVETMENT SHALL NOT CREATE THE APPEARANCE OF A WALL.
6. EMBED THE FOUNDATION STONES A MINIMUM OF 3' BELOW THE CHANNEL THALWEG.

JOINT PLANTED BOULDER REVETMENT

NOT TO SCALE



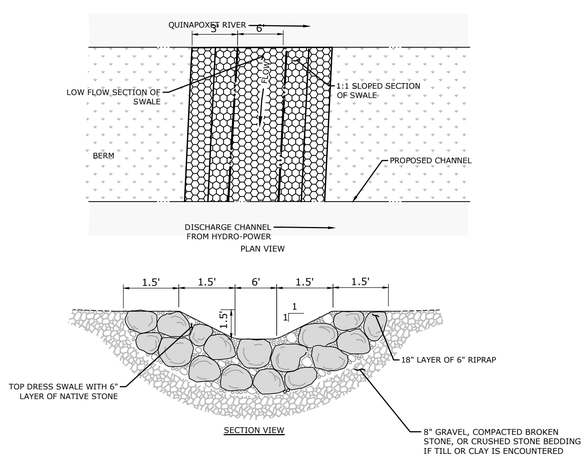
PLAN VIEW

SECTION VIEW - ROOTWAD USED FOR REVETMENT

NOTES:
1. USE 8 TO 12 INCH DIAMETER LOGS WITH ROOT WADS.
2. INSTALL THE LOG WITH ROOT WAD RESTING ON OR DRIVEN DOWN IN TO THE STREAM BOTTOM AT A 30-35 DEGREE ANGLE FROM THE STREAM BANK.
3. ANCHOR THE TRUNK AT LEAST 6 FEET INTO THE STREAM BANK.
4. USE 12" TO 18" DIAMETER STONES UPSTREAM AND DOWNSTREAM OF THE STRUCTURE TO PROTECT IT FROM EROSION. STONES SHALL BE ROUNDED RIVER STONES, AS APPROVED BY THE ENGINEER.
5. INSTALL AT A LOW PROFILE SUCH THAT THE TRUNK IS RESTING ON PROPOSED GRADE.
6. FINISHED ELEVATION OF THE ROOT WAD WILL BE DETERMINED IN THE FIELD.
7. CONTRACTOR TO FURNISH AND INSTALL ROOT WAD. WORK SHALL BE INCLUDED IN THE ITEM "INSTREAM FEATURES". CONTRACTOR SHALL RECEIVE APPROVAL FROM ENGINEER FOR USE OF SPECIFIC ROOT WADS.

ROOT WAD INSTALLATION

NOT TO SCALE

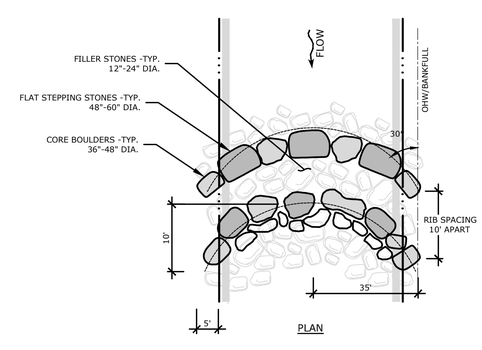


PLAN VIEW

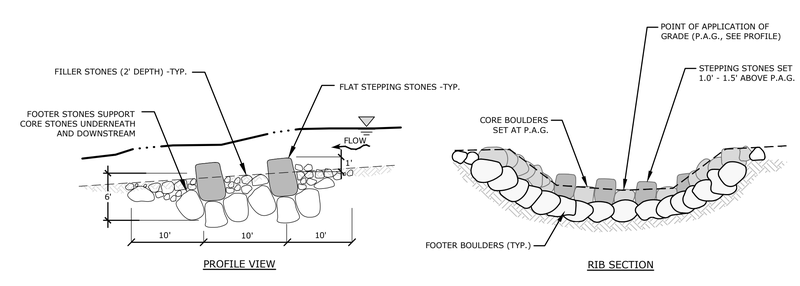
SECTION VIEW

HYDRAULIC INTERCONNECT FOR FISH

NOT TO SCALE



PLAN



PROFILE VIEW

RIB SECTION

FISH DETERRENT FEATURE

NOT TO SCALE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MBINC.COM

DESCRIPTION	DATE	BY

DETAILS

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	AWG	WAG
DESIGNED	DRAWN	CHECKED

SCALE: AS NOTED

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 23 OF 25

SHEET NAME: D-3

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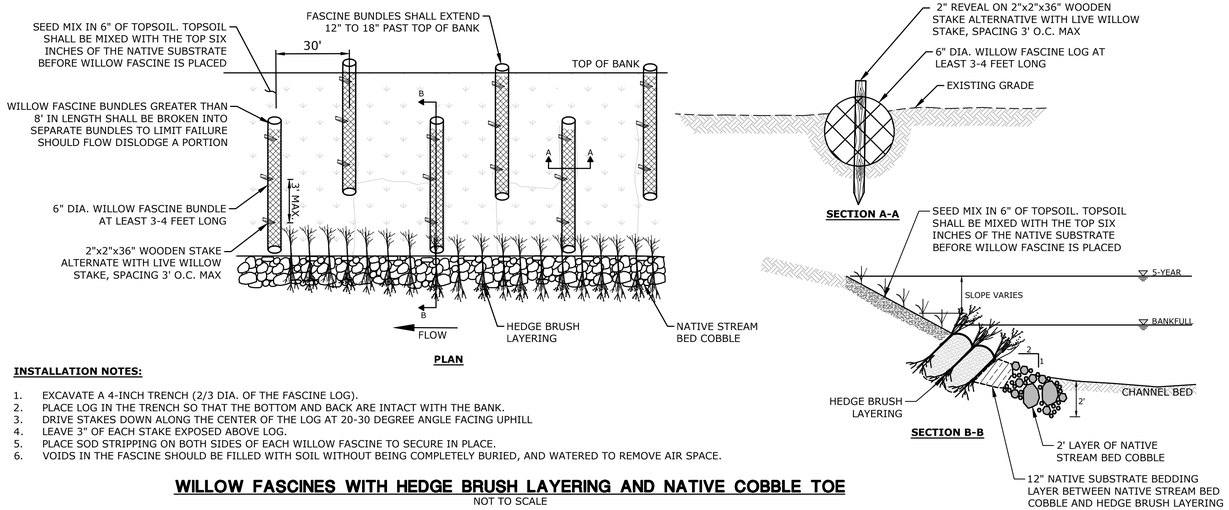
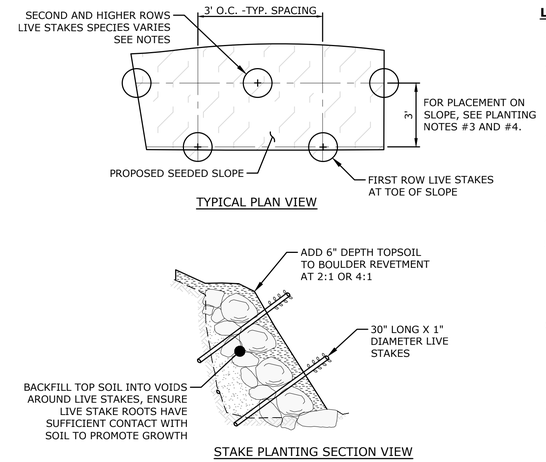


INSTALLATION NOTES:

1. EXCAVATE A 4-INCH TRENCH (2/3 DIA. OF THE FASCINE LOG).
2. PLACE LOG IN THE TRENCH SO THAT THE BOTTOM AND BACK ARE INTACT WITH THE BANK.
3. DRIVE STAKES DOWN ALONG THE CENTER OF THE LOG AT 20-30 DEGREE ANGLE FACING UPHILL
4. LEAVE 3" OF EACH STAKE EXPOSED ABOVE LOG.
5. PLACE SOD STRIPPING ON BOTH SIDES OF EACH WILLOW FASCINE TO SECURE IN PLACE.
6. VOIDS IN THE FASCINE SHOULD BE FILLED WITH SOIL WITHOUT BEING COMPLETELY BURIED, AND WATERED TO REMOVE AIR SPACE.

WILLOW FASCINES WITH HEDGE BRUSH LAYERING AND NATIVE COBBLE TOE

NOT TO SCALE

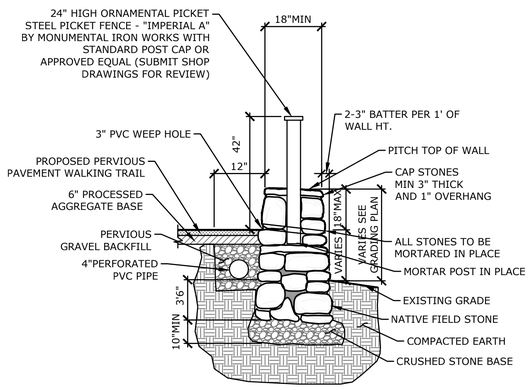


LIVE STAKE PLANTING NOTES:

1. INSTALL RIPRAP REVETMENT PER PLAN, AND PLACE 6 INCHES OF TOPSOIL AS SHOWN IN DETAIL.
2. ALONG THE TOE OF THE SLOPE (FIRST ROW), INSTALL 30" LONG X 1" DIAMETER PUSSY WILLOW (SALIX DISCOLOR) OR SIMILAR NATIVE WILLOW SPECIES SPACED 3' ON CENTER. THESE ARE TO BE INSERTED INTO PREDRILLED PILOT HOLES SLIGHTLY LARGER THAN THE STAKE DIAMETER AND BACKFILLED. STAKES SHOULD BE INSERTED TO 24" DEPTH.
3. HIGHER ON SLOPE (SECOND ROW), INSTALL 4' LONG X 1" DIAMETER LIVE STAKES OF PUSSY WILLOW (*SALIX DISCOLOR* OR SIMILAR NATIVE WILLOW SPECIES), SILKY DOGWOOD (*CORNUS AMOMUM),* RED-OSIER DOGWOOD *(CORNUS SERICEA)* AND GRAY DOGWOOD (*CORNUS RACEMOSA*) SPACED 3' ON CENTER. THESE ARE TO BE INSERTED INTO PREDRILLED PILOT HOLES SLIGHTLY LARGER THAN THE STAKE DIAMETER AND BACKFILLED. STAKES SHOULD BE INSERTED TO 36" DEPTH.
4. LIGHTLY TAMP TOPSOIL AROUND EACH STAKE AND SATURATE WITH WATER.
5. SEED BANK WITH A MIX CONSISTING OF NATIVE SPECIES THAT ARE AT LEAST MODERATELY DROUGHT TOLERANT, DO WELL ON POOR SOILS AND DEVELOP SUBSTANTIAL BELOW-GROUND BIOMASS. THE SLOPE SHOULD BE HAND RAKED TO SCARIFY THE SOIL SURFACE, THEN HAND SEEDED, HYDROMULCHED OR HAND SPREAD WITH A STRAW MULCH, AND RAKED LIGHTLY TO ENSURE SEED TO SOIL CONTACT. SEE SEEDING NOTES BELOW FOR SEED MIX COMPOSITION.
6. PLANT MATERIALS SHOULD BE PLANTED THE DAY THEY ARRIVE ON SITE. PLANTS AND CUTTINGS THAT CANNOT BE PLANTED THE DAY THEY ARRIVE SHALL BE STORED ON SITE UNDER A WET TARP TO PROTECT THEM FROM WIND, DIRECT SUNLIGHT, DRYING OR OTHER DAMAGE. CUTTINGS OR UNROOTED STOCK THAT IS NOT PLANTED WITHIN TWO DAYS AFTER ARRIVAL ON THE SITE SHALL BE DISCARDED UNLESS REFRIGERATED AT 40 TO 50 DEGREES FAHRENHEIT.
7. WILLOW SPECIES AND SOURCES SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION.

LIVE STAKE

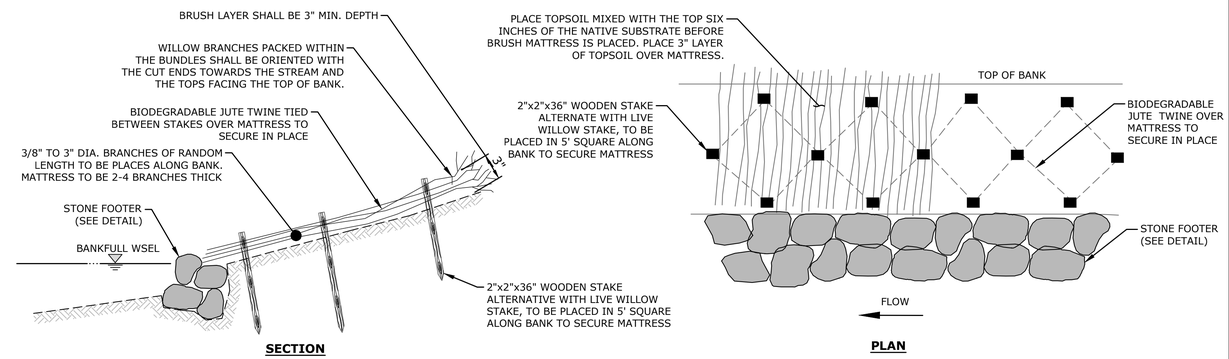
NOT TO SCALE



NOTES:
ALL MORTAR JOINTS SHALL BE DEEPLY RAKED AS TO AVOID MORTAR BEING SHOWN ALONG ANY EXPOSED WALL SURFACE. USE NATIVE FIELD STONE. STONE SHALL MATCH EXISTING FOUNDATION ON GRIST MILL. SUBMIT SAMPLES AND SHOP DRAWING FOR APPROVAL.

WALKING TRAIL STONE WALL & FENCE

NOT TO SCALE

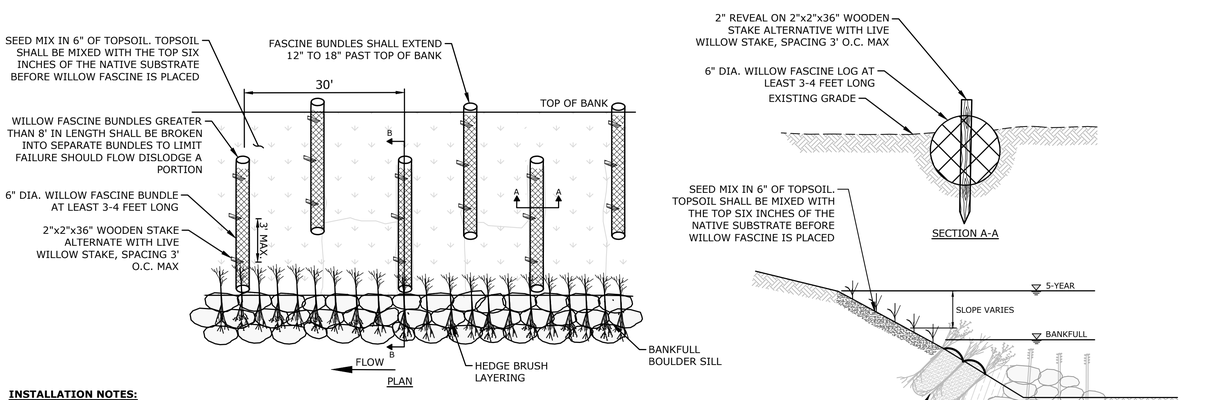


NOTES:

1. PLACE TOPSOIL MIXED WITH THE TOP SIX INCHES OF THE NATIVE SUBSTRATE BEFORE BRUSH MATTRESS IS PLACED.
2. PLACE MATERIAL WITH BASAL ENDS LOCATED TOWARDS BOTTOM OF SLOPE.
3. PLACE STAKES AT 5' SQUARE PATTERN TO SECURE MATTRESS.
4. SECURE MATTRESS MATERIAL WITH BIODEGRADABLE TWIN TIED TO 2"x2" STAKES.
5. PLACE 3" LAYER OF TOPSOIL OVER MATTRESS TO PROMOTE ROOTING OF MATERIAL, SEED AND MULCH.

BRUSH MATTRESS WITH STONE FOOTER

NOT TO SCALE

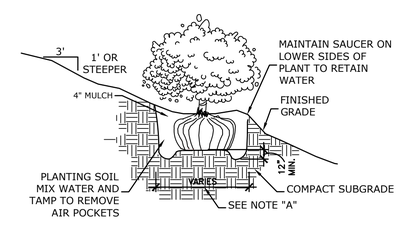


INSTALLATION NOTES:

1. EXCAVATE A 4-INCH TRENCH (2/3 DIA. OF THE FASCINE LOG).
2. PLACE LOG IN THE TRENCH SO THAT THE BOTTOM AND BACK ARE INTACT WITH THE BANK.
3. DRIVE STAKES DOWN ALONG THE CENTER OF THE LOG AT 20-30 DEGREE ANGLE FACING UPHILL
4. LEAVE 3" OF EACH STAKE EXPOSED ABOVE LOG.
5. PLACE SOD STRIPPING ON BOTH SIDES OF EACH WILLOW FASCINE TO SECURE IN PLACE.
6. VOIDS IN THE FASCINE SHOULD BE FILLED WITH SOIL WITHOUT BEING COMPLETELY BURIED, AND WATERED TO REMOVE AIR SPACE.

WILLOW FASCINES WITH BANKFULL BOULDER SILL

NOT TO SCALE

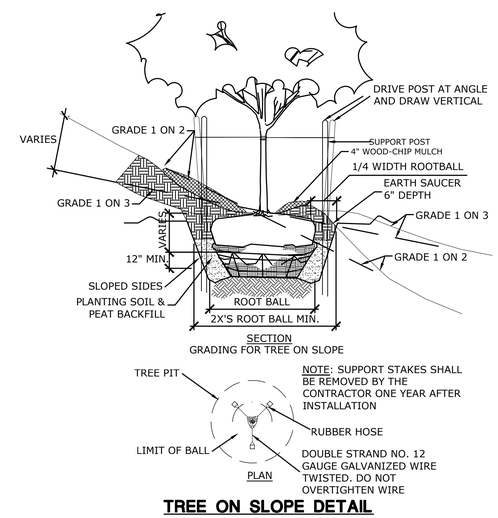


MULCHING OF PLANT BEDS:
UNLESS OTHERWISE DIRECTED SHREDDED MULCH SHALL BE PLACED TO A LIMIT OF ONE FOOT BEYOND THE CENTER OF THE OUTERMOST SHRUBS IN SHRUB BED.

NOTE "A":
FOR WIDTH SEE STANDARD SPECIFICATIONS

SHRUB ON SLOPE DETAIL

NOT TO SCALE



TREE ON SLOPE DETAIL

NOT TO SCALE

MILONE & MACBROOM
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
WWW.MMINC.COM

DESCRIPTION	DATE	BY

DETAILS
QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

DESIGNED	DRAWN	CHECKED
---	AWG	WAG

SCALE: AS NOTED
DATE: MAY 26, 2021
PROJECT NO.: 4673-03
SHEET NO.: 24 OF 25
SHEET NAME: D-4

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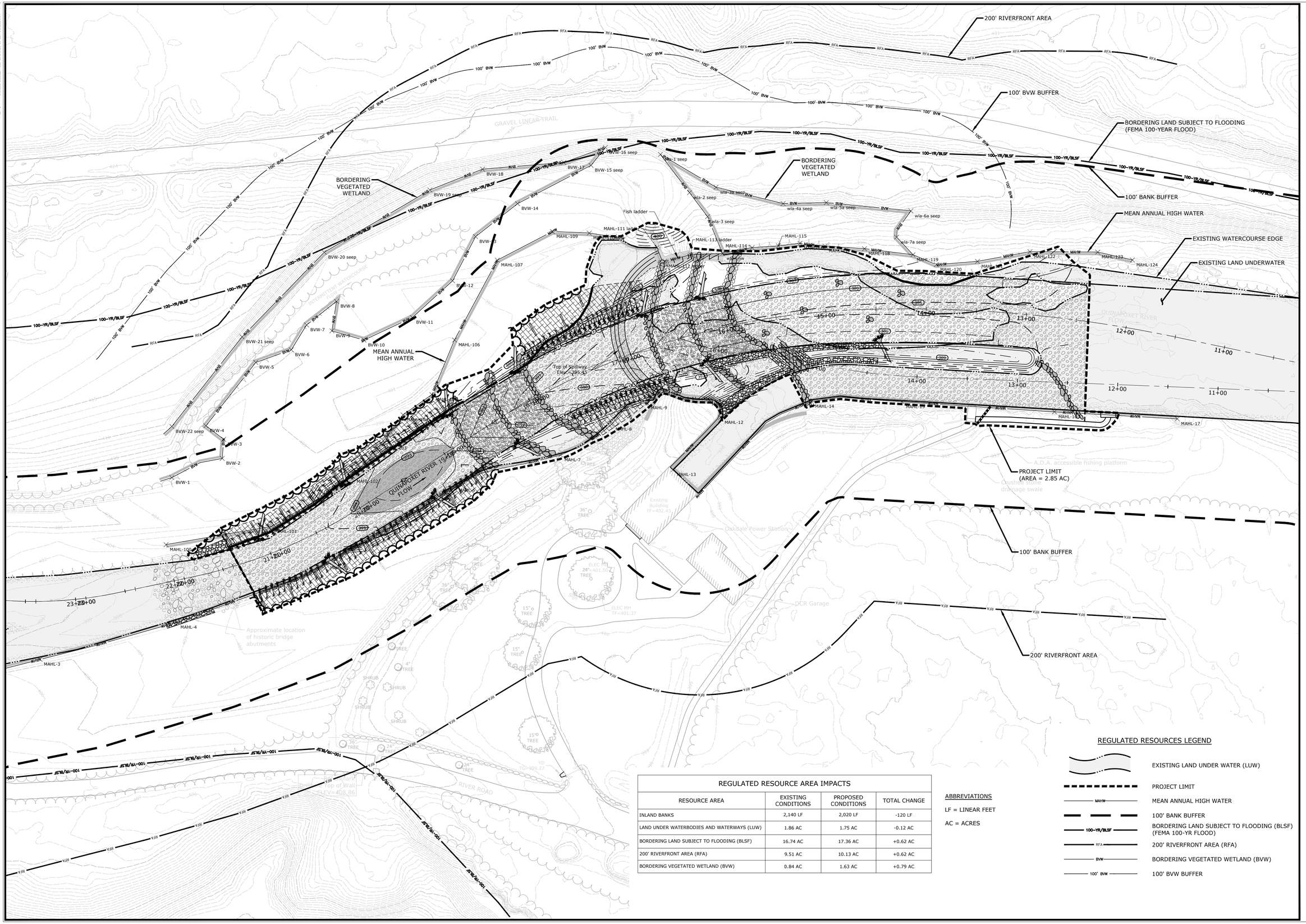

REGULATED RESOURCE AREA IMPACTS			
RESOURCE AREA	EXISTING CONDITIONS	PROPOSED CONDITIONS	TOTAL CHANGE
INLAND BANKS	2,140 LF	2,020 LF	-120 LF
LAND UNDER WATERBODIES AND WATERWAYS (LUW)	1.86 AC	1.75 AC	-0.12 AC
BORDERING LAND SUBJECT TO FLOODING (BLSF)	16.74 AC	17.36 AC	+0.62 AC
200' RIVERFRONT AREA (RFA)	9.51 AC	10.13 AC	+0.62 AC
BORDERING VEGETATED WETLAND (BVW)	0.84 AC	1.63 AC	+0.79 AC

ABBREVIATIONS

LF = LINEAR FEET

AC = ACRES

REGULATED RESOURCES LEGEND

- EXISTING LAND UNDER WATER (LUW)
- PROJECT LIMIT
- MAHW — MEAN ANNUAL HIGH WATER
- 100' BANK BUFFER
- 100-YR/BLSF — BORDERING LAND SUBJECT TO FLOODING (BLSF) (FEMA 100-YR FLOOD)
- RFA — 200' RIVERFRONT AREA (RFA)
- BVW — BORDERING VEGETATED WETLAND (BVW)
- 100' BVW — 100' BVW BUFFER

SLR
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773
SLRCONSULTING.COM

DESCRIPTION	DATE	BY

REGULATED RESOURCES

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

---	CME	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: MAY 26, 2021

PROJECT NO.: 4673-03

SHEET NO.: 25 OF 25

SHEET NAME: RR-1

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APPENDIX C

2020 BASIS OF DESIGN

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

Quinapoxet Dam Removal
Basis of Design Report (60% Design)

At Wachusett Reservoir
West Boylston, Massachusetts
November 2020

Prepared for:
The Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue, Building 39
Boston, MA 02129

MMI #4673-03-03

Prepared by:
MILONE & MACBROOM, INC.
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.mminc.com

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Appendix D HYDRAULIC COMPUTATIONS

ABBREVIATIONS/ACRONYMS AND DEFINITIONS

AHS	Archeological and Historical Services, Inc.
CFS	Cubic Feet per Second
3D	three-dimensional
DCR	Massachusetts Department of Conservation and Recreation
DEM	Digital Elevation Model
DER	Commonwealth of Massachusetts Division of Ecological Restoration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
Fps	feet per second
GCP	Ground Control Point
GPS	Global Positioning System
HEC-RAS	Hydrologic Engineering Center – *River Analysis System*
LiDAR	Light Detection and Ranging
MCP	Massachusetts Contingency Plan
MHC	Massachusetts Historical Commission
MMI	Milone & MacBroom, Inc.
MWRA	Massachusetts Water Resources Authority
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NLCD	National Land Cover Dataset
PNF	Project Notification Form
sUAS	Small Unmanned Aerial System
STA	River Station
USACE	United States Army Corps of Engineers
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey

1.0 INTRODUCTION

The Massachusetts Water Resources Authority (MWRA) has retained Milone & MacBroom, Inc. (MMI) to design, permit, and assist in the construction of a dam removal project for the Quinapoxet Dam in West Boylston, Massachusetts. The dam is located on the Quinapoxet River, upstream of the Wachusett Reservoir, and is part of the water supply infrastructure for the City of Boston.

1.1 Project Goals

The goals of the project include the restoration of free passage of fish and wildlife, naturalization of riverine hydrology, management of sediment during and after construction, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without impacting the MWRA and Massachusetts Department of Conservation and Recreation (DCR) water supply mission, the operations of the Quabbin Interflow Shaft #1, or the downstream Wachusett Reservoir.

1.2 Feasibility Study

A substantial amount of data collection and preliminary analysis was performed in 2016 as part of a Feasibility Study conducted by MMI to determine if removal of the dam will meet the stated project goals. MMI was retained by the Commonwealth of Massachusetts Division of Ecological Restoration (DER) to conduct a feasibility study and provide conceptual-level hydraulic modeling for the removal of the Quinapoxet Dam.

The study provided a detailed and in-depth look at the existing condition of the Quinapoxet River, its beds and banks, the condition of the dam, and critical success factors related to removal of the dam including fish passage through the former dam site, sediment management, and river stability of the postdam-removal channel and banks.

The 2016 Feasibility Study is included with this Basis of Design report in Appendix A.

1.3 Basis of Design

As part of the 2016 Feasibility Study, three conceptual channel configurations were explored for the postdam-removal conditions, the third of which was chosen as the preferred alternative if the project were to proceed. As part of the current work effort, the preferred alternative was used as a starting point and advanced. Because the basis of the design for this alternative was described in the Feasibility Study and remains relatively unchanged, information and analysis that was presented in the Feasibility Study will not be repeated here. This Basis of Design Report will only present new information, data collection, survey, analysis, computations, or design as it relates to the advancement of the dam removal design from Conceptual Design to 60% Preliminary Design.

2.0 PRELIMINARY DESIGN DATA COLLECTION

Topographic and bathymetric survey were performed in support of the Feasibility Study (MMI, 2016). To supplement and update the survey, additional data was collected in 2020 by MMI as described below.

2.1 UAS Flight

On May 28, 2020, MMI performed aerial photography of the project site. Using a small Unmanned Aerial System (sUAS), georeferenced photographs were captured along a grid-style collection area.

Ground Control Points (GCP) were placed during the flight and collected by traditional topographic survey by MMI on June 12, 2020. These points were used to georeference the aerial survey and ensure that the data would be accurately referenced horizontally in the North American Datum of 1983 (NAD83) and vertically in the North American Vertical Datum of 1988 (NAVD88).

The photogrammetry survey was performed by collecting both Global Positioning System (GPS) data and aerial imagery with a DJI Phantom 4 Pro UAS (DJI, 2017) and postprocessing the data with the *PIX4D Mapper* software (Pix4D SA, 2019) to develop a three-dimensional (3D) computer model of the project site. This model was downsampled, and 1-foot topographic contours were exported and used to update the basemapping. Planimetric features were also digitized from the data.

The updated basemapping was used as the basis for further design.

2.2 Historical and Archeological Investigation

As part of the commonwealth and federal permitting, it is required that any dam removal project be reviewed by the Massachusetts Historical Commission (MHC) for compliance with Section 106 of the National Historic Preservation Act. In order to meet this requirement, Archeological and Historical Services, Inc. (AHS) Cultural Resource Management was contracted to perform Cultural Resource Assessment and Examination Surveys on the subject parcel.

At the time of writing, this process is ongoing, and a Project Notification Form (PNF) has been submitted to MHC to initiate preapplication correspondence. The process will be ongoing and described in further detail when complete.

Preliminary site surveys did, however, discover the presence of two historical stone masonry bridge abutments at the upstream limits of the proposed project. The limits of the abutments have been identified and added to the basemapping, and the proposed work was revised to avoid disturbance of the abutments.

3.0 HYDRAULIC ANALYSIS

Hydraulic analysis of the Quinapoxet River at the project site was completed using version 5.0.7 of the *River Analysis System* software produced by the United States Army Corps of Engineers' (USACE) Hydrologic Engineering Center (HEC-RAS). A two-dimensional hydraulic model was developed to assess the complex hydrodynamics encountered where the river meets the tailwaters of the Quabbin aqueduct and the Wachusett Reservoir. Flows are computed across a two-dimensional network of cells upon a 3D terrain surface. Water surface elevations, flow depths, and velocities are computed at cell nodes and faces based on the St. Venant shallow-water approximations of the Navier-Stokes equations for 3D fluid flow, as numerically discretized by HEC. Boundary drag is computed based on Manning's roughness coefficients applied to the terrain. Output from the model is summarized below, and information relative to the model is attached In Appendix C.

3.1 Existing Conditions Modeling

A composite existing conditions terrain surface was developed using UAS-based photogrammetric mapping, supplemented by traditional terrestrial survey and Light Detection and Ranging (LiDAR)-derived topographic mapping. UAS survey was conducted in 2020 by MMI as described in Section 2.1 and covers approximately 8 acres surrounding the dam. Ground survey was completed by MMI on April 16 and 29, 2015, and included detailed survey of the dam, training walls, and 10 hydraulic cross sections upstream and downstream of the dam. One-meter grid resolution LiDAR-derived Digital Elevation Model (DEM) files are available from the MassGIS "OLIVER" data clearinghouse; mapping of this area was conducted in 2011. Approximate bathymetry for Quinapoxet and Thomas Basins in the Wachusett Reservoir was gleaned from publicly available bathymetry data provided by Navionics, Inc. The elevations in the model are referenced to NAVD 1988.

Approximately 8,000 linear feet of the Quinapoxet River were modeled, covering 250 acres of the Quinapoxet valley, including Quinapoxet Basin and over 25 acres of Thomas Basin. Nominal node spacing within the model domain was set to 20 feet, with a refined 12- to 15-foot hexagonal mesh within the channel and immediate overbanks of the Quinapoxet River. Breaklines define hydraulically significant terrain features along critical edges. Manning's roughness coefficients were assigned based on land cover type as identified in the 2016 National Land Cover Dataset (NLCD) for Massachusetts (Dewitz 2019) and confirmed by field reconnaissance. Regions were overridden as necessary where cover type was misidentified; generally this was limited to correcting areas of the stream channel that had been obscured by vegetation. Roughness values were based on assessment of on-site conditions, literature guidance (e.g., Chow 1959, USGS WSP 2339, USGS WRIR 83-4247), and engineering judgment (Table 3-1).

TABLE 3-1
Terrain Roughness Coefficients by Land Cover Type
(as Identified in 2016 NLCD)

Land Cover	Manning's *n*
Barren	0.025
Cultivated	0.06
Deciduous Forest	0.1
Developed Open Space	0.03
Evergreen Forest	0.1
Grassland	0.05
Impervious	0.02
Palustrine Aquatic Bed	0.07
Palustrine Emergent Wetland	0.08
Palustrine Forested Wetland	0.09
Palustrine Shrub/Scrub Wetland	0.1
Pasture/Hay	0.05
Scrub/Shrub	0.055
Open Water	0.06
Quinapoxet River	0.04 – 0.06

An inflow boundary condition for the Quinapoxet River was applied at the Interstate 191 bridge, about 1 mile upstream of the dam. Inflow from the Quabbin aqueduct was represented by an internal boundary condition at the outlet of the Oakdale powerhouse. A static water surface elevation boundary condition of 384.0 feet was set within the Thomas Basin of the Wachusett Reservoir, roughly 500 feet east of the railroad causeway. The Quinapoxet Dam is represented as an internal connection along its 140-foot arc, with flow computed in one dimension across the 6.5-foot-wide ogee weir (C_d = 3.9). The weir crest was set to a uniform elevation of 395.45 feet.

Hydrologic assessments performed during the Feasibility Study resulted in the estimation of 11 steady-state design flow events on the Quinapoxet River, listed in Table 3-2. Each of these was modeled under three independent discharge conditions from the Quabbin aqueduct: 0 cubic feet per second (cfs), 250 cfs, and 500 cfs. August Median Flow and May Mean Flow were used to assess fish passage during anticipated summer low-flow conditions and the higher flows expected during springtime spawning conditions, respectively.

TABLE 3-2
Modeled Flow Conditions on the Quinapoxet River

Flow	cfs
100-Year Flood	3,040
10-Year Flood	1,790
5-Year Flood	1,475
Bankfull Flow	830
99% Duration Flow	3.2
M7D2Y Low Flow	6.5
M7D10Y Low Flow	3.0
August Median Flow	13.3
May Mean Flow	88
85% Duration Flow	10
15% Duration Flow	120

4.0 DAM REMOVAL AND CHANNEL RESTORATION

The Quinapoxet Dam was constructed as an accretion-style dam and was built by overexcavation and dredging of the downstream portion of the channel as opposed to more traditional dams, which are constructed on the bed of the channel to impound water. Various dam removal alternatives were explored during the Feasibility Study phase; however, to protect the integrity of the downstream infrastructure, the majority of the material that was excavated downstream of the dam cannot be replaced as part of a restored channel.

Therefore, the primary constraint in the evaluated alternatives was the need to create a steeper channel than would form naturally upstream of the former dam location while mitigating the erosive forces generated under these conditions. The channel must also provide suitable flow velocities and depths for aquatic organism passage, especially during time periods that are critical for survival and spawning success for freshwater fish.

In order to avoid impacting the hydraulics or the operations of the Quabbin aqueduct or Oakdale powerhouse, the existing abutment walls and berms along the river's southern bank were retained, and a peninsula dividing the primary river channel from the Quabbin outlet is proposed. This longitudinal embankment from River Station (STA) 17+00 to STA 13+00 effectively establishes a tailrace channel for the Quabbin aqueduct, isolating its tailwaters from the proposed regrading of the Quinapoxet channel. Fish deterrent features, intended to discourage fish from being attracted to the cold discharge from the powerhouse, were incorporated into the terrain surface of the model as was an exit channel for those fish that do enter the proposed tailrace.

Proposed geometry of the postdam-removal channel reflects a bankfull channel base width of 80 feet in pool sections and 50 feet in riffles. Bankfull depth at the proposed riffles was established as approximately 2 feet. The proposed channel morphology consists of a riffle-pool geometry that involves grading from an upstream limit of STA 20+50 (which is located downstream of the historical stone bridge abutments), downstream to STA 13+00. Establishing a naturalized channel profile requires both removal of material upstream of the dam as well as placement of fill extending approximately 80 feet downstream of the former dam's location.

Two proposed boulder riffles act as robust grade controls and along with other proposed channel roughness features provide the critical functions of diffusing kinetic energy and resisting the erosive forces expected along this reach. They also provide refugia and habitat for aquatic organisms.

The proposed pool between STA 19+00 and STA 20+50 has a low point 2 feet deeper than the bed elevation at the riffle crest, a total length of 150 feet, and an upstream slope of 3.4%. The proposed riffles are centered approximately 220 feet apart and are 100 and 50 feet in length, respectively. The upstream riffle has a slope of 4%, with three boulder ribs that protrude 1 foot from the nominal channel bed elevation. The channel then shallows to 2% for just over 100 feet before dropping into the downstream boulder riffle at 4%, then shallows considerably. The proposed grading ties into the existing downstream channel at a slope of 0.15%.

The proposed means of postrestoration bank stabilization consists of a combination of treatments and features appropriate for anticipated hydraulic conditions at their respective locations. Robust

boulder revetment is proposed in critical areas with higher velocities while more natural, bioengineered bank treatments can be implemented in areas where erosive forces are less severe. Details regarding the design and analysis of the banks can be found in Section 4.4.

Engineering plans for the project are included in Appendix B.

4.1 Proposed Conditions Modeling

Proposed conditions modeling was generated from a finalized existing conditions model, which was copied and manipulated to reflect the proposed changes at the project site. These include dam removal and grading within the channel and overbank areas. The one-dimensional internal connection representing the dam was removed from the model geometry; breaklines and cell faces were realigned as necessary to accurately capture the proposed channel features that were incorporated into the terrain. Manning's roughness coefficients within the channel were modified to reflect the proposed conditions where appropriate.

Modeling results indicate that the proposed riffle-pool channel geometry is effective at distributing the highest velocities and shear stresses at the robust boulder features that are able to withstand them and that the river's turbulent energy is dissipated in the intermediate pools.

The proposed embankment is effective at isolating the Quabbin aqueduct tailwaters from the restored river channel, avoiding adverse impacts on operation of the Oakdale powerhouse. Sections of the tailrace peninsula downstream of the fish exit channel are modeled as overtopping in events exceeding the estimated bankfull flow; however, its functionality is not compromised under these conditions. During floods and the more substantial high flow events, a tailwater control on the Quinapoxet River is established by the Wachusett Reservoir that propagates upstream to the dam and powerhouse, exacerbated by the constrictions at the causeways that form the Thomas and Quinapoxet Basins. The proposed restored channel maintains velocity through the reach, resulting in reduced water surface elevations for several hundred feet downstream of the dam, slightly mitigating this condition at the powerhouse.

4.2 Effect of Dam Removal on Fish Passage

Consideration must be given to the channel restoration relative to the creation of aquatic habitat for the target species such as trout and landlocked salmon.

The existing dam prevents fish passage from the downstream reservoir into the upper reaches of the Quinapoxet River. This inhibits native species of fish from accessing miles of their natural habitat. Elements, features, and methods were incorporated into the proposed channel such that the restored conditions are expected to substantially improve fish passage through the site. Referring to a reference reach is a valuable tool when attempting to match the passability of natural conditions in a river restoration project. A pool-riffle reach approximately half of a mile upstream of the project site was assessed and used as a reference reach, where riffle-to-riffle spacing was measured as approximately 150 feet, and slope was measured as approximately 2 percent. The reference geometry, including riffle-to-riffle spacing, slope, and bankfull dimensions, was used to develop the proposed conditions. The United States Fish & Wildlife Service (USFWS) has performed a site assessment of the existing dam, which involved observing the selected

reference reach, and was in agreement as to its appropriateness and similarity to target conditions on the subject reach.

Using parameters provided by the USFWS, the hydraulic modeling results of each alternative were assessed relative to its suitability for fish passage for landlocked salmon (see Table 4-1). Hydrology was assessed by compiling flow information from United States Geological Survey (USGS) gauge No. 01095375 on the Quinapoxet River at Canada Mills near Holden, Massachusetts. Daily flow data were analyzed, and the May mean flow and August median flow were used to represent the higher and lower flow periods expected during critical periods for fish spawning and survival, respectively. The May mean flow was computed as 88 cfs, and the August median flow was computed as 13 cfs. Modeled flow velocities under these flows, with a 500 cfs discharge from the Quabbin aqueduct, are presented in Figures 4-1 and 4-2, respectively.

TABLE 4-1
Summary of Physical Abilities of Landlocked Salmon

Physical	Body length	12		18		in
	% Body Depth	0.2		0.2		
	Body Depth	2.4		3.6		in
	Frontal Area	4.52		10.18		in2
Swim Speed	Cruising	1.3	2.3	2.0	3.5	ft/s
	Prolonged	4	7	6	10.5	ft/s
	Burst	8	14	12	21	ft/s
Fatigue Time	Cruising					sec
	Prolonged	300	300	300	300	sec
	Burst	5	5	5	5	sec
Fatigue Distance	Cruising	INF	INF	INF	INF	ft
	Prolonged	2400	4200	3600	6300	ft
	Burst	20	35	30	52.5	ft

The hydraulic modeling indicates that postdam-removal velocities will be favorable for habitat creation even under low-flow conditions. The proposed pools provide year-round aquatic organism habitat, and the low-flow channel enables fish passage in predicted lower flow conditions based on the criteria in Table 4-2. Under higher springtime flows, modeled flow depths and velocities remain manageable for target freshwater fish species throughout the modified reach. Passage through the restored reach is expected to be dramatically improved, but flow depths may be only marginally improved at certain locations and discharge events (Figures 4-3 and 4-4). Hence, the proposed deeper pool areas, boulder clusters, and low-flow channel are intended to provide refugia even during drought conditions. These features will help achieve the project goal of restoring the river to a quasinatural state in terms of both hydraulic performance and aquatic habitat capacity.

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Proposed Conditions - May Mean Flow Velocity

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N

0 100
Feet

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FIG. 4-1

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Proposed Conditions - August Median Flow Velocity

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N

0 100
Feet

SCALE	1 " = 100 '
DATE	2020-11-06
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FIG. 4-2

TABLE 4-2
Fish Passage Requirements for Target Species

Parameter	*Atlantic Salmon (Salmo salar)*	*Eastern Brook Trout (Salvelinus fontinalis)*	*Brown Trout (Salmo trutta)*	*Rainbow Trout (Oncorhynchus mykiss)*
Life Stage	Adult	Adult		
Life Strategy	Anadromous	Freshwater		
Thermal Regime	Coldwater	32 - 77°F		
Spawning Temperatures (°F)	36.4 - 42.0°F	38 - 45°F		
Spawning Habitat	Gravel riffle areas	High elevation lakes and streams		
Major Run	May – mid July	April – July (juvenile)		
Minor Run	September – October	October – December (adult)		
Sustained Swimming Speed (fps)	5.0-8.8	2.0-7.2		
Minimum Depth (in)	5.7-6.6	5.0-6.0		
Time of Migration	Diurnal	---		

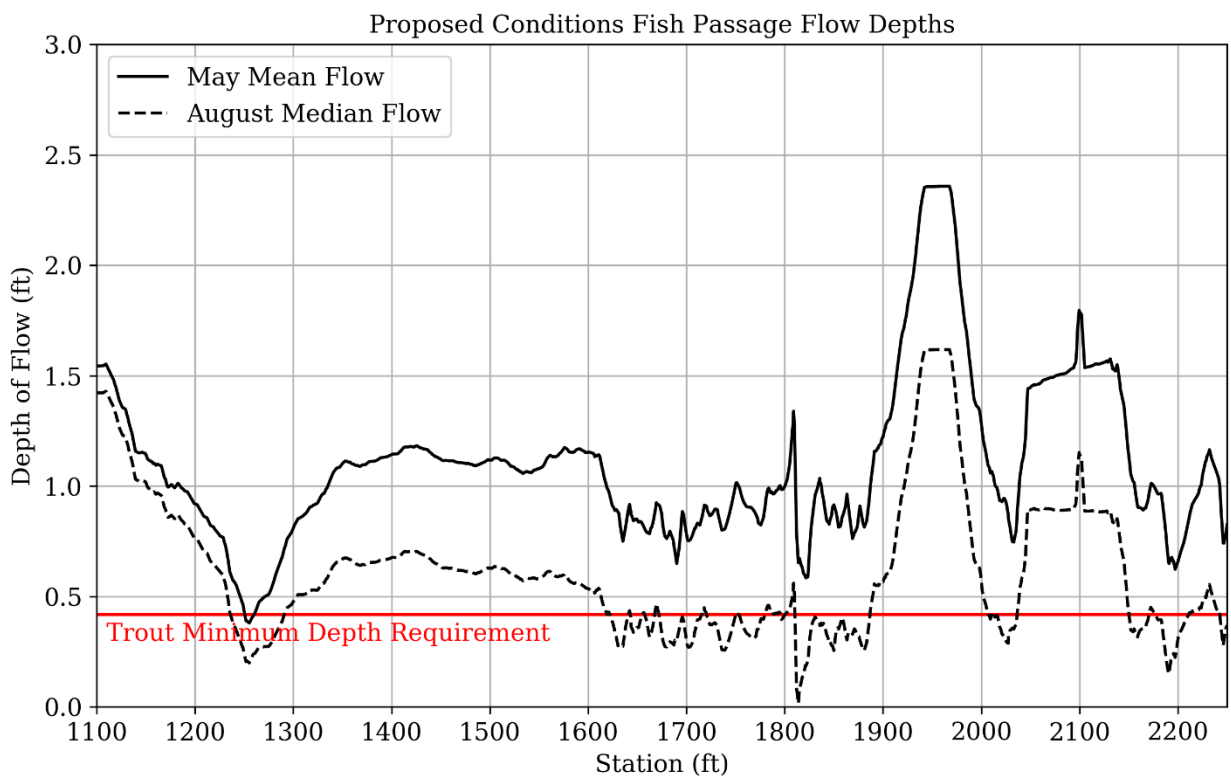

Figure 4-3: Flow depths under projected springtime higher flows and summertime lower flows, critical periods for fish passage

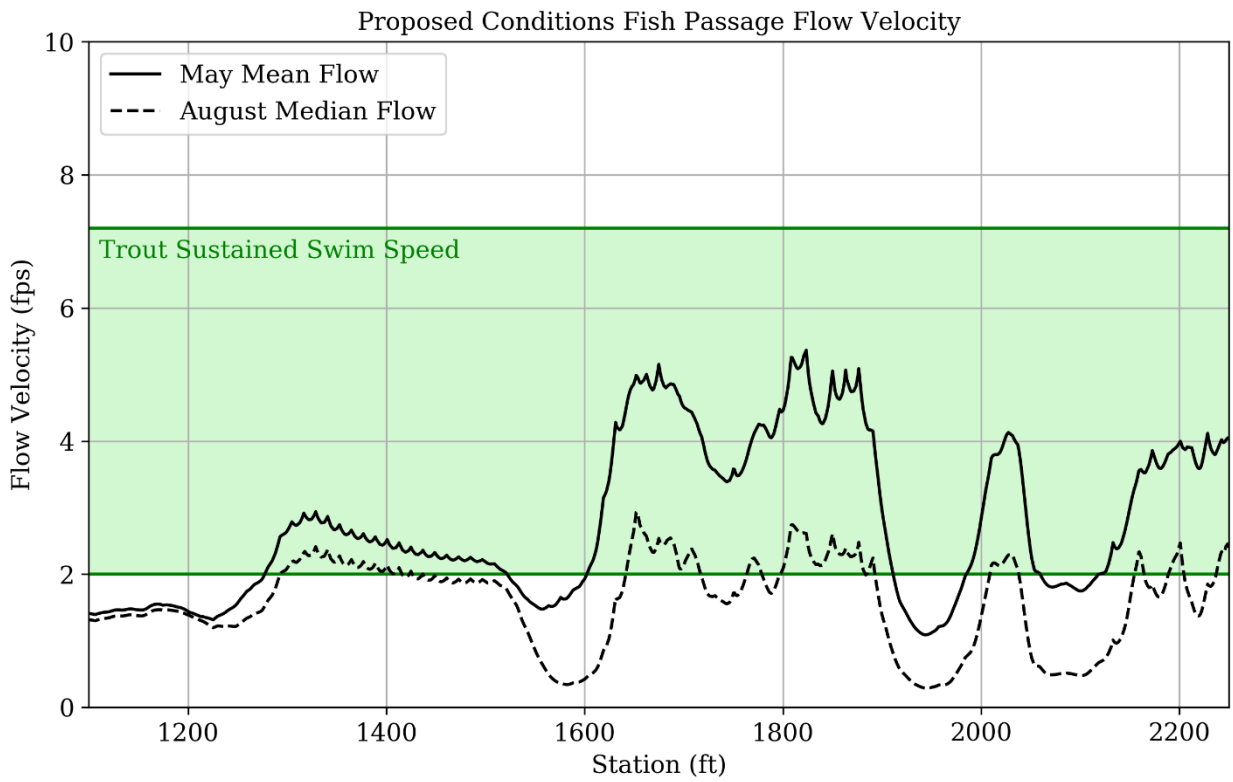

Figure 4-4: Flow velocities under projected springtime higher flows and summertime lower flows

The proposed fish deterrent features and an exit passageway from the tailrace may help keep fish from approaching the powerhouse discharge. Proposed fish deterrents were devised following assessment of existing hydrodynamics so as to avoid additional tailwater influence on the aqueduct. Nominal elevations of these irregular boulder structures were set to the normal water surface elevation of the Wachusett Reservoir (EL 384.0 feet) and located 150 feet and 375 feet downstream of the powerhouse. While flows are necessarily influenced by these features, there are no significant detriments to tailwater conditions, as demonstrated in Figure 4-5. In addition to acting as physical barriers, these features also generate high-flow velocities that may further dissuade fish from entering the tailrace, especially when the Quabbin aqueduct is discharging during low-flow conditions on the Quinapoxet River.

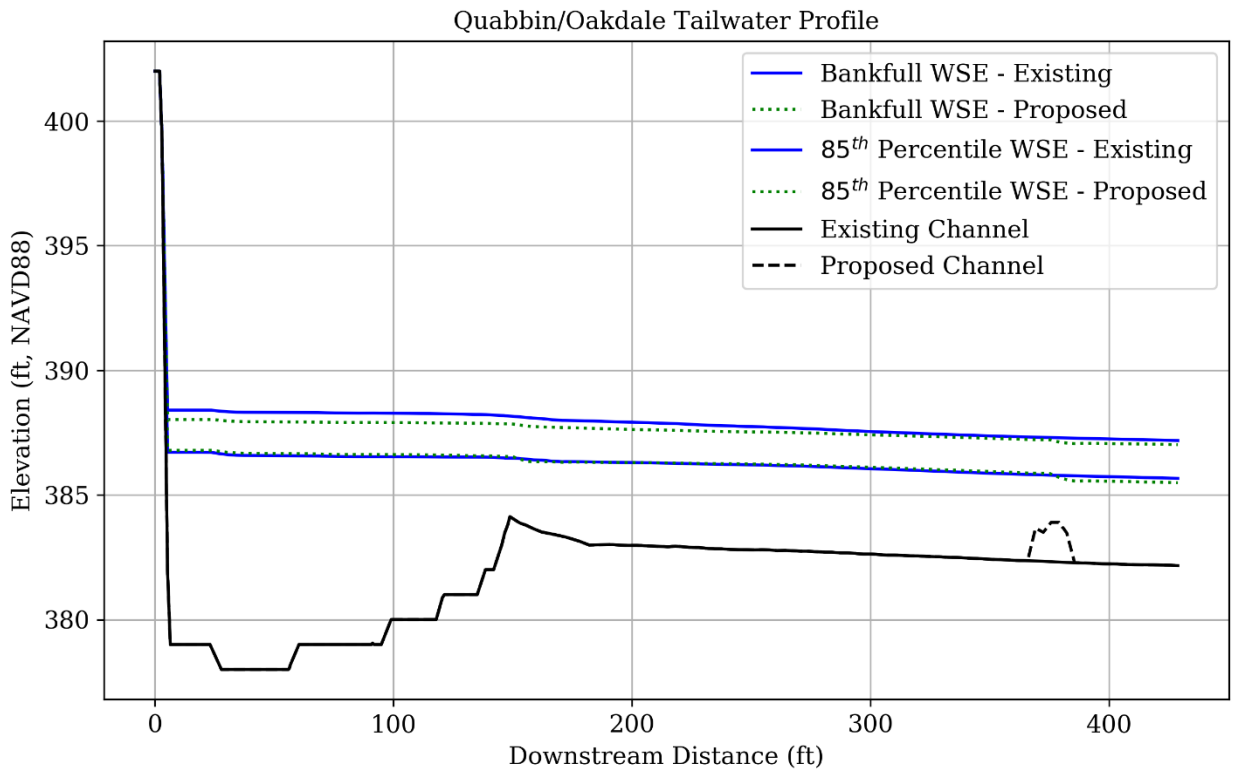

Figure 4-5: Tailwater profile downstream of the Oakdale powerhouse outlet of the Quabbin aqueduct. Bankfull flows (830 cfs) and the 85th percentile duration flows (10 cfs) are plotted under existing and proposed conditions, with a 500 cfs discharge from the aqueduct.

4.3 Channel Bed Stability Assessment

The proposed conditions modeling predicts that water velocities through the restored channel reach will increase following dam removal. Erosion occurs when the hydraulic forces in the flow exceed the resisting forces of the channel boundary (Fischenich, USACE). Permissible, or critical, velocity is defined as the maximum velocity for the channel that will not cause erosion of the channel boundary. Table 4-3 is a summary of boundary types and permissible velocities per the USACE Fischenich report. These values are useful in evaluating the stability of channel banks given estimated velocities and known bank material.

TABLE 4-3
Substrate Types and Permissible Velocities

Substrate Type	Substrate Size	Permissible Velocity (ft/sec)	Permissible Shear Stress (lb/sq ft)
Gravel/Cobble	2-in.	3-6	0.67
	6-in.	4-7.5	2.0
	12-in.	5.5-12	4.0
Riprap	6-in. d_{50}	5-10	2.5
	9-in. d_{50}	7-11	3.8
	12-in d_{50}	10-13	5.1
	18-in d_{50}	12-16	7.6
	24-in d_{50}	14-18	10.1

The highest velocities and shear forces are predicted near the center of each riffle feature. Velocities of up to 14 feet per second and shear stresses of up to 6.1 pounds per square foot are expected across the boulder riffle crests during the estimated 100-year flood. In this event, velocity in the proposed pool is up to 8.5 feet/second with shear stresses under 2 lbs/ft^2. Modeled channel shear stress along the proposed channel thalweg is presented graphically in Figure 4-6 while two-dimensional shear stress distributions are mapped in Figures 4-7 and 4-8.

The Fischenich study does not include 48-inch-diameter boulders in its permissible shear and velocity table; however, 24-inch-diameter riprap is capable of withstanding all the velocities and shear stresses predicted for the project reach in up to the 100-year flood. The stone riffles are proposed to be constructed with 36-inch to 48-inch-diameter core boulders and 12-inch to 36-inch filler stone to provide for an additional safety factor against displacement and for added channel protection. Channel bed material within the pool areas would need to tend toward the larger gravel/cobble gradations in order to remain stable in the modeled 100-year flood.

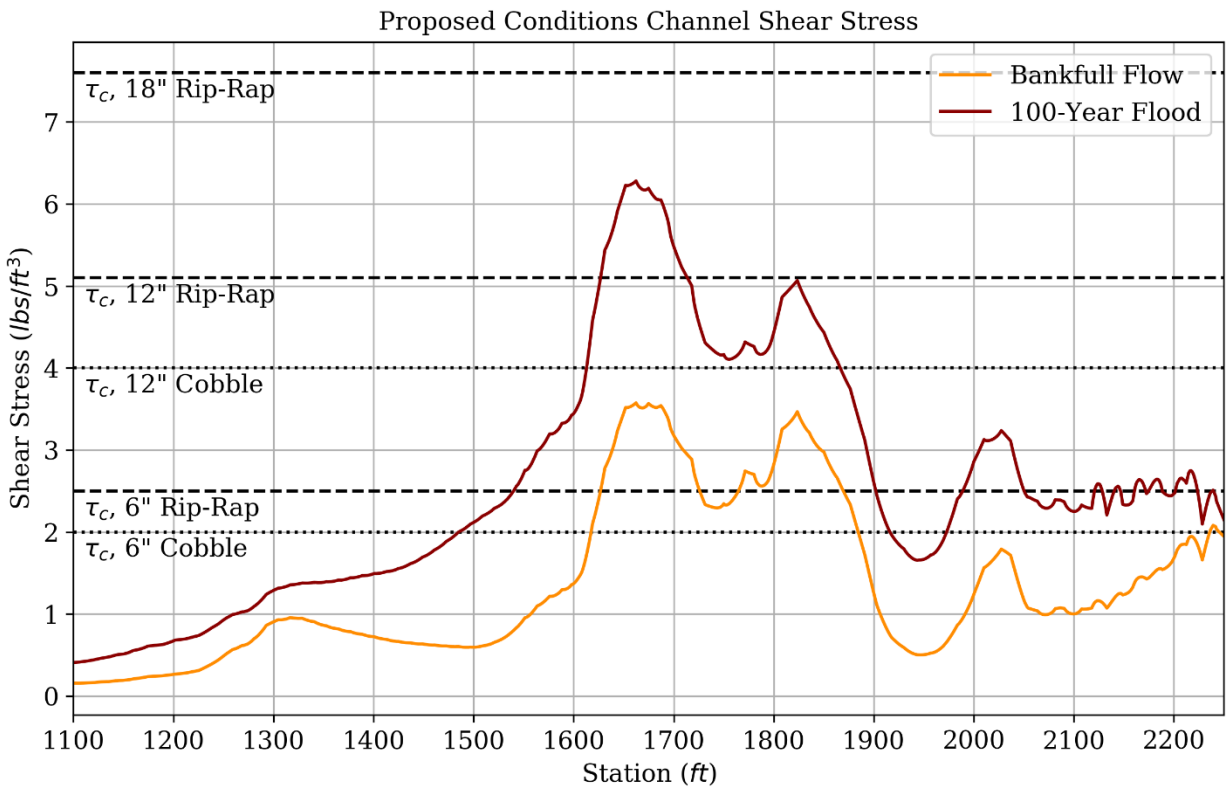

Figure 4-6: Modeled shear stresses acting on the channel bed under proposed conditions for estimated bankfull flow and 100-year flood flow

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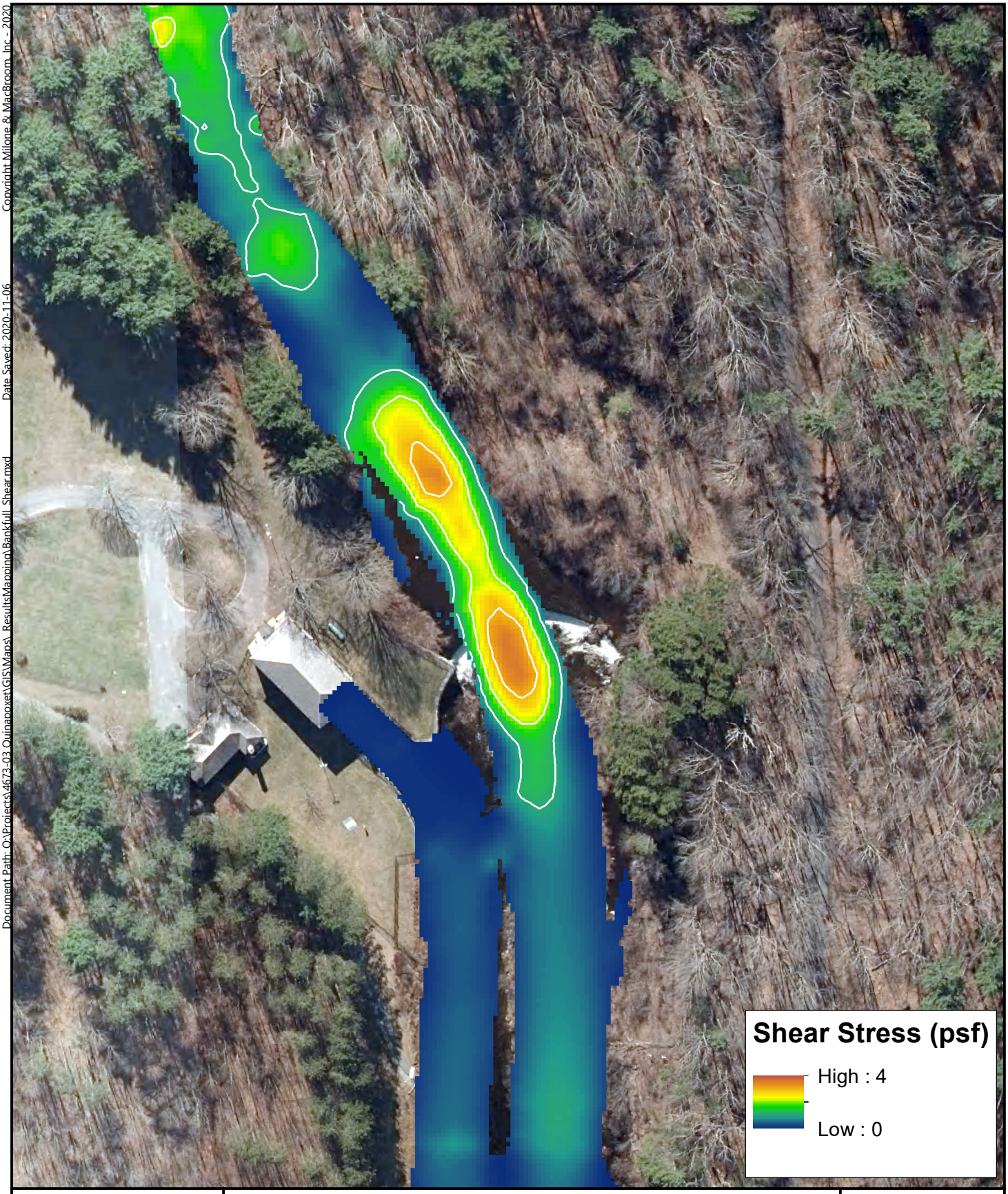

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Proposed Conditions - Bankfull Flow Shear Stress

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N

0 100
Feet

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FIG. 4-7

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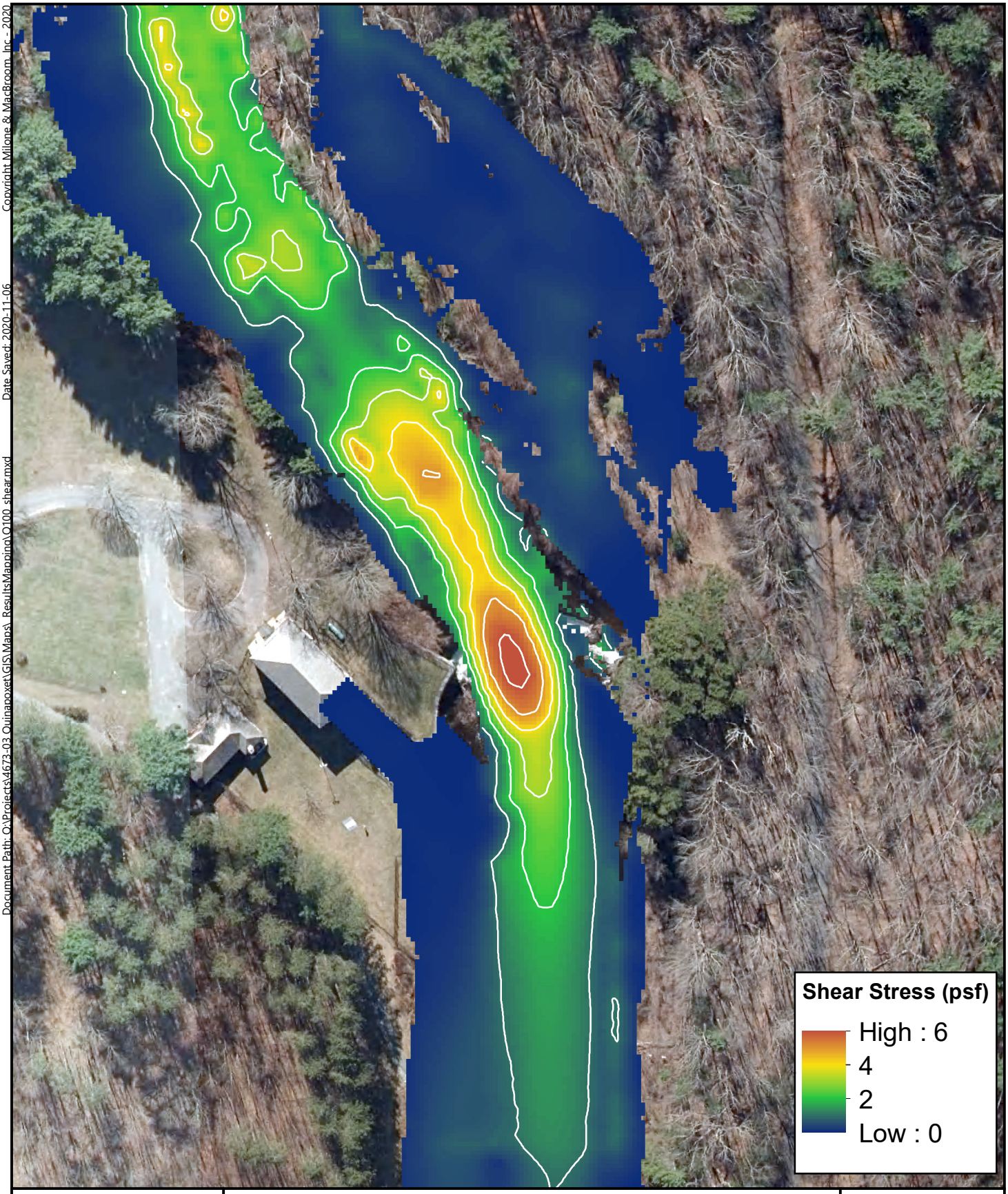

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Proposed Conditions - 100-Year Flood Shear Stress

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N

0 100
Feet

SCALE	1 " = 100 '
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FIG. 4-8

The substrate downstream of the dam was determined through pebble count analyses in the project area and is characterized by coarse gravel and cobbles. The substrate upstream of the dam is characterized by finer material, with higher volumes of fine and medium gravel than the downstream reach. The upstream D_{50} was determined to be 92 mm (3.6 inches), and the downstream D_{50} was determined to be 121 mm (4.8 inches). Both of these particle sizes fall within the "medium cobble" grain size class (Wentworth, 1922).

The computed mean particle size (D_{50}) of the composite sample (accounting for both the natural bed armoring and the underlying cohesive substrate) was estimated at 106 mm. Figure 4-9 presents a graph relating sediment stability and channel velocity.

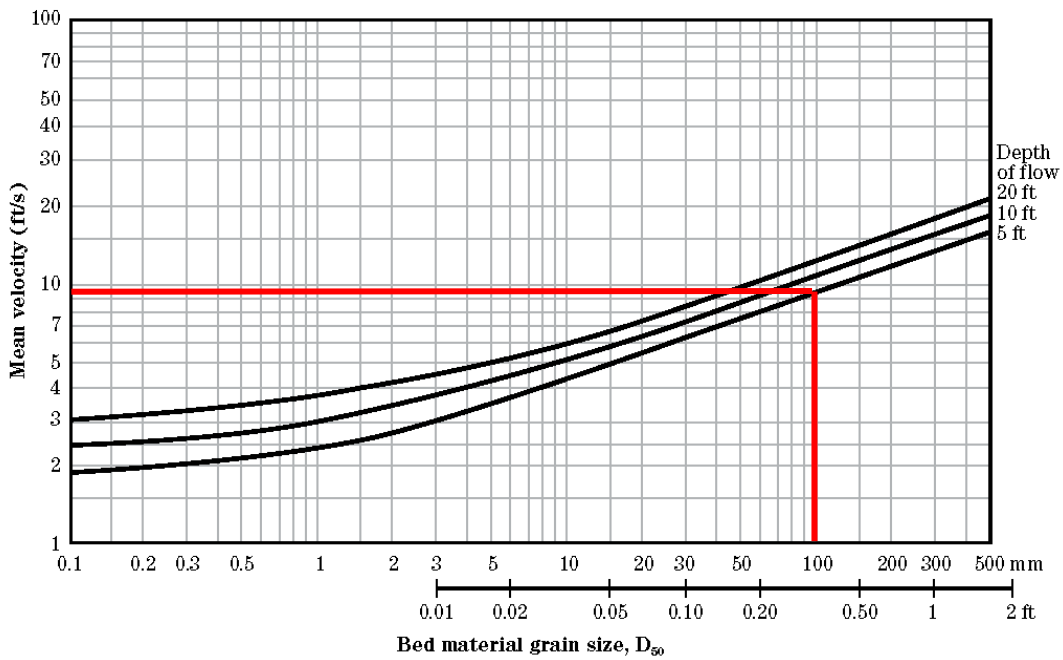

Figure 4-9
Permissible Velocity vs. Material Grain Size (D_{50}) – USACE, 1994

The threshold velocity for the analyzed sediment sample is approximately 9.5 feet per second where flow is under 5 feet deep. Generally, the maximum channel velocities predicted for the 1% annual chance peak discharge under proposed conditions are less than 10 feet per second and flowing from 5 to 7 feet deep. At the proposed boulder riffles, flow velocity peaks between 12 and 14 feet per second (fps), and water is between 4 and 5 feet deep. More frequent storm events are predicted to generate lower velocities. The restored channel bed will be appropriately armored with larger gravel and cobbles to withstand the erosive forces that are anticipated during flood conditions on the Quinapoxet River.

4.4 Bank Stability Assessment

Modeled flow velocities generally diminish with proximity to the banks but may still exceed 10 fps along the channel margins at the proposed riffle features during a 100-year flood. Proposed boulder revetment will consist of 1- to 2-foot-diameter stone keyed into the channel bed a minimum of 4 feet below the finished thalweg elevation. Revetment stone was sized according to Equation EM-1601 based on guidance in HEC-23 Design Guide 4, which recommended a median stone diameter of 1.4 feet (FHWA-NHI, 2009). Boulder riffle ribs will key into the bank revetment to provide additional stability to the restored channel. Random boulder clusters and random channel roughness are proposed along the outside of bend to create flow diversity and turbulence, decrease shear stresses during high flow events, and help maintain bank stability by encouraging deeper flows in the center of the channel.

Concentrating the highest velocities and shear forces at the two proposed riffles allows for less imposing, naturalized bank treatments elsewhere. These include root wad deflectors, naturalized cobble revetment, hedge brush, and willow fascine plantings. Live-staked boulder revetment and bankfull sills provide robust bank stabilization while effectively diffusing erosive forces. Proposed sills and bankfull benches also enable flows and velocities to be distributed across larger cross-sectional areas, reducing the reliance on hard-armoring treatments.

4.5 Floodplain Impacts

Hydraulic modeling of the estimated 100-year flood indicates that the proposed dam removal and river restoration will not have adverse impacts on adjacent properties. Slight reductions in inundation extent are expected along with slight reductions in base flood elevations, as shown in Figures 4-10 and 4-11. The hazards associated with a potential dam failure will be eliminated.

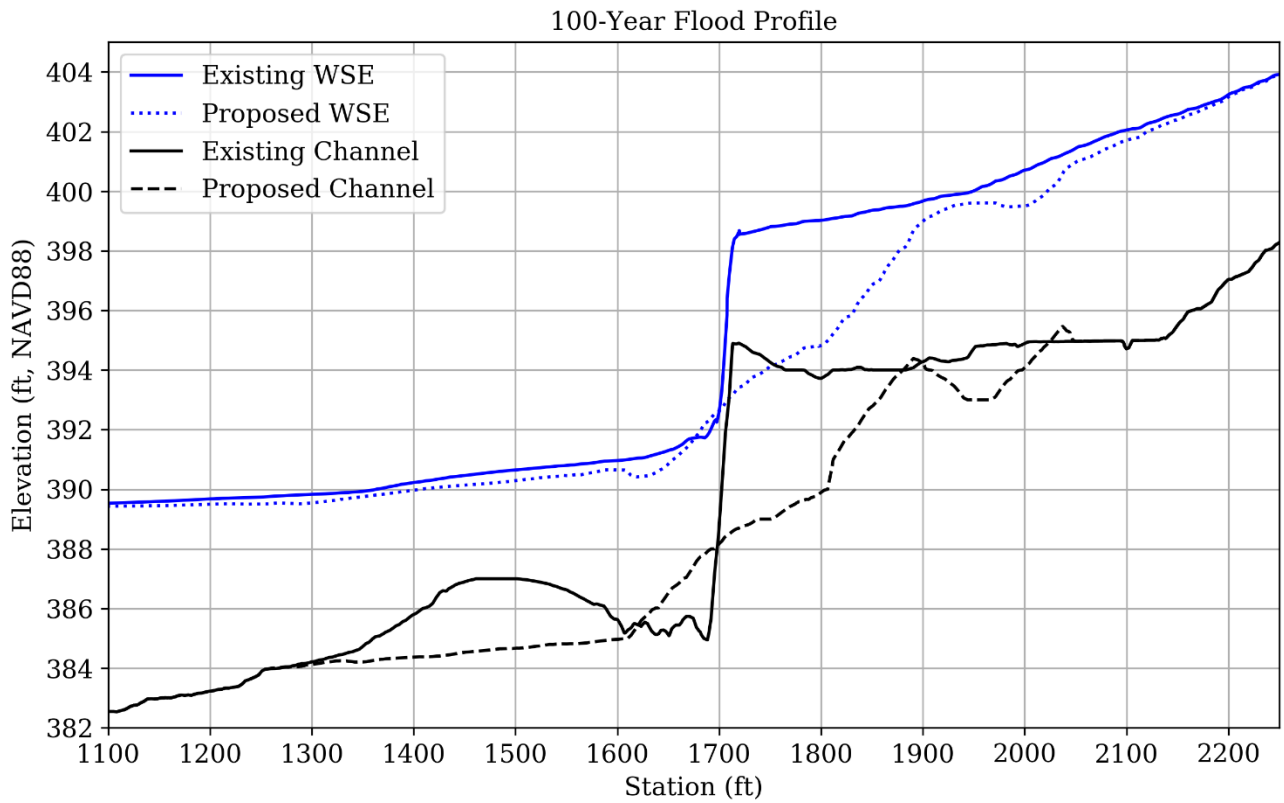

Figure 4-10: Comparison of modeled 100-year flood elevations under existing and proposed conditions. 500 cfs release from the Quabbin aqueduct is modeled in both cases.

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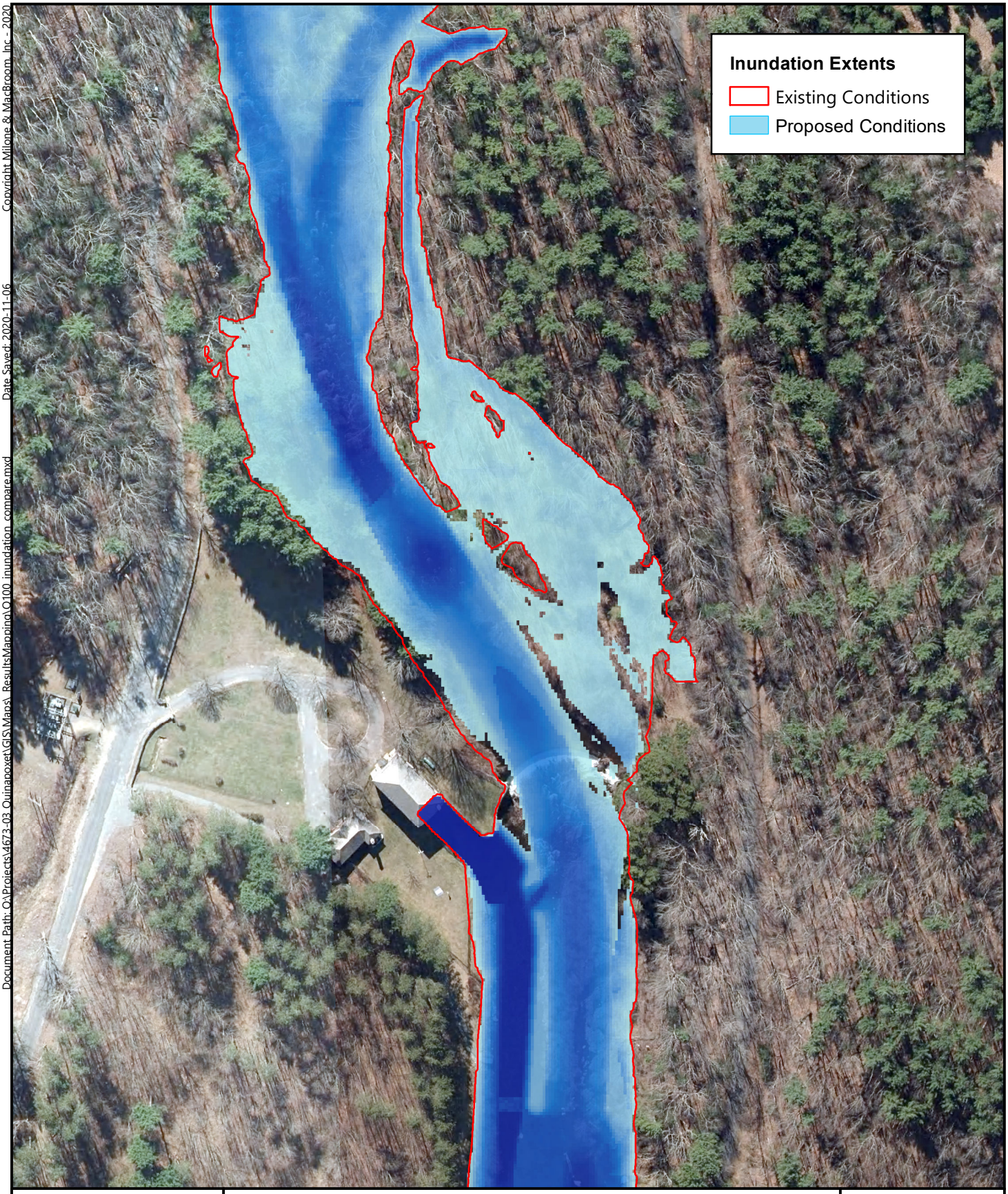

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100-Year Flood - Existing and Proposed Conditions

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N

0 150
Feet

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FIG. 4-11

5.0 CONSTRUCTION PLAN

5.1 Erosion, Sedimentation, and Bypass Water Control during Construction

The water control plan has been carefully considered prior to construction such that both low-flow and high-flow situations can be controlled without allowing turbidity releases downstream into the Wachusett Reservoir. The MWRA is required to maintain water in the reservoir to the utmost of quality standards to maintain the drinking water supply for the city of Boston. As such, the contractor will be required to take extra precautions before, during, and after construction to effectively mitigate the risk of untreated sediment-laden stormwater runoff from flowing into the downstream receiving waters or of any turbid waters from the construction site leaving the controlled area and discharging downstream.

5.1.1 Daily Low Flows

The design plans have been prepared with three phases of bypass water control to divert the active flow of the Quinapoxet River around the active work area, depending upon the construction activities taking place during that time. All vegetative and structural erosion and sediment control practices shall be constructed according to the standards and specifications in the *Massachusetts Erosion and Sediment Control Guidelines*. Construction route locations will be finalized with MWRA prior to start of construction but are preliminarily depicted on the design plans. One access is proposed to allow construction equipment to access the area upstream of the dam, which will use existing lawn and paved areas on MWRA. A second construction access is proposed downstream of the dam, utilizing an existing pedestrian walking path. Temporary construction access roads, staging, and stockpile areas will be limited to MWRA-owned property or roadway rights of way.

5.1.2 Low Flows (USGS Gauge No. 01095375)

A stream gauge on the Quinapoxet River (USGS Gauge No. 01095375, Quinapoxet River at Canada Mills Near Holden, Massachusetts) is located about 3 miles upstream of the project site on the Quinapoxet River. It has 24 years of continuous record starting on November 21, 1996.

The gauged watershed area is 46.3 square miles compared to 57 square miles at the project site. Table 5-1 provides monthly mean flows from the data available on the gauging station as computed by the USGS and adjusted for the change in watershed area.

TABLE 5-1
Summary of Low Flows at Project Site

Month	20th-Percentile Duration (cfs)	Mean Monthly Discharge (cfs)	80th-Percentile Duration (cfs)
January	28	84	125
February	36	89	127
March	67	161	224
April	82	189	257
May	48	99	134
June	24	76	108
July	9	30	42
August	6	20	26
September	4	20	22
October	7	37	53
November	12	57	88
December	18	95	158

Note:
1. Shaded cells represent the anticipated construction window and the flows chosen for design of the construction bypass.
2. USGS Quinapoxet River at Canada Mills Near Holden, Massachusetts, Measured at USGS Gauge No. 01095375, (Transferred to the Project Site)

5.2 Construction Phasing

5.2.1 Water Control – Phase I

The first construction phase involves the cofferdamming of low flows around the southern portion of the dam. The removal of a portion of the dam and impoundment excavation shall be completed once the work area is isolated from active flow in the Quinapoxet River and fully dewatered. Removal of this portion will provide space for a passive, gravity bypass of the Quinapoxet River to be installed in Phase II.

5.2.2 Water Control – Phase II

The second phase involves cofferdamming, diverting water through gravity-fed bypass pipe, and, if necessary, pumping of low flows around the work area, with smaller sumps and groundwater pumps installed throughout the work site as needed to maintain completely dry conditions. Phase II will also require a culvert crossing under the construction road to allow access to the work area. Disassembling of the remaining dam, fish ladder, and appurtenances; removal of existing islands; and construction of the new channel can be completed in dry conditions during the second phase of construction. Once the main channel is complete, water can be transitioned into the reconstructed riverbed.

5.2.3 Water Control – Phase III

The third phase of water control will require cofferdamming of the exit from the Oakdale Power Station outlet channel with a smaller sump and groundwater pump to maintain completely dry conditions. As soon as the exit channel is fully dewatered, installation of fish-deterrent features on the side channel can be performed. All discharges from temporary bypass pipes shall end in a plunge pool designed to provide a soft landing for outmigrating fish. Once the channel is

complete, floodplain work outside the wetted portion of the channel can be constructed. This would be easiest to perform in the driest months of mid to late summer.

Table 5-1 of this report presents the calculated mean monthly flows for the project site. The design of the water control cofferdams, culverts, and pumps are often for the 80th percentile duration flow for the period of construction; however, such flows for the project site would incur significant costs for pumping. It is recommended that a passive bypass in a gravity-fed pipe be designed to convey the 80th percentile of flows (80 cfs – 35,900 gallon/minute) during the anticipated construction window of May through August.

5.2.4 High Peak Flows (Flood Contingency Plan)

The contractor that is selected to perform the work will be required to prepare and submit a Flood Contingency Plan and an Emergency Operations Plan. The project site is located within the 1% annual chance floodplain zone and is subject to flooding. Weather reports provided by the National Weather Service shall be monitored. If a significant precipitation event is forecast to occur during the construction period and flows are expected to exceed that which the low-flow water is capable of conveying, the contractor shall stop work, remove equipment from the floodplain, and secure the project site as needed to accommodate the elevated flows.

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APPENDIX A

2016 FEASIBILITY STUDY

Quinapoxet Dam Removal: Feasibility Study Quinapoxet River at the Wachusett Reservoir

West Boylston, Massachusetts

June 30, 2016

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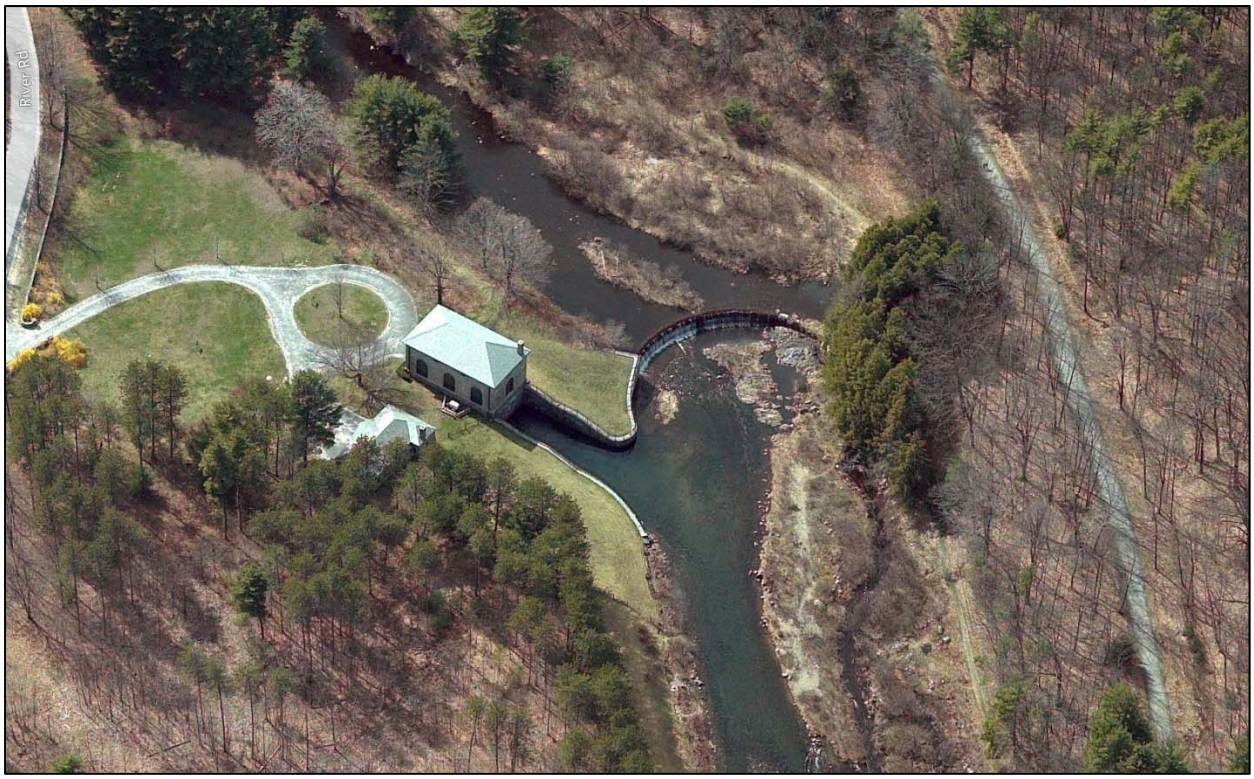
Quinapoxet Dam Removal: Feasibility Study
Quinapoxet River at the Wachusett Reservoir

West Boylston, Massachusetts
June 30, 2016

MMI #2688-37



Prepared for:
The Commonwealth of Massachusetts
Division of Ecological Restoration
251 Causeway Street, Suite 400
Boston, MA 02114

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ABBREVIATIONS/ACRONYMS AND DEFINITIONS

CFS	Cubic Feet per Second
CY	Cubic Yards
DCR	Massachusetts Department of Conservation and Recreation
DEEP	Connecticut Department of Energy & Environmental Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
LIDaR	Light Detection and Ranging
MCP	Massachusetts Contingency Plan
MDC	Metropolitan District Commission
MMI	Milone & MacBroom, Inc.
MWRA	Massachusetts Water Resources Authority
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
STA	River Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Milone & MacBroom, Inc. (MMI) was retained by the Commonwealth of Massachusetts Division of Ecological Restoration (DER) to conduct a feasibility study and provide conceptual-level hydraulic modeling for the removal of the Quinapoxet Dam.

The goals of the project include restoration of free passage of fish and wildlife, naturalization of riverine hydrology, sediment management, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without causing impact to MWRA and DCR water supply operations to an underground aqueduct connecting the Quabbin Reservoir to the Wachusett Reservoir called "Quabbin Interflow Shaft #1" or the downstream Wachusett Reservoir.

The Quinapoxet Dam was constructed below the pre-existing grade of the river bed, and material downstream of the dam was dredged to create the nine-foot-high drop. As such, removal of the dam will not involve the magnitude of sediment management that many dam removals face. Instead, it will be native substrate that is to be removed from behind the dam.

Initial sediment and sampling was performed in support of the feasibility analysis, and found that the currently submerged sediments can be expected to comply with the limits established by the MCP for contaminated soils once the Quinapoxet Dam is removed and the sediments are exposed. Based upon the results of the sampling, special handling or provisions to limit exposure are not anticipated to be required.

Assessment of existing conditions involved hydrologic and hydraulic assessment. Hydrology was obtained using USGS *StreamStats*, as well as by performing statistical analysis on a nearby USGS Stream Gauge. The flows compiled during this process were used to assess the hydraulic characteristics of the dam under existing conditions, as well as three alternative dam removal scenarios.

Removing the dam and creating a constant-slope channel from upstream to downstream was considered as Alternative #1. Two additional alternative removal concepts were assessed utilizing riffle-pool types of geomorphology in an attempt to mitigate the high velocities and shear stresses. Flood flow velocities and shear stresses were lower and more manageable, and low-flow velocities and depths were found to be more favorable for fish passage in both Alternatives #2 and #3. Alternative #2 sought to provide some material reuse on site, but was found infeasible because any grading downstream of the dam could impact the operation of the Quabbin Interflow.

Conceptual design by its nature does not include detailed grading or refined channel design. However, based upon HEC-RAS analysis and conceptual design analysis, Alternative #3 has the best potential for long-term hydraulic and aquatic habitat restoration in the Quinapoxet River, while maintaining stable channel morphology and protecting the downstream reservoir from sedimentation. Critical design features will be adequate channel armoring and creation of a low-flow channel for fish habitat.

1.0 INTRODUCTION

Milone & MacBroom, Inc. (MMI) was retained by the Commonwealth of Massachusetts Division of Ecological Restoration (DER) to conduct a feasibility study and provide conceptual-level hydraulic modeling for the removal of the Quinapoxet Dam.

The goals of the project include restoration of free passage of fish and wildlife, naturalization of riverine hydrology, sediment management, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without causing impact to MWRA and DCR water supply mission, the operations of the Quabbin Interflow Shaft #1, or the downstream Wachusett Reservoir.

A photo log of the dam and surrounding areas as well as an aerial index plan is included in Appendix A, and a site location map is shown on the following page in Figure 1-2.

1.1 Site History

The Boston metropolitan area population grew rapidly through the end of the 19th century, in part due to the advent of indoor plumbing. Planners at the time had not anticipated this level of development and the water supply to the city became inadequate. Wachusett Reservoir was constructed in Clinton on the South Branch of the Nashua River in order to meet Boston's water supply needs for the first quarter of the 20th century. The work was completed in 1905 and the reservoir was filled in 1908. The 7-square-mile reservoir with 63 billion gallons of water doubled greater Boston's water supply system, and at the time was the largest public water supply reservoir in the world.

The Quinapoxet River enters the Wachusett Reservoir from the west, where a semicircular dam was constructed across the river in the Oakdale Village of West Boylston. The dam was constructed in the early 1900s as part of the Wachusett Reservoir construction project. The original 1902 design plans refer to the dam as *"the circular concrete dam on the Quinapoxet River, Wachusett Reservoir Section 10."* The DCR Office of Dam Safety (ODS) inventory of dams lists this dam as the Quinapoxet Accretion Dam – MA Dam #02523. The term "accretion dam" has created some confusion regarding the construction and original purpose of this dam.

Normally, dams are constructed across an existing river channel, and the dam structure itself extends vertically above the stream bed to create an impoundment of water behind the dam above the normal stream channel elevation.

Figure 1-1: Construction of the Quinapoxet Dam, circa 1905

SOURCE(S):
Basemap: Image courtesy of USGS Earthstar Geographics SIO © 2015 Microsoft Corporation © 2015 HERE © AND

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MXD: Y:\2688-37\Maps\Fig 1-2.mxd

FIgure 1-2: Site Location Plan

Quinapoxet Dam Removal Project
Quinapoxet River

LOCATION: West Boylston, Massachusetts

Map By:	JCS
MMI#:	2688-37
Original:	7/9/2015
Revision:	7/10/2015
Scale:	1 in = 1,000 ft

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(203) 271-1773 Fax: (203) 272-9733
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This change in the river hydraulics slows the velocity of the river and subsequently causes sediment that is carried in the river to settle out behind the dam as the velocity slows. Almost all dams accumulate sediment in their impoundments. However, this is not the case with the Quinapoxet Accretion Dam for reasons described below.

The Metropolitan Water and Sewerage Board annual reports from the early 20th century reference the following activities: *"…excavating earth and gravel from shallow portions of the reservoir at Oakdale, for enlarging a portion of the channel of the Quinapoxet River west of the Worcester, Nashua, & Portland Division, building a concrete dam across the Quinapoxet River at the upper end of this channel."* Review of the original construction drawings, photo documentation, and the original channel profile shows that the crest of the Quinapoxet Dam spillway is only slightly higher than the channel upstream of the dam by a few feet. This is evident in the photograph in Figure 1-1 where the spillway is near the same elevation as the rocky cobble streambed. The spillway height of 9 feet was created by excavating and removing the channel *downstream* of the dam to the Wachusett Reservoir. The dam appears to have been constructed not to impound and trap sediment upstream of the dam but to allow lowering of the gradient of the downstream channel reach for the purpose of reducing velocities so that accretion could occur in the downstream channel prior to entering the reservoir.

The original design intent of the Quinapoxet Dam is critical to understanding the next phase of investigation and design of dam removal alternatives. With a spillway constructed at essentially the upstream channel bed elevation, there is likely to be relatively little accumulated sediment upstream of the dam and therefore a reduced risk of high volumes of contaminated materials. The exception is the area along the left bank, which is now vegetated and above the river elevation.

1.2 Physical Setting

The Quinapoxet Dam is located due east of State Route 190 in West Boylston, Massachusetts. Refer to Figure 1-2 for a site location map depicting the dam location and major nearby landmarks. As can be seen in Figure 1-3, the Quinapoxet Dam is located amidst the picturesque setting of the MWRA's Oakdale Transfer Facility at the outlet of the Quabbin Aqueduct Shaft #1.

The Quinapoxet Dam is located upstream of two sediment basins serving the Wachusett Reservoir. The first, upstream basin is called the Quinapoxet Basin (formed by the railroad causeway and arch bridge conduit that both predate the reservoir), and the second, downstream basin is called the Thomas Basin (formed by Route 12 and Route 140 causeway and bridge). The Thomas Basin flows into Wachusett Reservoir at the same water surface elevation as the reservoir.

Figure 1-3: Quinapoxet Dam

The dam is a 250-foot-long, 18-foot-high earthen embankment and stone masonry structure. The most visually compelling component of the dam is its 135-foot-long 9-foot-high stone masonry and concrete arched spillway. The

earthen embankment portion is limited to the right side, adjacent to the granite block transfer station. A concrete pool/weir type of fishway is located along the northern abutment and appears to be in good condition; however, this type of structure is poorly suited for the warm water species living in the reservoir.

The Mass Central Rail Trail is located on the left of river, approximately 100 feet from the dam. This is an active recreational trail for walkers, bikers, and runners and is the primary vista to the site and the spillway.

2.0 FIELD ASSESSMENT AND SURVEY

2.1 FIELD SURVEY

Survey was performed by MMI in April 2015. General topographic survey was performed of the Quinapoxet Dam spillway, earthen abutment, and surrounding area; ten cross sections of the channel were surveyed to provide model input to evaluate the hydraulics of the Quinapoxet River. Survey is referenced horizontally to the North American Datum of 1983 (NAD 1983) and vertically to the North American Vertical Datum of 1988 (NAVD 88). Topographic data was collected and processed in conformance with T-2 accuracy standards, and was certified by a surveyor licensed in the State of Massachusetts. Figure 2-2 (Survey Location Plan) depicts river stationing and survey cross sections. A complete topographic map is provided in Appendix B.

2.2 RIVER CHANNEL CHARACTERISTICS

MMI staff inspected the Quinapoxet Dam and the surrounding area on April 14, 2015. To facilitate description of the river reach, it was characterized by segments upstream, adjacent, and downstream of the dam. River stationing was used to refer to locations along the river. Stationing is measured in feet, and is presented in the format of RS XX+XX. Refer to Figure 2-2 for stationing along the river. Field notes from the site investigation can be found in Appendix C. A photo log is included in Appendix A

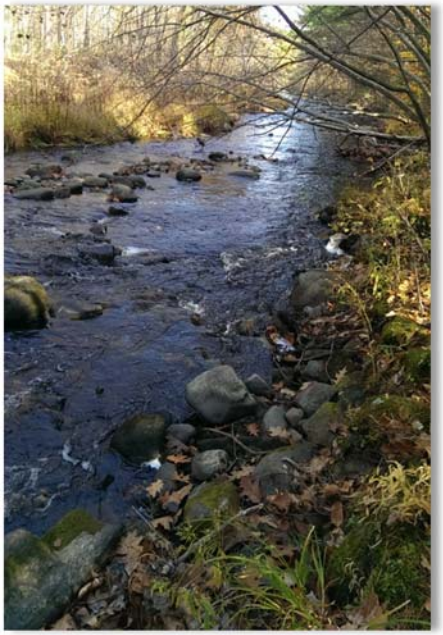
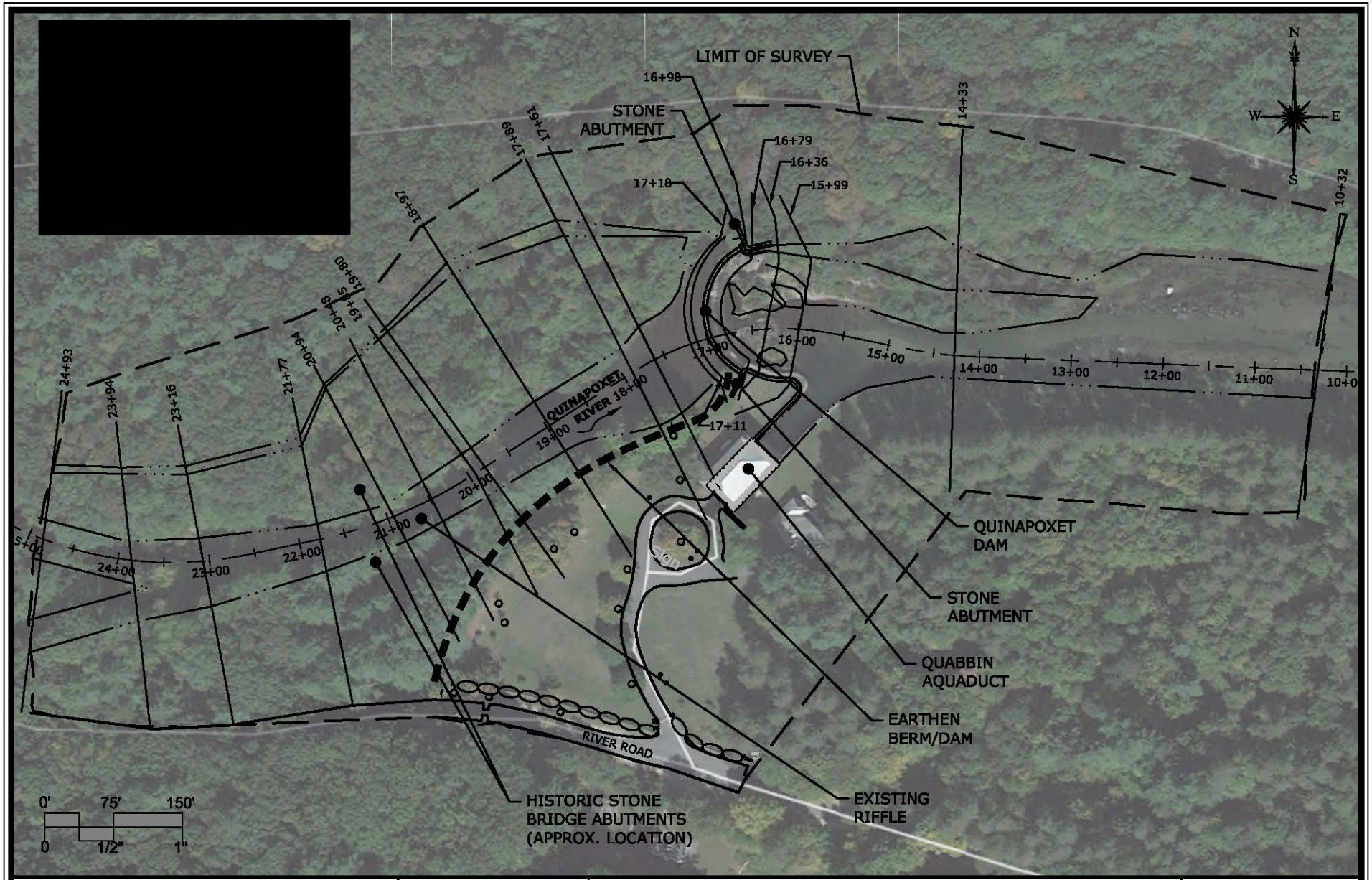


Figure 2-1: View of Channel Upstream of Quinapoxet Dam

The dam impoundment extends only 400 to 500 feet upstream of the structure. It is shallow and fairly narrow, which is consistent with the history and construction. Approximately 1,500 feet upstream of the dam, flow splits around a vegetated island, where the river is free-flowing with a rocky cobble bottom, as shown in Figure 2-1. Flow recombines into a single channel approximately 600 feet upstream of the dam. The river is located within an unnumbered FEMA designated floodplain and, based on a review of FEMA mapping, the entire area appears to be under the backwater influence of the downstream reservoir and sediment basins. The FEMA mapping and associated information is provided herein as Appendix G.



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DATE	7/9/2015
SCALE	1" = 150'
PROJ. NO.	2688-37
DESIGNED	JCM
DRAWN	JCS
CHECKED	JCM

SURVEY LOCATION PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

REVISED: --

PROJECT PHASE:

DRAWING NAME:

FIG. 2-2

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Drawing: W:\DESIGN\2688-37-DE\CAD\HEC-RAS SECTIONS AERIAL-REV.DWG Layout Tab:8.5X11H
Plotted by: JAMESM On this date: Mon, 2015 July 13 - 6:08pm

2.2.1 Upstream of the Dam

The channel upstream of the dam can be characterized as a gravel/cobble/boulder bed and was found to have generally vegetated and stable banks. Overall, the channel planform, slopes, and widths appear more consistent with natural conditions than those downstream of the dam, which were subject to heavy material removal and dredging operations during construction of the Quinapoxet Dam. No signs of active erosion, or aggradation were noted, and the river has good access to a mature forested floodplain. The river bifurcates around a large vegetated island, converging to a single channel approximately 600 feet upstream of the Quinapoxet Dam.

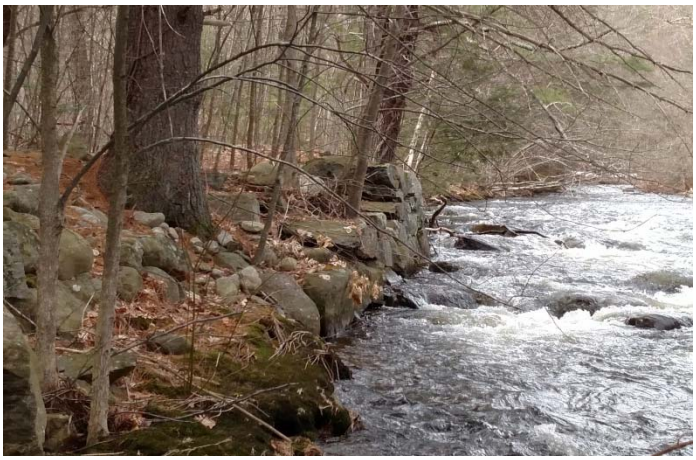


Figure 2-3: View of historic bridge abutment approximately 400 feet upstream of the Quinapoxet Dam

The remains of historic bridge abutments (see Figure 2-3) were found in the river near RS 21+00, approximately 400 feet upstream of the dam. The abutments are old stone masonry, and appear to be stable. Stone armoring historically placed around the abutments consists of stone on a 1:1 to 2:1 slope. The channel had well-vegetated stable banks armored with root mass and boulders at heights of 3 to 4 feet. The channel bed substrate consisted of sandy gravel and cobble and appeared to be reasonably stable.

Just downstream of the bridge abutments, approximately 375 feet upstream of the Quinapoxet Dam, a riffle segment has formed with steeper slope, faster velocities, and larger cobble/boulder substrate (see Figure 2-4). The riffle section is stable, although what appears to be a man-made berm along the left bank is armored with stone and serves to channelize flows. Velocities in this reach were visibly higher than in surrounding areas.

The reach of channel up to 200 feet upstream of the Quinapoxet Dam flattens out in slope and becomes wider as it approaches the dam. Channel substrate consists of sandy cobble and boulders. Both the channel armoring and bank armor (boulders and root mass) appear to be stable and consist of native materials, although sediment along the northern bank where backwater eddying occurs consisted of finer sands and organics.

Figure 2-4: View of riffle section approximately 375 feet upstream of the Quinapoxet Dam

2.2.2 Downstream of the Dam

Directly downstream of the Quinapoxet Dam, another riffle has formed due to bedrock outcroppings and large boulder-sized material. A glide section approximately 300 feet downstream of the dam flows directly into a second riffle, which then flows into the backwater of the reservoir at approximately station 11+00. Due to the heavy dredging and manipulation of the channel downstream of the dam, the river is overly wide and very flat.

Figure 2-5: View of channel downstream of Quinapoxet Dam

The channel and banks continue to be characterized as well armored, with willow vegetation on the banks and imbricated boulders and cobbles throughout the channel bottom. As the channel approaches the reservoir backwater, the impounded longitudinal slope approaches zero. This causes some of the finer sediments to drop from suspension and accumulate. Channel substrate includes some cobble and gravel along with increasingly fine sandy material as the river approaches the reservoir.

Table 2-1 presents a summary of channel characteristics that were measured in the field at different locations along the channel.

TABLE 2-1
Quinapoxet River Field Measurements
(Existing Dam Located at 17+00)

	STA: 21+75	STA: 20+75	STA: 19+00	STA: 14+00	STA: 11+00	STA: 8+00
Low-Flow Width	75'	50'	67'	56'	115'	160'
Low-Flow Depth	1'-2.5'	2'-3'	2'-3'	1'-4'	0.5'-2'	Varies
Bankfull Width	85'	N/A	72'	65'	150'	165'
Bankfull Depth	2'-3.5'	N/A	3'-4'	3.5'-6.5'	2'-3.5'	2'-3'
Channel Slope	1.5%-1.75%	1.75% U/S 0.4% D/S	0.4%	0.9%	0.9% U/S 0.0% D/S	0.0%
Stream Velocity	4-5 fps	8-10 fps	4 fps	5 fps	3-5 fps	0 fps
Bank Height	3'-4'	4'-7'	3'-4'	10'	8'	6.5'
Bank Slope	3:1	1:1 to 2:1	N/A	N/A	3:1	3:1
Bank Material	Vegetated	Stone	Vegetated	Vegetated	Vegetated	Vegetated
Channel Substrate	Sand/Cobble 1-2' Boulder	1'-3' Boulder	Sand/Cobble & Boulders	Cobble & Boulders	Cobble, Sand & Boulders	Sand/Gravel Organic

2.3 GEOMORPHIC ASSESSMENT

The Quinapoxet River in the area of the dam has been heavily impacted by anthropogenic activity. The construction of the dam was disruptive to the morphology of the river, specifically downstream of the dam, as a result of over-excavation and over-widening of the channel. Upstream of the dam, the river is relatively similar to the natural morphology. Further upstream, the abutments of a former bridge located approximately 600 feet upstream of the dam cause a channel constriction, increasing velocities and causing a riffle to form.

The low sinuosity, intermittently high banks, and limited floodplain are characteristics of a Rosgen Type B channel, while cobble and gravel bed material is a type 3/4 substrate. The regional hydraulic geometry equations (Bent, USGS, 2013) yield a predicted bankfull width of 75 to 77 feet and a depth of 3.1 feet, similar to the data measured in the field.

Due to the channel shape and manipulation, naturalized bankfull elevations are difficult to determine from field evaluation. A reference section approximately 300 feet upstream of the dam yielded a bankfull channel width of 65 feet, but even this may be overly wide for the natural channel. Approaching the dam, aggradation has widened the channel and created a coarse bed, as fines continue to be washed downstream. The bed slope ranges from 1.5 to 1.75%.

Figure 2-6 presents a historic plan of the dam construction from 1902. It indicates the pre-dam channel alignment along the northern bank and shows the approximate extents of channel dredging downstream of the dam.

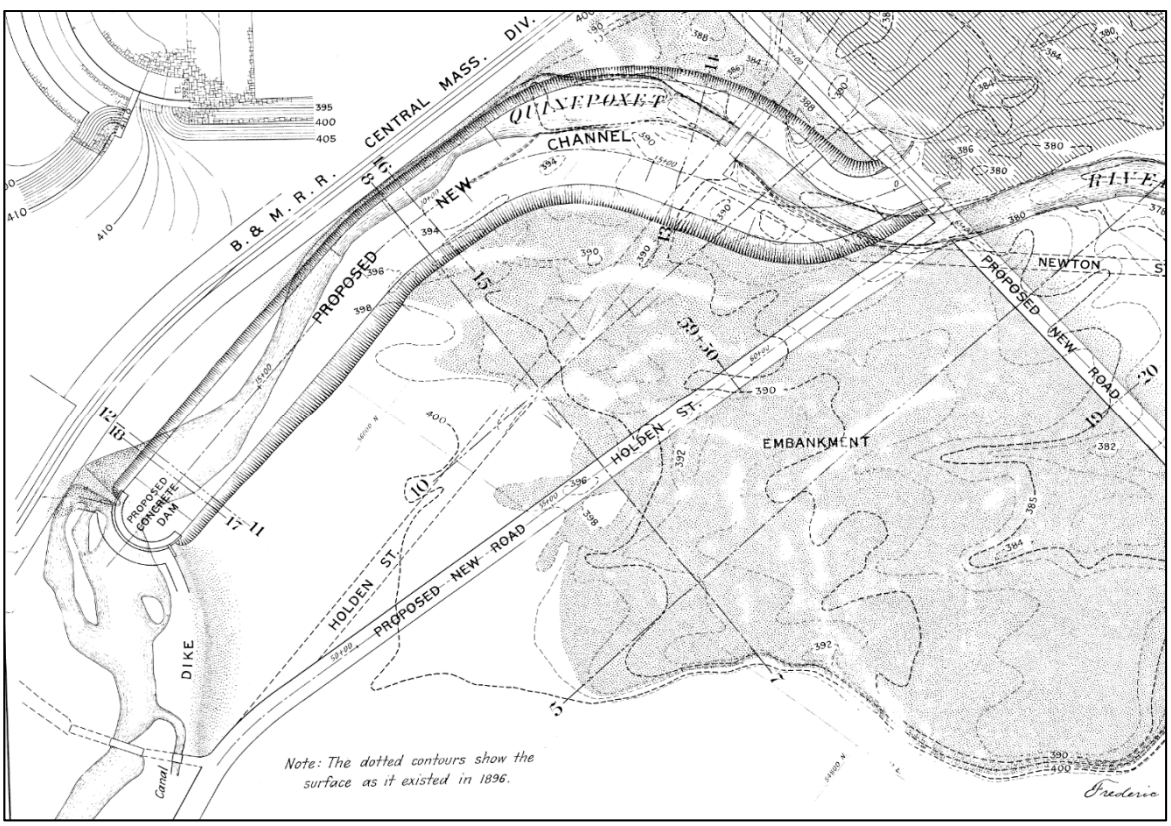


Figure 2-6: Historic plan for dam construction and channel dredging

Table 2-2 presents a summary of geomorphic characteristics for the area upstream of the dam as well as downstream of the dam. The characteristics presented downstream of the dam are the result of manipulation and dredging, and are only presented as reference.

TABLE 2-2
Geomorphic Characteristics of the Quinapoxet River

	Upstream of Dam	Downstream of Dam[1]
Average Bed Slope	1.75%	0.5%
Bed Substrate	Sandy Gravel with Cobble and some Boulders	Sandy Gravel with some Silts and Organics
Sinuosity[2]	1.1	1.0
Entrenchment[3]	1.7 - 2.2	1.3
Profile Type	Pool and Riffle	Impounded
Bedform Spacing	Riffle to Riffle Spacing: 150 feet	None
Bankfull Dimensions (W x D)	65'-75' Wide x 2'-3' Deep	150'-165' Wide x 2'-3' Deep
Low-Flow Dimensions (W x H)	50'-60' Wide x 1'-3' Deep	115'-160' Wide by 1'-2' Deep
Rosgen Classification	B/C 3/4	F 4/5

Notes:
1. Channel downstream of the Quinapoxet Dam heavily modified by activities related to the construction of the dam and reservoir.
2. Sinuosity = (Channel Length) / (Valley Length)
3. Entrenchment = (Floodplain Width) / (Bankfull Width)

2.3.1 Channel Pattern

Old pre-dam photographs of the river plus the MMI sediment transport analysis revealed a coarse bed of gravel to cobble-size substrate material. The existing sinuosity is low (1.1), representing a relatively straight channel typical of a Rosgen Type B at first glance.

The most stable planform pattern for the proposed channel was checked, anticipating whether or not it might tend to meander. The first solution was Kleinhans' stream power approach, which forecasts channel activity and pattern based upon energy expenditure. The computed stream power is 149 watts per square meter, which for a D50 of 92 millimeters corresponds to a wandering or braided channel (similar to the old 1905 photograph). This implies the banks need to be strong and high to confine the channel.

The second approach is use of the empirical Church diagram. The plotted values once again suggest a wandering pattern, confirming the need for lateral confinement.

2.4 PEBBLE COUNTS

To characterize the size distribution of the bed armoring, two Wolman pebble counts (Wolman, 1954) were performed within the project extents. A pebble count seeks to characterize the armoring layer of sediment that remains on a stream bed by measuring independent particles and plotting the results. The resulting data was used in combination with hydraulic modeling to assess the bed armoring size and stability. The median particle size throughout the study area can be classified as cobble and gravel. These results are presented in Figure 2-7, while full pebble count results are included in Appendix C. Table 2-3 presents the statistical characteristics of the particle sizes.

TABLE 2-3
Channel Bed Particle Characteristics

Characteristic[1]	Downstream Size (mm)	Upstream Size (mm)
D16	39	11
D35	77	57
D50	121	92
D84	322	232
D95	489	581

Note:
1 – DX = Median sediment size such that X% of the particles are finer.

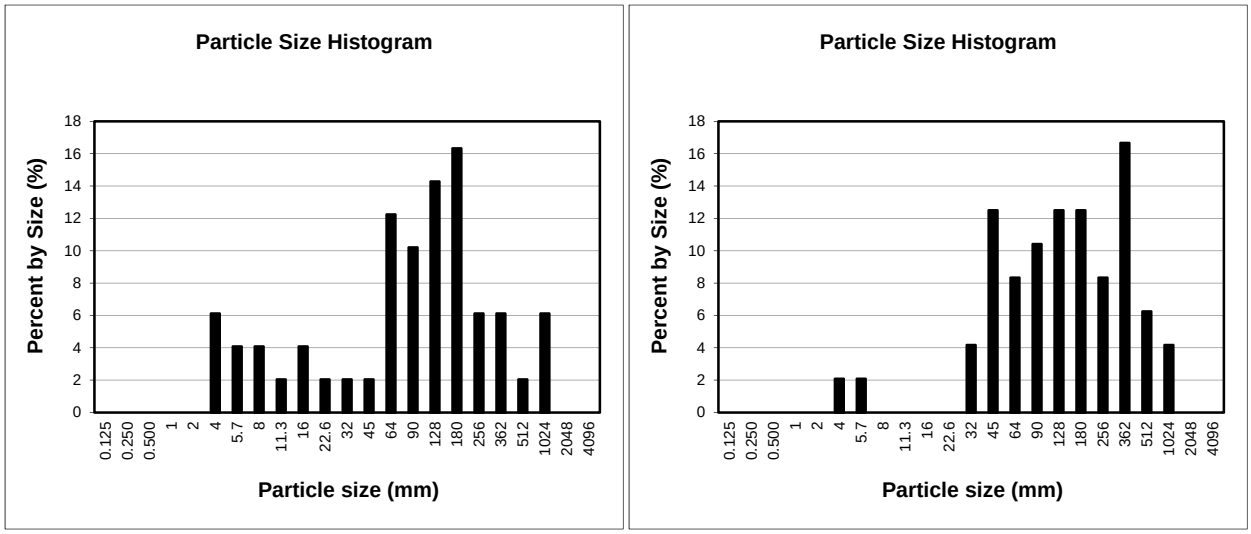
2.5 SEDIMENT SAMPLING AND RESULTS

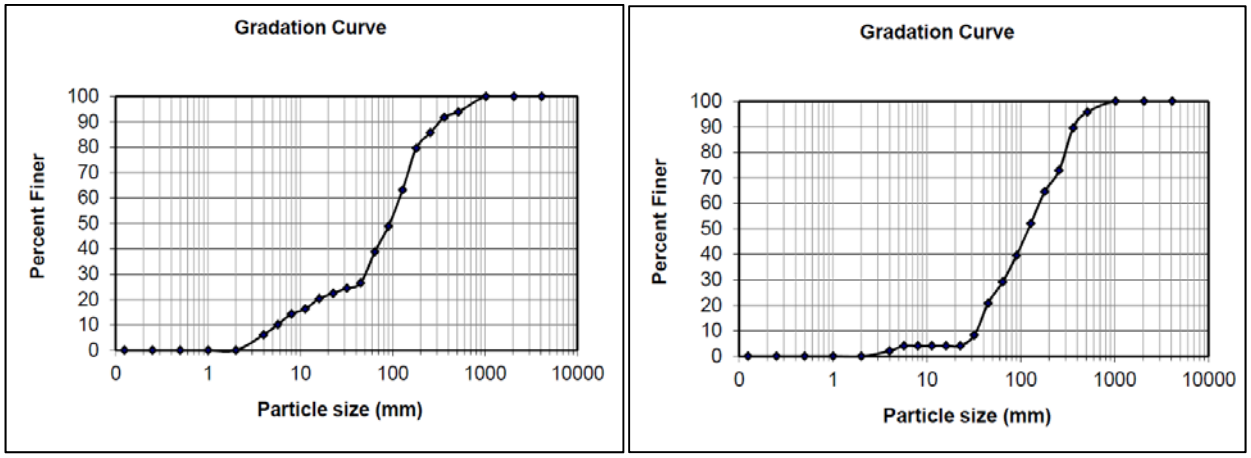
Because the Quinapoxet River feeds the Wachusett Reservoir, a drinking water reservoir for the Greater Boston Metropolitan Area, water quality is of the utmost importance. The water authority removed the mills and industrial structures located within the watershed prior to the construction of the dam and reservoir. Therefore, industrial activities were halted over 100 years ago, and the potential for modern contaminants is believed to be low, except for highway runoff.

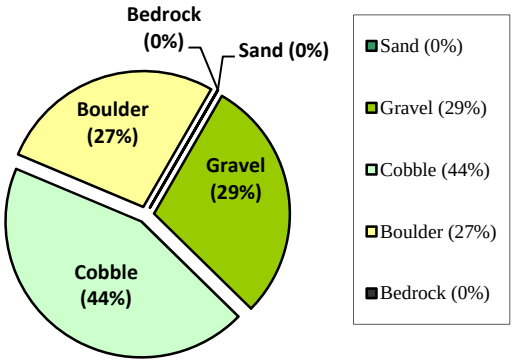
In addition to the low potential for contaminants, much of the sediment in the stream bed is comprised of coarse-grained sand/gravel/cobble. The absence of fine-grained sediments often prevents contaminants from settling out, which provides another factor that lowers the risk of contamination in the sediment.

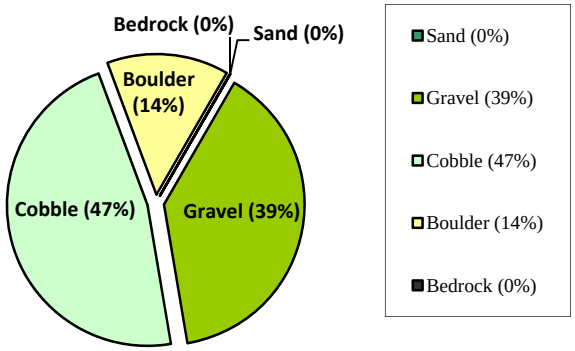
FIGURE 2-7
Channel Bed Particle Distribution – Pebble Count Results

UPSTREAM OF THE DAM | **DOWNSTREAM OF THE DAM**









2.5.1 Sampling Methods

On June 3, 2015, MMI staff performed sediment sampling of material anticipated to be impacted by the potential removal of the Quinapoxet Dam. Based upon preliminary estimates and sampling probe depths, Table 2-4 presents the estimated volumes of material to be removed or relocated during the dam removal process. These volume estimates are based upon rough order of magnitude assumptions of post-dam removal channel grade and are subject to refinement as design is progressed. They are roughly equivalent to the volume that may be associated with Dam Removal Alternative 1, discussed in Section 4.0 of this report. Figure 2-8, as well as supporting documentation found in Appendix D, presents the basis for the estimated volumes.

Figure 2-8
Sediment and Substrate Volume Representation

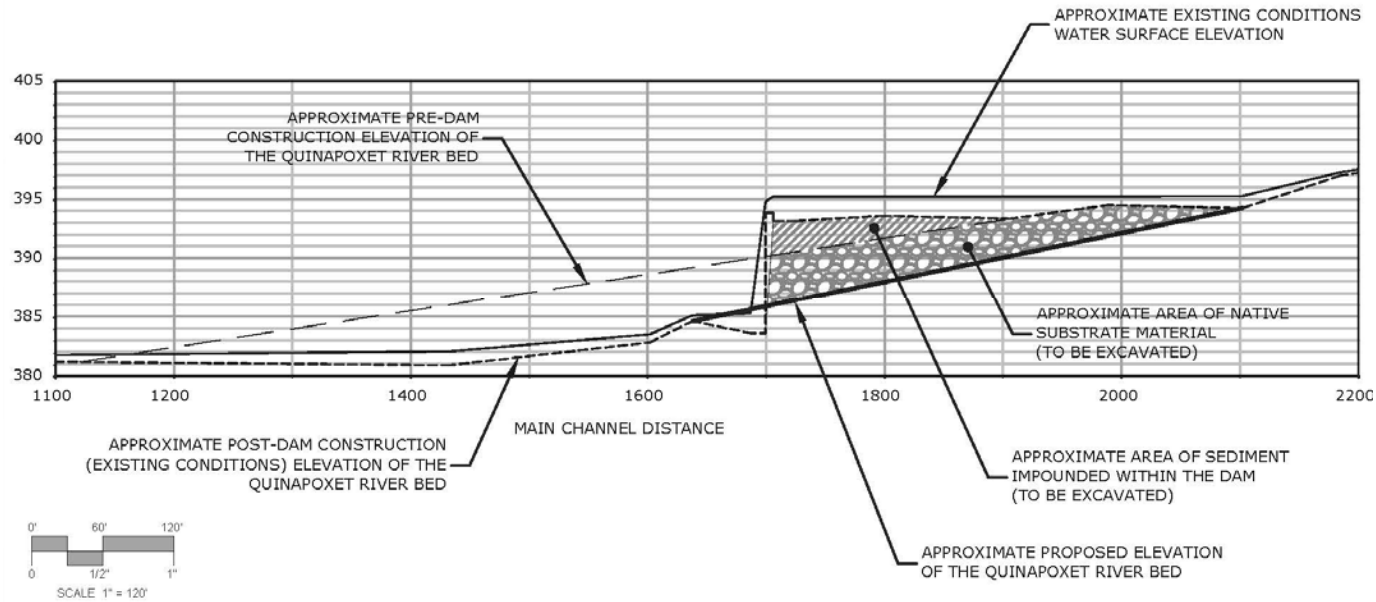


TABLE 2-4
Summary of Material Volumes Generated During Dam Removal

Material	Volume
Native (Pre-Dam) Substrate	3,265 CY
Impounded Sediment	1,365 CY
Total Material	4,630 CY

MMI Staff collected samples from five locations in total. The location of each sample location was recorded with a hand-held GPS unit. Figure 2-9 presents a map of the sample locations.

Three "sediment" samples (designated SS-1, 2, and 3 on Figure 2-9) were collected from the bed substrate in the actively flowing river; two of which were collected from the impoundment area upstream of the dam and one from downstream of the dam. The sediment samples were collected

using clear plastic Lexan sleeves, to a depth of approximately 12 inches below grade. Staff trained in water safety and chemical sampling protocol collected the sediment samples. Multiple cores were obtained at each sample location to provide sufficient material for laboratory analysis.

In addition to the three sediment samples taken from the Quinapoxet River, two additional "soil" sample test pits (designated TP-1 and TP-2 on Figure 2-9) were collected in overbank areas, where historic mapping indicates the channel was located prior to being moved to accommodate the dam. These overbank samples were acquired using a rubber-tired backhoe to excavate topsoil and organic litter to the depth of historic sediments.

All samples were placed into laboratory-supplied pre-cleaned glassware of appropriate volume for the requested analyses. Sampling equipment was cleaned between samples using a solution of water and Alconox. Disposable sample gloves were worn when handling sample material and sample containers. Each sample jar was labeled with the date of collection, sample location, sample depth, and time of sample collection. Chain of custody forms were maintained for all samples.

The samples were stored on ice while in the field and then placed in refrigerated storage at MMI's Cheshire, Connecticut office. The samples were relinquished to a courier for the selected laboratory on June 3, 2015. Alpha Analytical of Westboro, Massachusetts provided the requested analytical services. Table 2-5 presents a list of the analytes measured.

TABLE 2-5
Sediment Sample Analytes

Analyte	Analyte
Arsenic	Total Organic Carbon
Cadmium	Total Solids
Chromium	Ignitability
Copper	Conductivity
Lead	Organochlorine Pesticides
Mercury	Specific Conductance
Nickel	Cyanide Reactivity
Zinc	Sulfide Reactivity
Polycyclic Aromatic Hydrocarbons (PAHs) (EPA 8270C)	Grain Size Analysis
Polychlorinated Biphenyls (PCBs)	
Extractable Petroleum Hydrocarbons (MA DEP ETPH method)	

The TCLP analysis for metals was subsequently cancelled based upon the mass-based results as per the provisions of 314 CMR 9.07(2)b. The analytical methods utilized comply with the Commonwealth of Massachusetts *401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States Within the Commonwealth (314CMR 9.07 (2))*. Additional parameters as included in MA DEP Policy #COMM-97-001 were also specified. A total of 5 composite samples were analyzed to provide the initial characterization screening.

SOURCE(S):
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP,

N

Figure 2-9: Sediment Sampling Locations

MXD: Y:\2688-37\Maps\Sed Sample Location.mxd

Quinapoxet Dam

LOCATION: West Boylston, Massachusetts

Map By:	DRM
MMI#:	2688-37
Original:	5/1/2015
Revision:	6/17/2015
Scale:	1 in = 83 ft

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2.5.2 Sampling Results

Results of the grain size distribution indicate that substrate consists primarily of sandy gravel, omitting the larger cobbles. Table 2-6 presents a summary of the sample characteristics. Full sampling results and grain size distributions are included in Appendix D. The average grain size distribution of the upland soil samples ranged between 20% - 30% gravel and 60% - 80% sands, with very few fines. The average grain size distribution of the in-water sediment samples were very similar, ranging between 20% - 30% gravel and 60% - 80% sands, with very few fines.

TABLE 2-6
Summary of Sediment Grain Size

	D15 (mm)	D50 (mm)	D85 (mm)
TP-1	0.4	2.0	8.4
TP-2	0.6	2.0	10.0
SS-1	0.4	2.1	9.1
SS-2	0.6	2.5	11.3
SS-3	0.7	2.8	11.5

The Massachusetts Department of Environmental Protection (MA DEP) has established criteria associated with the management of dredged material. These criteria are specified in the 401 Water Quality Certification Regulations and are codified at 314 CMR 9.07. This regulation, together with a December 2007 guidance document published by the MA DEP entitled "Dam Removal and the Wetland Regulations," incorporate by reference certain provisions of the Massachusetts Contingency Plan (310 CMR 40). In particular, references are made to reportable concentrations for soil and to specific chemical thresholds identified as the S-1 soil standards. These standards dictate the various sediment management options that are available for approval as part of a 401 Water Quality Certification.

The results of the chemical analyses were compared to the MCP Reportable Concentrations. All of the results were "not detected" and/or were less than the reportable concentration. In general, all chemical concentrations were "not detected" and the noted concentrations of metals were at levels that are considered indicative of natural background concentrations.

MMI has identified the opportunity for a limited amount of shoreline placement and upland reuse of sediment as part of this project. Such activity is regulated under the 401 Water Quality Certification (314 CMR 9.07(9)). As such, the laboratory results were compared to the MCP S-1/GW-1 standards. Similarly, none of the standards were exceeded in any of the samples analyzed. The results of the chemical analyses were not specifically compared to the Consensus-Based Sediment Quality Guidelines (MacDonald, et al., 2000) due to the low or "not detected" results of the analyses.

2.5.3 Sampling Conclusions

The sampling conducted in June 2015 supports a finding that the currently submerged sediments can be expected to comply with the limits established by the MCP for contaminated soils once the Quinapoxet Dam is removed and the sediments are exposed. Contaminant levels appear consistent upstream, within, and downstream of the impoundment. Based upon the results of the sampling, the sediments

will not require special handling or provisions to limit exposure. On-site and off-site reuse appears to be possible based upon sediment quality assessment that indicated that none of the samples exceeded MCP S-1/GW-1 levels or ecological effects thresholds. Similarly, the soils in the upland area to the north of the impoundment appear to be absent of anthropogenic contaminants and representative of naturally occurring soil.

These conclusions are based upon the preliminary characterization of soil and sediment as presented above. Based upon the results of the sediment and soil sampling, it appears that design plans can be advanced without the need for additional sampling. Absent a source identification, there is no reason to suspect that the minor concentrations of the pesticides dieldrin and chlordane are the result of anything other than the lawful application of pesticides in accordance with manufacturers' instructions.

2.6 Wetland Resource Areas

On June 29, 2015, a MMI wetland scientist delineated wetlands and watercourses within the immediate vicinity of the dam subject to the provisions of the Rule and Regulations of the Massachusetts Wetlands Protection Act and Section 404 of the Clean Water Act. Wetlands were delineated using the methodology provided in the *U.S. Army Corps of Engineers (USACOE) Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region.* The resource area boundaries and wetland flags were collected using a hand-held GPS device and incorporated into project base mapping (see Appendix B, drawing EX-1).

Wetland delineation was completed from approximately 100 feet downstream and 500 feet upstream of the dam. A wetlands report is provided in Appendix E that includes USACOE transect forms completed in the field and GIS mapping of the wetland communities. Refer to Appendix E for detailed report of functions and values of the wetland communities mapped within the project area.

2.7 Geotechnical Borings

In many dam removals, the upstream impoundment has filled with sediment through years of aggradation, and removal of the dam allows the sediment to be removed and the existing channel slope to be utilized. The Quinapoxet dam was constructed on a bedrock outcropping along the north (river-left) bank, and was done as an accretion-style dam. This implies that the impoundment upstream of the dam is at or near pre-dam geometry and slope, and the channel downstream of the dam was excavated. Therefore, removal of material upstream of the dam to provide adequate slope of the channel will require the removal of native material, the substance of which is unknown. Five geotechnical borings were performed upstream of the existing dam to assess this material, as well as to identify the depth to bedrock. A memorandum summarizing the results of this investigation is included in Appendix J. Table 2-7 below provides a summary of the findings.

TABLE 2-7
Summary of Geotechnical Borings

ID	Bedrock Elevation (feet)	Boring Depth (feet)	Proposed Excavation Depth*
B1	< 374.2	374.2	386.9
B2	< 374.1	374.1	386.6
B3	< 374.1	374.1	386.5
B4	< 374.5	375.5	388.2
B5	< 374.3	374.3	390.1

*Note: Excavation depth based upon Alternative 1

3.0 EXISTING CONDITIONS

3.1 Dam Classification

A dam inspection by Fuss & O'Neill in February 2007 identified the Quinapoxet Dam as a non-jurisdictional structure based upon an impoundment size of 4.5 acre-feet and a height of 9 feet. In June 2007, GZA conducted a more detailed Phase 1 dam inspection and reported the dam to be 18 feet high with 75 acre-feet of floodwater storage and therefore classified it as an intermediate size dam with a significant hazard potential. MMI's review of the two reports indicates that Fuss & O'Neil used the height of the *spillway* and not the height of the *dam* to compute impoundment size, and is incorrect. While the Office of Dam Safety database maintains the non-jurisdictional designation, MMI believes this to be in error, as the regulations do not allow for this designation for structures over 15 feet high or greater than 50 acre-feet of storage. While the issue of dam designation does not materially affect its removal, it does place a greater sense of importance.

3.2 Dam Construction

The crest length of the spillway was found to be 158 linear feet along a semicircular arc with a radius of 75 feet. The crest of the spillway is made of rounded 4-foot-wide concrete blocks (see Appendix C). Along the northern edge of the dam is a 4-foot-wide fish ladder approximately 86 feet long. Fine sediment and organics were found to be deposited upstream of the dam outside of this area. Immediately upstream of the dam, 6-inch to 18-inch cobble and boulders were the predominant composition of the channel armoring. Just beyond the immediate edge of the dam structure, the stone size is reduces to 6-inch to 12-inch cobble with little sand material and no evident organic muck material. As is typical with an accretion dams, very little material has been deposited upstream of the dam that was not originally native to the channel bed.

Exposed ledge was visible along the northern 42 feet of the spillway. The height of the spillway outside of the exposed ledge area was measured to be approximately 8 feet to the apron base, but is as short as 5 feet along the northern bank due to the ledge outcrop. The tapered apron base was measured at approximately 10 feet long with a change in height of 2 feet over its length. Leaks and cracking were observed at the corner of the spillway as well as the southern retaining wall with minor water flowing into and out of the cracks. Photos of the dam and fish ladder structure can be seen in the photo log attached as Appendix A.

3.3 Historic Land Uses

Construction of the Wachusett Reservoir was a westward expansion of Boston's municipal water supply system at the turn of the 20th century. By 1919, there were renewed concerns about potential water supply shortages for the city. The Quabbin Reservoir, located further to the west, was constructed to meet those needs. The interconnection from the Quabbin Reservoir was constructed, and the Quabbin Aqueduct discharges to the Quinapoxet River at Shaft 1 just downstream of the Quinapoxet Dam. The powerhouse and tunnel discharge are all located immediately behind the earth embankment portion of the dam. This critical infrastructure will need to be fully considered in any dam removal scenario.

Prior to the construction of the Quinapoxet Dam and in a few cases after the construction of the dam, the Quinapoxet River was used locally as a source of power for mills. The Canada Mills site owned by L.M. Harris Manufacturing Co. located approximately 1,500 linear feet upstream was the first mill site removed in 1899 before construction of the Quinapoxet Dam. The Metropolitan District Commission razed the Springdale mill site during construction of the Quinapoxet Dam in 1905. Further upstream along the Quinapoxet River, the Lovellville and Quinapoxet mills sites were both removed in 1916 and 1929 respectively. Directly downstream of the Quinapoxet Dam was the site of the Harris Mill, which was destroyed by fire 52 years prior to the completion of the Quinapoxet Dam. The destroyed Harris Mill was replaced by the Whiting Mill in 1874, which itself was abandoned and demolished by 1897. The Harris Mill was used to manufacture both wire fabric and cotton cloth. The larger Whiting Mill was used to manufacture cotton cloth, light sheeting, and show drills. None of the mill sites likely pose a severe risk to the contamination of materials impounded on site due to the dates of removal and the known activities that took place at the mills.

In the town of Holden, Massachusetts there is a former landfill that was relocated during the construction of Interstate 190, which may have caused metal contamination in the Quinapoxet River. The former Holden landfill was open from 1955 to 1987 as a municipal landfill for the town of Holden. Between 1980 and 1981 it was noted that there was leaching from the landfill area. This was investigated by the United States Environmental Protection Agency (U.S. EPA) and detectible levels of contamination, specifically arsenic, were found. Between 1980 and 1985, 38 groundwater wells were installed in order to monitor the site. The data showed that only one groundwater well contained a concentration of arsenic higher than the U.S. EPA drinking water standard.

MMI searches of the Sanborn Library for fire insurance maps certified that no fire insurance maps exist for the Quinapoxet Dam property. A list of the compiled resources is included in Appendix F.

3.4 Hydrology

The hydraulic modeling process and natural stream channel design necessary for restoration of the Quinapoxet River require determination of peak flood flow for this segment of the river. This data is obtainable via multiple methods, which can be used as both a check of available data and for an improved understanding of ranges and trends of flows at the Quinapoxet Dam. Hydrology data may be developed from statistical analysis of gauge data, regional regression equations such as the USGS Wandle method, rainfall runoff models, or from exact measurement. Data obtained from various sources is detailed below, while full compilations of USGS *StreamStats* output and stream gauge regression analysis have been included in Appendices F and G.

3.4.1 USGS Gauge Data and Regression Equations

USGS hydrology internet *StreamStats* software (Version 3 Beta) provides a weighted estimate of low-flow and bankfull flow rates at the Quinapoxet Dam based on regression equations using precipitation data and gauge station estimates. Wandle's regression equations for Central Massachusetts were used to calculate the 20% (5-year), 10% (10-year), and 1% (100-year) annual chance flows. The supporting computations are provided in Appendix H.

3.4.2 HEC-SSP 17B Analysis of Gauge Data

The USGS maintains a stream gauge on the Quinapoxet River at Canada Mills near Holden, Massachusetts. USGS Gauge 01095375 is located approximately 3.5 miles upstream from the mouth at Wachusett Reservoir and approximately 3 miles upstream of the Quinapoxet Dam. The drainage area to this gauge is 46.3 square miles, as compared to the 57-square-mile watershed at the project site (as computed by *StreamStats*). The period of record of the gauge is from 1996 to present.

In order to recalculate a flood frequency curve for the USGS Gauge 01095375, a flood frequency analysis was conducted with the available stream gauge data using the U.S. Army Corps of Engineers (USACE) computer model HEC-SSP that utilizes the national standard bulletin 17B procedure (USGS, 1981). The flows calculated in HEC-SSP were used with Wandle's regression equations and the procedure for "Sites on Gauged Streams" in the article *Estimating Peak Discharges of Small, Rural Streams in Massachusetts* (Wandle 1983). These are summarized in Table 3-1. The ratio of the contributing watershed area for USGS Gauge 01095375 and the watershed area of Quinapoxet Dam were used to calculate the 20% (5-year), 10% (10-year), and 1% (100-year) annual chance flows at the project site.

TABLE 3-1
Summary of Quinapoxet River Flood Discharges

Source	Design Flow for Annual Recurrence Interval (cfs)		
	5-year (20%)	10-year (10%)	100-year (15)
HEC-SSP 17B Analysis	1,474	1,791	3,041

Note: cfs = cubic feet per second

3.4.3 Low-Flows

In order to assess fish passage potential, mean monthly streamflow rates were predicted based upon *Streamstats*, and the Canada Mills gauge. *StreamStats* also provides information on likely seasonal flows that are based on periods of time that correspond to significant ecological conditions as noted in Table 3-2. Actual values vary due to water supply withdrawals or low-flow augmentation release.

TABLE 3-2
Seasonal Flows from USGS Streamstats Analysis

Streamflow Statistics	Definitions	Median Discharge (cfs)[1]
D99	Streamflow exceeded 99 percent of the time	3.21
M7D10Y	7-Day mean low-flow that occurs on average once in 10 years	3.21
M7D2Y	7-Day mean low-flow that occurs on average once in 2 years	6.47
AUG D50	August streamflow exceeded 50 percent of the time	13.3
Mean May[2]	Mean flow for the month of May	88
Mean June[2]	Mean flow for the month of June	73
Mean July[2]	Mean flow for the month of July	29
Bankfull	Bankfull streamflow	829

Notes:
1. cfs = cubic feet per second
2. Mean May, June, and July flows provided by USGS No01095375 gauge data, at Canada Mills, Holden MA, period of record (1996 – 2014).

4.0 ALTERNATIVES ANALYSIS

Hydraulic analysis of the Quinapoxet River at the project site was completed using the HEC-RAS (River Analysis System) software program (version 4.1), created by the USACE. The model is used to compute water surface profiles for one-dimensional, steady state, and gradually varied flow. By creating cross sections of the existing and proposed channel geometry, this model can accommodate a full network of channels, a dendritic system, or a single river reach. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed flow conditions. Output from the model is summarized below, and information relative to the model is attached In Appendix I.

Water surface profiles are computed from one cross section to the next by solving the one-dimensional energy equation with an iterative procedure called the standard step method. Energy losses are evaluated by friction (Manning's Equation) and the contraction/expansion coefficient multiplied by the change in velocity head at each section. The momentum equation is used in situations where the water surface profile is rapidly varied, such as hydraulic jumps. These situations include mixed flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence.

4.1 Existing Conditions Modeling

MMI developed an existing conditions model of the Quinapoxet River from survey data. Typically a hydraulic model would be compared to any published studies performed by FEMA; however, a detailed study of the Quinapoxet River has not been completed by FEMA. The FEMA Flood Insurance Rate Map (FIRM), dated July 4, 2011, indicates Zone A predicted floodplain limits. A flood zone identified as Zone A does not have elevations associated with its limits. Rather, as indicated in the preliminary Flood Insurance Study for Worcester County, an approximate estimation was used to delineate the floodplain. The methods used to produce a Zone A are not documented by FEMA. Determining floodplain limits with approximate methods includes a combination of USGS Flood Prone Area Maps, USGS topographic maps, wetlands information, aerial photographs, historic observation, field survey, use of a regional relationship developed between the drainage area, and depth of flooding based on regression analyses of gauged streams. The July 16, 2014 FIS for Worcester County does not explicitly describe the approximate method used in the delineation of the Quinapoxet River Zone A floodplain that appears on the FIRM. The effective FIRM is found in Appendix G.

The existing conditions survey was completed by MMI on April 16, 2015 and April 29, 2015 and included detailed survey of the dam, training walls, and 10 cross sections upstream and downstream of the dam. This data was combined with statewide topographic information from 2011 (obtained with LiDAR, available through the State of Massachusetts Office of Geographic Information MassGIS) to develop a detailed base map of the channel, impoundment and overbank areas. The elevations in the model are referenced to the North American Vertical Datum of 1988 (NAVD 1988).

The Manning friction coefficients were selected based upon field observations. A Manning's n of 0.03 was used for the channel upstream of the dam. A Manning's n of 0.04 was used downstream of the dam. A Manning's n value of 0.1 was used for the wooded overbanks.

The existing dam was input into the HEC-RAS model as an inline structure with a width of 6.5 feet. Based on field observations, the upstream embankment side slope was entered as 0.15 and the

downstream embankment side slope was entered as zero. The weir shape is broad crested with a weir coefficient of 2.6.

A normal slope of 0.014 feet per foot (ft/ft) was applied as the upstream boundary condition and a normal slope of 0.0002 ft/ft was applied as the downstream boundary condition. The model was run in a mixed flow regime. The existing conditions geometry was used in numerous plans to evaluate water surface elevations and velocities for various design parameters including flood flows (5- through 100-year flows based on 17B analysis) and fish passage (*StreamStats*-developed flows for bankfull, D99, M7D2Y, M7D10Y, and AUGD50).

Modeling results indicate that the existing channel is subject to high velocities for larger storm events. A summary of velocities and shear stresses for various flows under existing conditions is provided in Table 4-1.

TABLE 4-1
Existing Conditions Predicted Flood Velocities and Shear Stress

Station	Channel Velocity (ft/sec)			Shear Stress (lb/sq ft)		
	Bankfull	10% ACR	1% ACR	Bankfull	10% ACR	1% ACR
2177	7.8	10.0	11.9	2.82	3.95	4.97
2094	5.5	8.2	11.1	0.94	1.84	3.14
1980	6.1	8.8	10.6	1.27	2.37	3.07
1897	5.0	8.0	11.5	0.63	1.50	2.89
1789	3.7	5.7	7.1	0.37	0.76	1.10
1718	1.9	3.0	3.9	0.10	0.21	0.33
Dam						
1679	3.1	4.4	5.5	0.41	0.74	1.04
1636	6.4	8.0	8.7	2.28	3.58	2.81
1599	4.8	6.1	6.7	0.93	0.82	0.82
1433	6.2	10.1	11.3	0.55	0.80	0.85
1032	1.6	2.2	2.7	0.01	0.07	0.09

Notes:
1) ACR = Annual Chance of Recurrence

4.2 Effect of Dam Removal on Fish Passage

The proposed dam removal project must consider aquatic organism passage for both aquatic and riparian wildlife in the area. Dams such as the Quinapoxet cause a blockage to fish passage and habitat continuity from upstream to downstream. Even with a properly functioning fish ladder, dams cause habitat fragmentation. Fragmented populations that are forced to survive independently can be destroyed without the ability to adapt to changing needs in their food supply, breeding areas, predatory concerns, and even genetic diversity.

Barriers to aquatic organism passage can occur in a variety of ways, such as when water velocity, turbulence, and depth become impassible to the species that are native to the watercourse. They can also cause segmentation of riparian wildlife populations that travel along streambanks.

Fish passability between the reservoir and the upstream river is one of the primary goals of the project. This involves warm water lake species such as carp, bass, perch, and pickerel that are likely to reside in

the lake and unlikely to travel in fast water as well freshwater stream species that occasionally swim downstream into lakes. The latter include brown trout, rainbow trout, dace and darter, and pike. As such, the ability of the proposed channel to provide fish passage for various species of trout and landlocked salmon was assessed using a spring and low summer flow.

The low summer flow was the median August flow provided by *StreamStats*, while the spring flow was the median May flow taken from the USGS gauge recordings of the Canada Mills gauge on the Quinapoxet. Design flows are listed below in Table 4-2.

TABLE 4-2
Peak Flow Rates Used to Assess Fish Passage

Frequency	Peak Flow (cfs)
Spring Flow	88
Summer Flow	13

Generally accepted values for "burst" swimming velocities and flow depth during the migratory season are 6 feet per second and 6 inches of flow depth, respectively, for the target species. More specific information on these species is presented in Table 4-3, as compiled from numerous sources.

TABLE 4-3
Fish Passage Requirements for Target Species

Parameter	*Atlantic Salmon (Salmo salar)*	*Eastern Brook Trout (Salvelinus fontinalis)*	*Brown Trout (Salmo trutta)*	*Rainbow Trout (Oncorhynchus mykiss)*
Life Stage	Adult	Adult		
Life Strategy	Anadromous	Freshwater		
Thermal Regime	Coldwater	32 - 77°F		
Spawning Temperatures (°F)	36.4 - 42.0°F	38 - 45°F		
Spawning Habitat	Gravel riffle areas	High elevation lakes and streams		
Major Run	May – mid July	April – July (juvenile)		
Minor Run	September – October	October – December (adult)		
Sustained Swimming Speed (fps)	5.0-8.8	2.0-7.2		
Minimum Depth (in)	5.7-6.6	5.0-6.0		
Time of Migration	Diurnal	---		

A restored channel through the location of the dam would need to provide adequate water depths for the selected species (up to approximately 6 inches) during the spring and summer, combined with flow velocities that are lower than the swimming speeds as well as adequate shelter to provide fish habitat. Since the naturalistic channel upstream of the dam already has a 1.5 percent slope and good habitat, it can be considered an interim reference reach or template for the restored downstream channel.

The restoration analysis focuses on the Atlantic salmon and various types of trout native to the northeast. Table 4-3 summarizes basic information on these two species compiled from numerous sources. Critical to fish passage design are water velocity and depth. Resulting water velocities and depths cannot be excessive or shallow as to prevent fish passage. The limiting velocity criteria will be at the lower range for eastern brook trout, at 2.0 to 7.2 feet per second (fps). Atlantic salmon have a higher tolerance at 5.0 to 8.8 fps.

4.3 Proposed Conditions Modeling

The alternatives analyzed for the Quinapoxet Dam removal and channel restoration reflect various site constraints and predicted post dam removal channel geometry. The dam was constructed by over-excavation and dredging of the downstream portion of the channel, and the removal of the dam must be completed without replacing the material removed during its construction in order to protect the integrity of the downstream infrastructure. Therefore, the primary constraint in the evaluated alternatives was the need to create a steeper channel than would naturally have formed, while mitigating high velocities from developing. The channel should also provide suitable flows velocities and depths for freshwater fish passage.

Concept geometry was developed for three alternatives for the reach extending to just below the existing dam to approximately 480 feet upstream of the dam. Similar bankfull geometry was applied in all three alternatives, with slopes and channel features providing the primary differences in the evaluated alternatives. River stations are graphically depicted on the HEC-RAS cross section location map, included in Appendix I.

The proposed conditions model was created by revising the existing conditions geometry to incorporate the proposed changes at the project site. This included the removal of the existing dam, incorporation of channel features, channel grading, and overbank grading. Manning's roughness coefficients were modified to reflect the proposed conditions.

Conceptual geometry of the post-dam removal channel reflects a bankfull channel base width of 80 feet in pool sections and 50 feet in riffle sections. Bankfull depth at the proposed riffles was modeled as 2 feet, while the pool sections were modeled as deeper using an iterative process that involved running the model and adjusting bed elevation to fully contain the bankfull flow. Where feasible, floodplain benches were incorporated into the design. The existing abutment walls and berms along the river's southern bank were retained.

The two primary concerns are: (1) protection of the drinking water supply reservoir from excessive sediment mobility; and (2) fish passage. Alternatives were evaluated with these criteria in mind.

4.3.1 Alternative 1 – Constant Channel Bed Slope from RS 2094 to RS 1599

This alternative involves the removal of the U-shaped spillway and regrading the channel from RS 15+99 to RS 20+94 at a constant slope of 2.1%. Most fishery species will be able to survive and migrate in channels near two percent slope, as long as they have roughness, resting areas, and shelter. The modeled stream had a base width of 60 feet, a depth of 2 feet, with side slopes of 4:1. Upper bank slopes were tied into existing grade at slopes not exceeding 3:1. A higher Manning's roughness coefficient of 0.06 was applied in the channel, reflective of anticipated bed armoring and channel

features. A concept sketch with profile is presented in Figure 4-1. A summary of velocities and shear stresses for various flows with Alternative 1 is provided in Table 4-4.

Natural channels with a 2.1 percent slope would typically fall within the Rosgen Type B with fast run and riffle profile types. Pools would be rare or absent. The natural bed would be fairly rough, with many cobbles and boulders that slow flow and create eddies and turbulence.

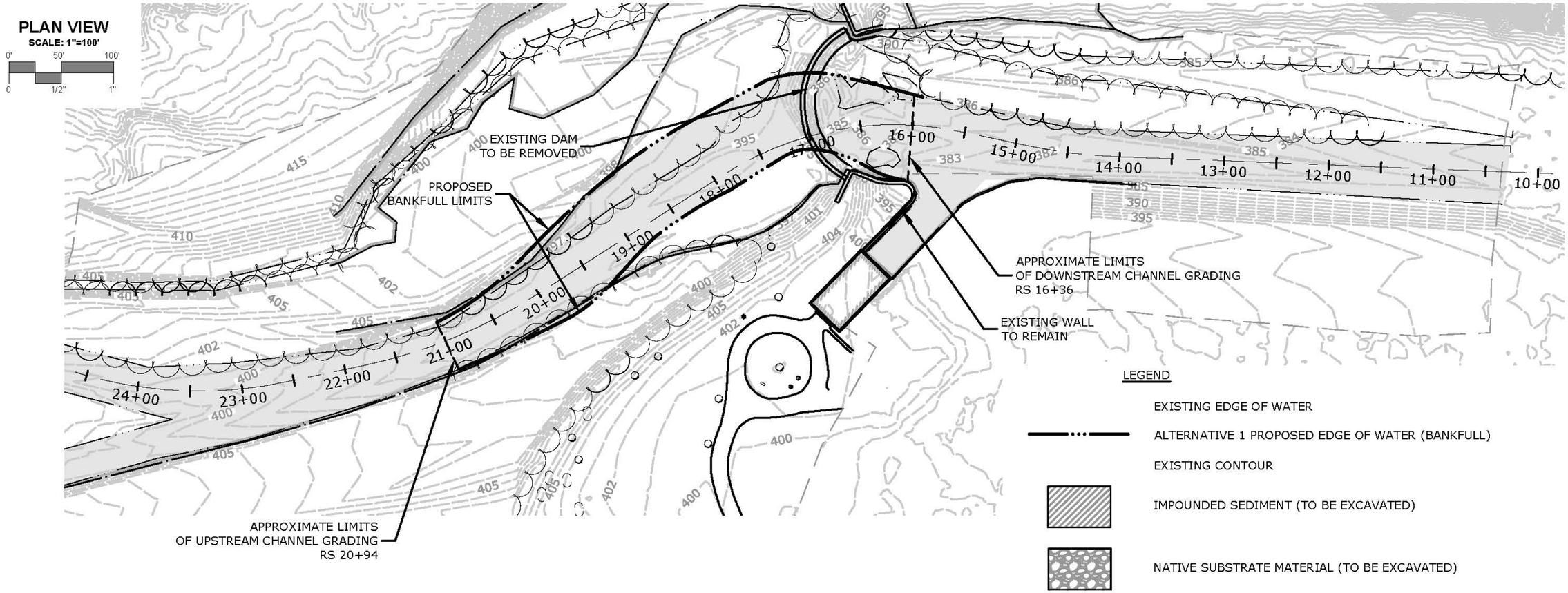
TABLE 4-4
Proposed Conditions Predicted Velocities and Shear Stress for Alternative 1
(Stations are listed from upstream to downstream)

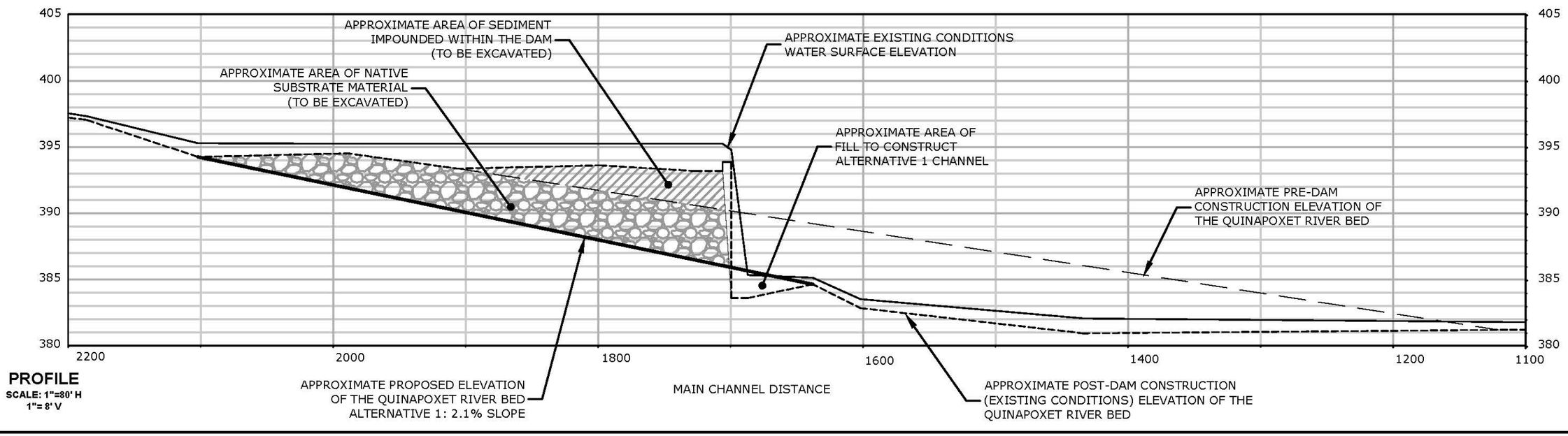
Station	Channel Velocity (ft/sec)			Shear Stress (lb/sq ft)		
	Bankfull	10% ACR	1% ACR	Bankfull	10% ACR	1% ACR
2177	7.8	10.0	11.9	2.82	3.95	4.97
2094	8.6	11.1	13.1	2.66	3.74	4.63
2048	8.1	12.9	**16.6**	6.00	13.87	**21.13**
1985	4.8	6.9	8.9	1.79	3.22	5.06
1897	6.4	8.0	9.3	3.56	4.65	5.66
1789	5.1	7.0	8.4	2.01	3.33	4.35
1718	6.0	7.5	9.1	2.98	4.05	5.39
Dam (rem)						
1679	4.8	7.0	9.0	1.80	3.38	5.26
1636	6.4	8.0	7.3	3.77	5.69	4.16
1599	5.0	5.3	5.6	0.93	0.82	0.82
1433	4.8	6.2	6.7	0.55	0.80	0.85
1032	1.6	2.2	2.7	0.04	0.07	0.09

Notes:
1) ACR = Annual Chance of Recurrence
2) Bold indicates high values that may induce erosion and scour.

Modeling results indicate that the restored channel would be subject to high velocities at the upstream end of the project reach. Flow would be supercritical upstream of RS 20+48, with a hydraulic jump predicted to occur at RS 20+48. Below this section, flow is predicted to be subcritical. High velocities and shear stresses are predicted in conjunction with the turbulence associated with the hydraulic jump. Bed and bank armoring using stones sized to resist these erosive forces should be sufficient to address any threat of potential headcut associated with this jump. The details for this armoring and any proposed channel features will be explored in later design phases. Alternately, advanced design could evaluate changes in channel width and shape to create a lower energy transition in this reach.

Velocity and depths for spring and summer flows are presented in Table 4-5. Results indicate that velocities are predicted to be below the threshold of 6 feet per second in all areas during the selected flows, and that adequate flow depth will be provided during low flows.





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ALTERNATIVE 1: CONCEPT PLAN AND PROFILE

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

PRELIMINARY FEASIBILITY & ENGINEERING DESIGN

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Figure 4-1

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TABLE 4-5
Proposed Alternative 1 Predicted Velocities and Depths for Spring and Summer Flows

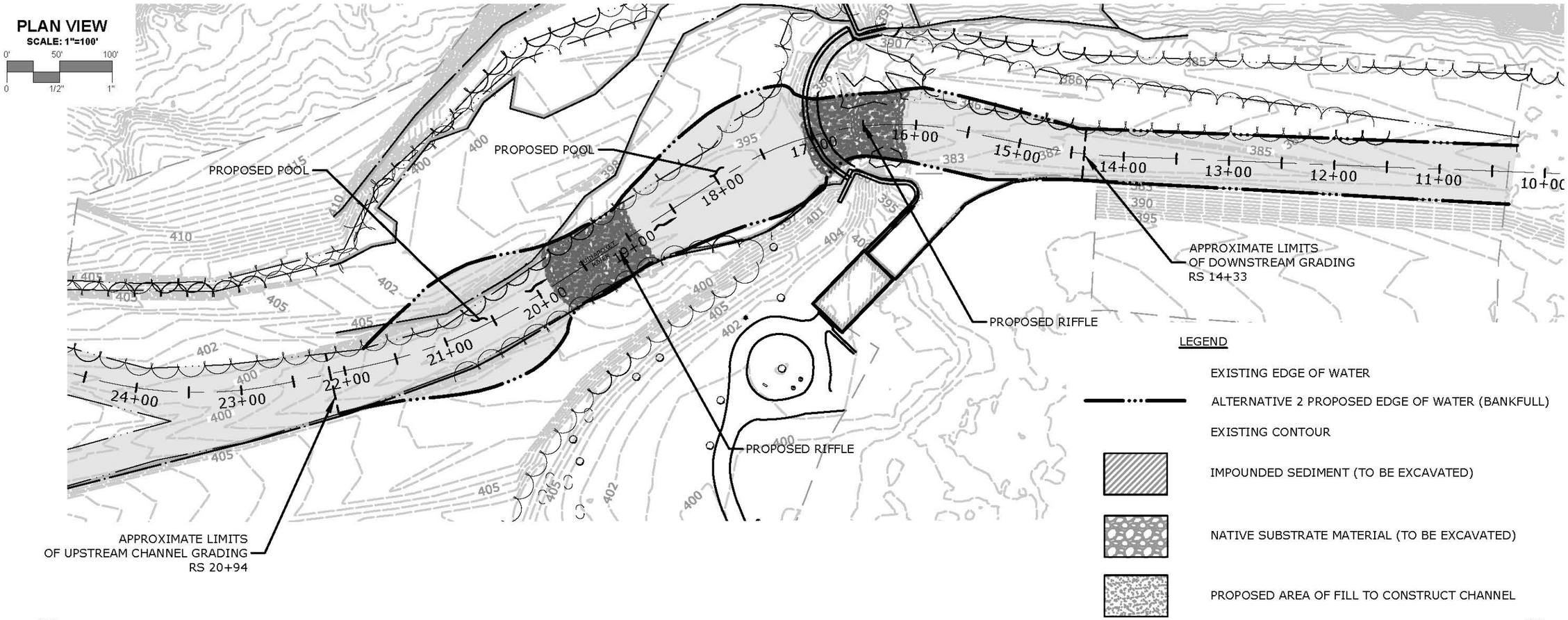
Station	Channel Velocity (ft/sec)		Flow Depth (in)	
	Spring Flow	Summer Flow	Spring Flow	Summer Flow
2177	3.8	2.3	8	3
2094	3.3	1.6	14	7
2048	4.1	2.8	12	6
1985	1.9	1.0	13	6
1897	4.1	2.8	12	6
1789	1.9	1.0	13	6
1718	4.1	2.8	12	6
Dam (rem)				
1679	1.8	1.0	14	6
1636	4.0	2.9	14	6
1599	4.8	2.9	15	8
1433	1.7	0.6	24	13
1032	0.7	0.4	18	8

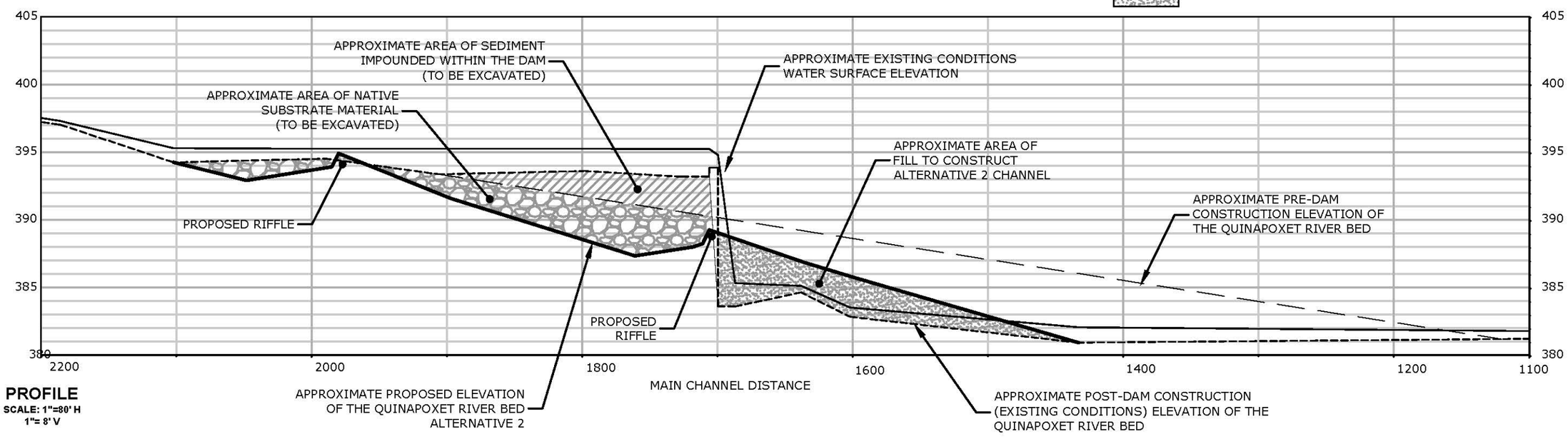
Predicted flow depth at the upstream end of the project (RS 2177) matches existing conditions at 3 inches, which is insufficient for fish passage. In order to provide adequate depth for fish passage, a narrow 2- to 4-foot-wide low-flow channel with an approximate depth of 1 foot would need to be incorporated into the design of the post-dam removal channel. Variations in channel base width is required in conjunction with this low-flow channel to assure adequate water depth during summer months.

4.3.2 Alternative 2 – Riffle-Pool Channel Extending from RS 2094 to RS 1433

This alternative involves a riffle-pool geometry that limits upstream grading to RS 20+94 and extends channel grading downstream to RS 14+33. The incorporation of these riffles and channel roughness (i.e. boulder clusters) reduces predicted velocities through the restored reach. Riffles were modeled as 100 feet in length, having a slope of 4%, with the crest 1 foot higher than the channel bed. Pools were modeled with a low point 1 foot lower than the bed elevation at the riffle crest, a total length of 190 feet, and a shallower upstream slope of 3%. The geometry includes two riffle-pool features, spaced 275 feet apart, and tying in to the existing riffle structure at RS 21+77. An iterative process was utilized to optimize the revised cross sections for both bankfull and 1% annual chance flows, and to minimize the predicted channel velocities. A concept sketch with profile is presented in Figure 4-2.

Modeling results indicate that the riffle-pool channel effectively reduces predicted velocities and shear throughout the restored reach. Although flow through the riffle portions will experience slightly higher velocities, the riffle stone and in-stream features could be appropriately sized to withstand such forces. A summary of velocities and shear stresses for various flows with Alternative 2 is provided in Table 4-6.





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QUINAPOXET RIVER

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Figure 4-2

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TABLE 4-6
Proposed Conditions Predicted Velocities and Shear Stress for Alternative 2

Station	Channel Velocity (ft/sec)			Shear Stress (lb/sq ft)		
	Bankfull	10% ACR	1% ACR	Bankfull	10% ACR	1% ACR
2177	7.9	8.9	10.2	5.14	5.53	6.65
2094	2.4	3.7	4.9	0.29	0.61	0.96
2048	1.7	2.8	3.7	0.12	0.31	0.52
1985	2.9	4.5	5.8	0.41	0.87	1.36
1980	7.2	8.2	9.6	4.30	4.73	6.10
1897	7.5	10.7	12.5	4.69	8.57	10.90
1789	2.1	3.2	4.3	0.22	0.44	0.71
1761	1.7	2.7	3.8	0.13	0.30	0.55
1718	2.8	4.4	5.9	0.36	0.77	1.32
1711	2.9	4.3	5.5	0.57	1.16	1.78
1706	6.1	8.4	9.3	2.91	5.01	5.57
Dam (rem)						
1679	7.1	9.4	11.3	4.12	6.52	8.81
1636	7.6	9.1	10.4	4.85	6.05	7.23
1599	7.7	10.0	11.6	2.95	4.28	5.29
1433	4.8	5.1	5.0	0.53	0.52	0.45
1032	1.6	2.2	2.7	0.04	0.07	0.09

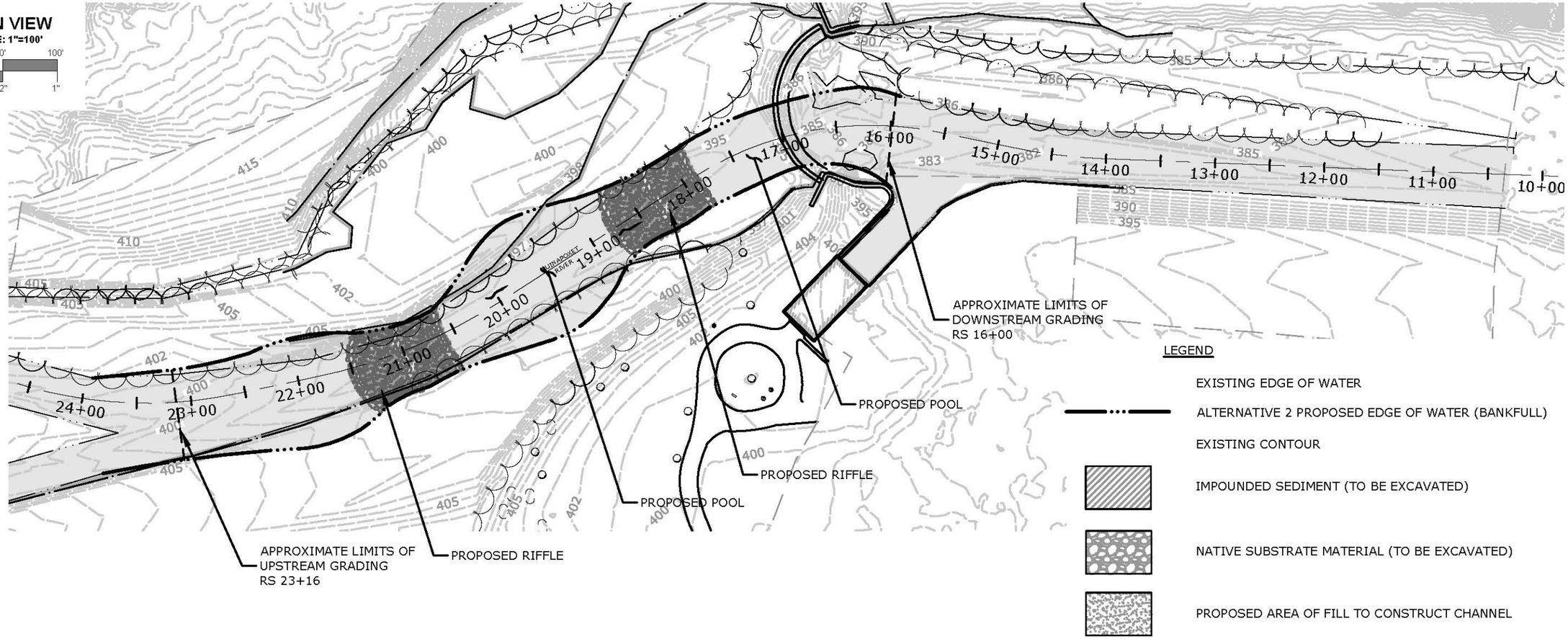
Notes:
1) ACR = Annual Chance of Recurrence
2) Bold indicates high values that may induce erosion and scour.

Although Alternative 2 reduces the predicted velocities as compared with Alternative 1, the proposed grading would extend beyond the immediate dam area and would fail to preserve the existing confluence of the Quabbin Reservoir Aqueduct with the Quinapoxet River approximately 145 feet downstream of the dam.

4.3.3 Alternative 3 – Upstream Riffle-Pool Channel from RS 2316 to RS 1636

This alternative involves a similar riffle-pool geometry and feature spacing as in Alternative 2, but limits the downstream channel work to RS 1636 (immediately downstream of the dam). The geometry utilized in Alternative 2 is essentially shifted upstream, resulting in channel grading that extends an additional 200 feet upstream as compared with Alternative 2. Riffles were modeled as 100 feet in length, having a slope of 4%, with the crest 1 foot higher than the channel bed. Pools were modeled with a low point 1 foot lower than the bed elevation at the riffle crest, a total length of 160 feet, and a shallower upstream slope of 3%. To tie in the proposed geometry at the downstream face of the dam, a 2.7% rock run was modeled from RS 17+89 to RS 16+36. A concept sketch with profile is presented in Figure 4-3.

The resulting channel velocities for the 1% annual chance storm are similar to those achieved with Alternative 2, with the exception of a predicted hydraulic jump in the region of the rock run at the removed dam location. Further evaluation of scour countermeasures and channel features may be necessary at this location to prevent erosive forces. A summary of velocities and shear stresses for various flows with Alternative 3 is provided in Table 4-7.



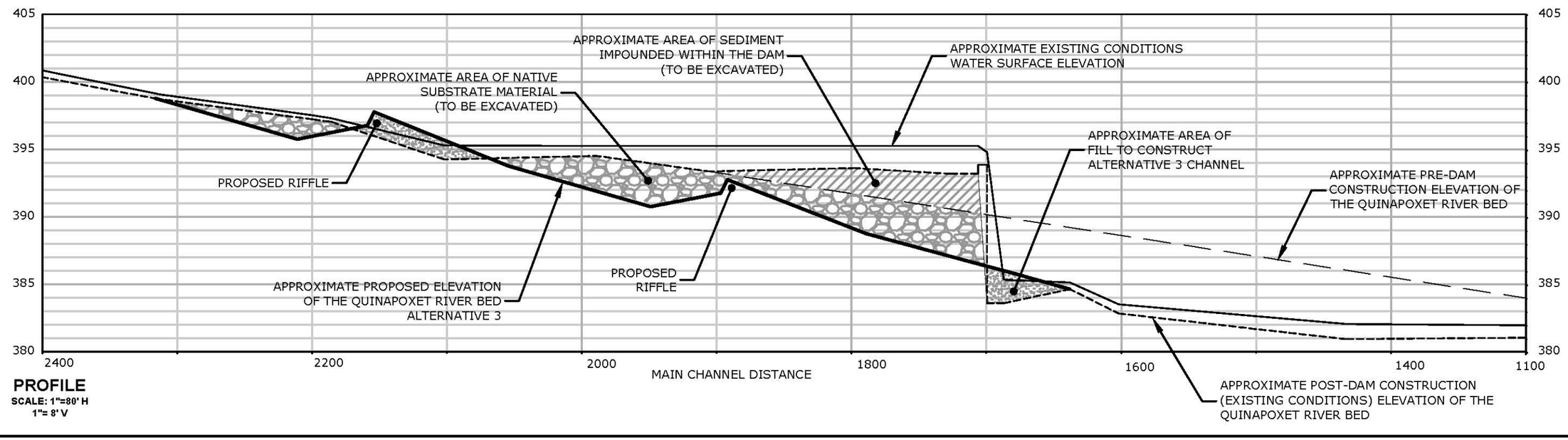


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Figure 4-3
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TABLE 4-7
Proposed Conditions Predicted Velocities and Shear Stress for Alternative 3

Station	Channel Velocity (ft/sec)			Shear Stress (lb/sq ft)		
	Bankfull	10% ACR	1% ACR	Bankfull	10% ACR	1% ACR
2177	2.0	3.2	4.4	0.14	0.34	0.60
2159	3.4	5.1	6.4	0.77	1.64	2.39
2154	6.7	8.3	9.3	3.68	4.98	5.75
2094	7.7	10.2	**12.5**	5.15	8.01	**11.35**
2054	6.7	8.2	9.6	3.70	4.93	6.14
1980	2.0	3.2	4.4	0.18	0.44	0.75
1949	1.6	2.7	3.9	0.09	0.24	0.46
1897	2.7	4.4	5.9	0.49	1.20	2.06
1892	6.5	8.1	9.5	3.48	4.77	6.02
1789	6.2	9.9	11.6	3.09	7.35	9.28
1718	6.6	8.2	9.7	3.54	4.85	6.22
Dam (rem)						
1679	6.4	8.9	10.6	3.36	5.87	7.80
1636	6.6	8.3	6.9	3.74	5.10	2.92
1599	5.0	5.3	5.6	0.93	0.82	0.82
1433	4.8	6.2	6.7	0.55	0.80	0.85
1032	1.6	2.2	2.7	0.04	0.07	0.09

Notes:
1) ACR = Annual Chance of Recurrence
2) Bold indicates high values that may induce erosion and scour.

While velocities and shear stresses in selected areas are high, these concerns can be mitigated as design is advanced with slight adjustments to geometry, roughness, scour protection, and other mitigation methods that would be typically associated with a more advanced engineering design.

Results indicate that flow will be sufficiently deep through the restored channel to support migration during low flow, and velocities are predicted to be below the threshold of 6 feet per second in all areas for spring and summer flow conditions. A narrower low flow channel with a minimum depth of 6 inches is necessary to provide adequate water depth through the riffle sections. Although it is not feasible to replicate the complicated flow and velocity patterns of water as it flows between large rocks such as those proposed for the riffle structures, it is possible to approximate the effect in the model using elevated roughness values. In reality, flow depth across the surface of the ramp will be more varied, with deeper and shallower areas than those predicted by the model. These results are presented in Table 4-8.

While velocities appear to be favorable to support fish passage, water depths during the low summer flow in certain areas may provide a challenge. It will be critical to fish passability that a narrow low-flow channel could be incorporated into the design of the restored channel to provide adequate depths during the summer dry season, especially at the riffle cross sections.

TABLE 4-8
Proposed Alternative 3 Predicted Velocities and Depths for Spring and Summer Flows

Station	Channel Velocity (ft/sec)		Flow Depth (in)	
	Spring Flow	Summer Flow	Spring Flow	Summer Flow
2159	0.8	0.2	28	19
2154	4.0	2.7	13	6
2094	3.1	1.7	15	7
2054	4.2	2.8	12	6
1980	0.5	0.1	29	21
1949	0.3	0.1	40	31
1897	0.6	0.2	28	19
1892	4.2	2.8	12	6
1789	2.9	1.7	15	8
1718	3.2	2.0	14	7
Dam (rem)				
1679	2.8	1.6	15	8
1636	3.6	2.2	12	6
1599	4.5	2.9	15	8
1433	1.7	0.6	24	13
1032	0.7	0.4	18	8

4.4 Sediment Stability Assessment

The proposed conditions modeling for all three alternatives predicts that water velocities through the restored channel reach will increase following dam removal. Erosion occurs when the hydraulic forces in the flow exceed the resisting forces of the channel boundary (Fischenich, U.S. Army Corps of Engineers, USACE). Permissible, or critical, velocity is defined as the maximum velocity for the channel that will not cause erosion of the channel boundary. Table 4-9 is a summary of boundary types and permissible velocities per the USACE Fischenich report. These values are useful in evaluating the stability of channel banks given estimated velocities and known bank material.

TABLE 4-9
Substrate Types and Permissible Velocities

Substrate Type	Substrate Size	Permissible Velocity (ft/sec)	Permissible Shear Stress (lb/sq ft)
Gravel/Cobble	2-in.	3-6	0.67
	6-in.	4-7.5	2.0
	12-in.	5.5-12	4.0
Riprap	6-in. d_{50}	5-10	2.5
	9-in. d_{50}	7-11	3.8
	12-in d_{50}	10-13	5.1
	18-in d_{50}	12-16	7.6
	24-in d_{50}	14-18	10.1

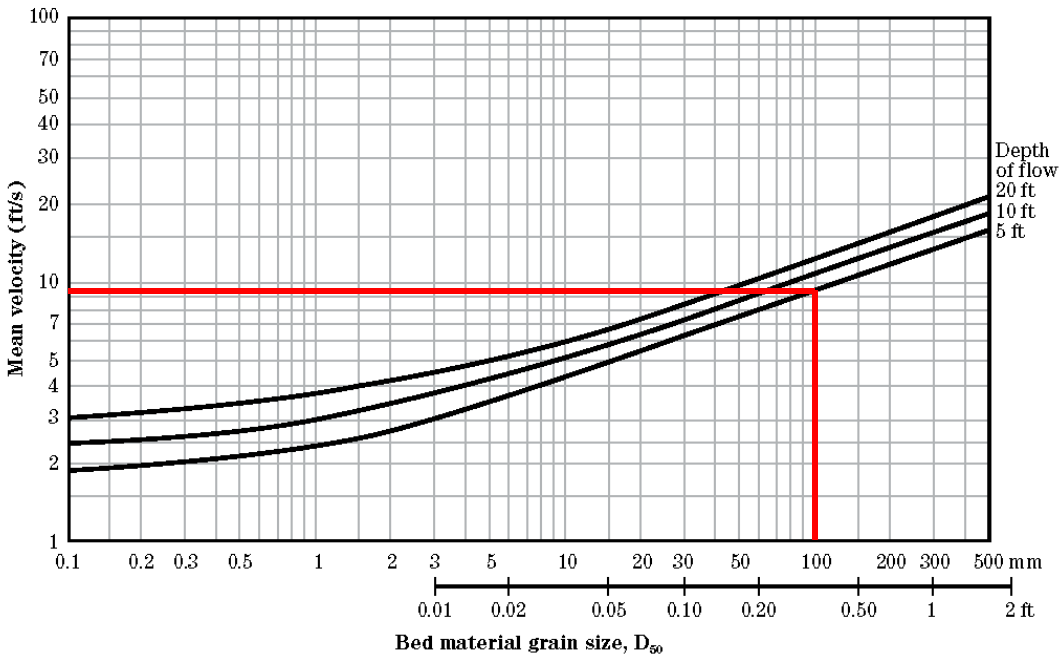
The highest velocities and shear forces are predicted near the center of each riffle structure. While all alternatives increase velocities over existing conditions due to the steepening of the channel, alternative 1 presents the worst case with velocities over 18 feet per second and shear stresses nearing 25 lb/sf at one cross section. Alternatives 2 and 3 present velocities that may be easier to accommodate through the use of additional bed armoring and grade control structures.

The Fischenich study does not include 48-inch diameter boulders in its permissible shear and velocity table, however the 24-inch diameter riprap is capable of withstanding nearly all of the velocities and shear stresses on the order of the predicted values for the project reach, with the exception of shear predicted during a 100-year storm at river stations 2094 and 1789. Both of these stations are located within proposed riffles, so would be more heavily armored with larger boulders. The stone riffles can be constructed with 36-inch to 48-inch diameter core boulders and 12-inch to 36-inch filler stone. Channel materials within the pool areas would need to tend towards the larger gravel/cobble material to withstand predicted velocities.

The substrate downstream of the dam as determined through pebble count analyses and test pits in the project area is characterized by coarse gravel and cobbles. The substrate upstream of the dam is characterized by finer material, with higher volumes of fine and medium gravel than the downstream reach. The upstream D_{50} was determined to be 92 mm (3.6 inches), and the downstream D_{50} was determined to be 121 mm (4.8 inches).

The computed mean particle size (D_{50}) of the composite sample (accounting for both the natural bed armoring and the underlying cohesive substrate) was estimated at 106 mm. Figure 4-4 presents a graph relating sediment stability and channel velocity.

FIGURE 4-4
Permissible Velocity vs. Material Grain Size (D_{50}) –USACVE, 1994



The threshold velocity for the analyzed sediment sample is approximately 9.5 feet per second. The maximum velocity predicted for the 1% annual chance peak discharge for Alternative 1 exceeds 18 ft/s, and is 13.7 ft/s and 13.5 ft/s for Alternatives 2 and 3, respectively. More frequent storm events are predicted to generate lower velocities. The restored channel, pursuing any of the three alternatives, will need to be armored with larger gravel and cobbles to withstand these erosive forces.

5.0 OTHER DAM REMOVAL CONSIDERATIONS

5.1 Sediment Management and Material Removal

The existing channel upstream of the Quinapoxet Dam does not contain a large impoundment with accumulated sediment like typical dams due to its construction. This is explained in further detail in prior sections. However, a relatively small layer of accumulated sediment where the bed has aggraded slightly appears to have settled upstream of the dam. This sediment accumulation is estimated at a volume of 1,365 cubic yards. In order to assess the potential sediment impact, we compare the impounded volume against the estimated annual watershed sediment yield. The dam has a watershed of 57 square miles.

Based upon watershed characteristics (climate, till, mixed forest cover) and our database, the watershed annual sediment yield is estimated to be 50 tons per square mile per year, or 2,850 tons per year. The coarse sediment is assumed to have a unit weight of 95 pounds per cubic foot, equal to 2,565 pounds per cubic yard. As a result, the estimated annual sediment yield is 2,226 cubic yards per year. Consequently, the 1,365 cubic yards of stored sediment is equal to only 0.6 average years of inflow and is not significant.

Removal of the dam will require construction of a new channel to account for the 9 feet of vertical drop currently held in place by the dam. This will require removal of material in order to construct the proposed channel, as filling in the downstream is not feasible due to the Quabbin Interconnect. The following Table 5-1 presents estimated quantities of sediment, and underlying native substrate that will be impacted by the three alternatives presented in Section 4.

TABLE 5-1
Summary of Material Volumes Generated During Dam Removal

Material	Alternative 1 Volume (CY)	Alternative 2 Volume (CY)	Alternative 3 Volume (CY)
Native (Pre-Dam) Substrate	3,265	2,415	2,730
Impounded Sediment	1,365	1,365	1,365
Total Material Removed	4,630	3,780	4,095
Total Fill	0	2,560	0
Net Material	4,630 EXCESS	1,220 EXCESS	4,095 EXCESS

The three presented alternatives all deal with an excess of material to be removed from the site or managed in some way. Alternative 2 provided for some on-site reuse by filling the downstream channel, however this was deemed infeasible as mentioned above, due to the presence of the Quabbin Interconnect.

Sediment and excess material management options generally include the following:

- Allow natural erosion
- Stabilize in place

- Relocate to pool perimeter
- Dredge and remove

Given the downstream reservoir, natural erosion is not an option as the eroded sediment would begin filling the reservoir. Similarly, stabilizing in place would not allow for a sloped channel to be constructed in lieu of the 9-foot drop held in place by the existing dam. Relocation of the sediment to the banks and floodplain may be an option for consideration in advanced design phases, but the problem of armoring the sediment from future mobility adds significant cost and complication. The easiest and recommended approach is to transport the sediment off-site and dispose of in a non-floodprone location.

5.2 Sediment Transport and Equilibrium Channel

The ideal channel size, slope, and pattern for physical and habitat stability is one that has its river processes close to an equilibrium state under quasi-natural conditions. This means that for its bankfull discharge and sediment load, the channel does not aggrade or degrade (scour) over long term time spans. The flow and sediment load are in balance with the channel characteristics.

After first looking into sediment competence (size of threshold sediment particles), a sediment transport model was developed using the Corps of Engineers SAM software. The input data includes the peak flow rate, sediment gradation, and bank resistance, plus an initial trial channel slope and width (to reduce iterations).

The results indicate that the optimum channel top width would be 60 feet with a slope of 0.018 feet per foot. The range of successful solutions is a top width of 50 to 90 feet, and a slope of 0.018 to 0.020. These values are very close to the measured channel conditions upstream of the aggraded pool, suggesting use of that section as a reference reach for physical and biological replication. The full results of the SAM analysis can be found in Appendix I

5.3 Effect of Dam Removal on Water Quality

Dam removal can affect downstream water quality through the release of stored sediment, particularly fine grain sediment, or release of contaminated material. At the Quinapoxet dam, site inspections and sediment testing reveal minimal silt and clay, and limited total volume of sediment that can likely be reused on site or off site. Laboratory tests do not reveal contaminated material that could be released or go into solution. In summary, dam removal will have a minimal impact on water quality.

5.4 Effect of Dam Removal on Aquatic Habitat and Fish Passability

Consideration must be given to the channel restoration relative to the creation of aquatic habitat for the target species such as Trout and Landlocked Salmon.

The existing dam prevents fish passage from the downstream reservoir into the upper reaches of the Quinapoxet River habitat from occurring. This inhibits the ability of many native species of fish from accessing miles of native habitat. If considered during design, there are elements, features, and methods that can be employed such that the final channel will provide fish passable conditions through the site. Referring to a reference reach is a valuable tool when attempting to match the passability of

natural conditions in a river restoration project. A pool-riffle site approximately a half mile upstream of the subject reach was assessed and used a reference reach, where riffle to riffle spacing was measured at approximately 150 feet, and slope was measured as approximately 2 percent.
The riffle to riffle spacing, slope, and bankfull dimensions were used to develop both Alternatives 2 and 3. The United States Fish and Wildlife (USFW) performed a site assessment of the existing dam, which involved observing the selected reference reach, and were in agreeance as to its appropriateness and similarity to the subject reach.

Using parameters provided by the United States Fish and Wildlife Service (USFWS), the hydraulic modeling results of each alternative was assessed relative to its suitability for fish passage for Land Locked Salmon (see Table 5-2). Hydrology was assessed by compiling flow information from USGS gage No. 01095375 on the Quinapoxet River at Canada Mills near Holden, MA. Daily flow data was generated, and the 15% daily exceedance flow and the 85% daily exceedance flows were used to assess low flow periods and higher flow periods throughout the spring/summer/fall seasons. The lower flow (85% daily exceedance) was computed as 10 cubic feet per second, and the higher flow (15% daily exceedance) was computed as 120 cubic feet per second.

TABLE 5-2
Summary of Physical Abilities of Land Locked Salmon

Physical	Body length	12		18		in
	% Body Depth	0.2		0.2		
	Body Depth	2.4		3.6		in
	Frontal Area	4.52		10.18		in2
Swim Speed	Cruising	1.3	2.3	2.0	3.5	ft/s
	Prolonged	4	7	6	10.5	ft/s
	Burst	8	14	12	21	ft/s
Fatigue Time	Cruising					sec
	Prolonged	300	300	300	300	sec
	Burst	5	5	5	5	sec
Fatigue Distance	Cruising	INF	INF	INF	INF	ft
	Prolonged	2400	4200	3600	6300	ft
	Burst	20	35	30	52.5	ft

Appendix K has full results of the assessment, but shows a wide range of passable velocities. While no alternative show full passage for all parameters, most showed that even in the higher flows, velocities could be kept below 4 feet per second, in localized peaks in velocity could be minimized. Alternative 1 had the overall highest consistent velocities, due to the lack of bed variability in the proposed profile. Alternatives 2 and 3.

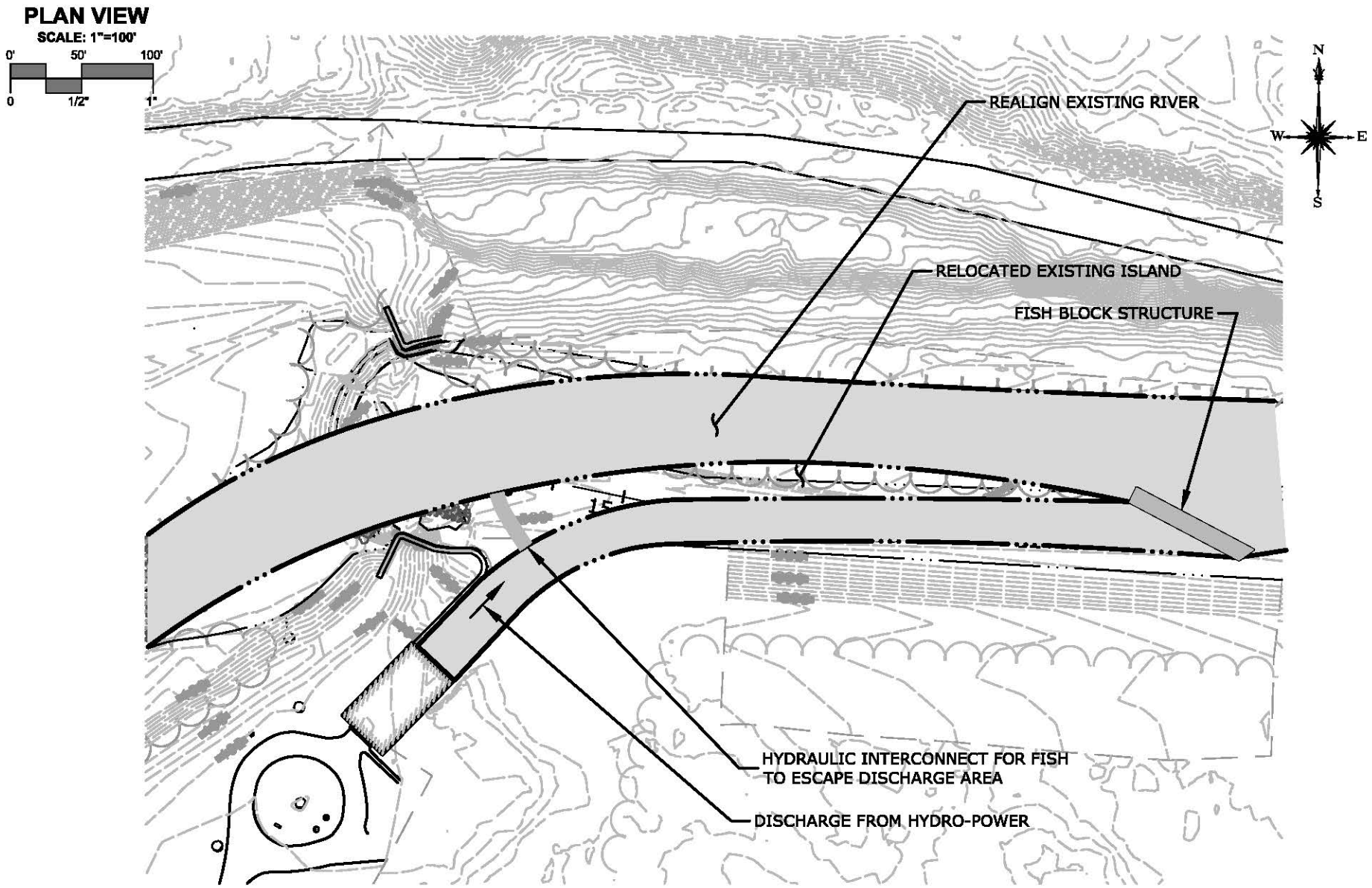
The hydraulic modeling indicates that post-dam removal velocities will be favorable for habitat creation even under low-flow conditions, but that shallow depths may continue to be a challenge. Therefore we would recommend that the installation of deeper pool areas, boulder clusters, and a low-flow channel be considered as part of the project as the design is advanced to the next stage. These features will help

achieve the project goal, to restore the river to a pre-dam state in both hydraulic and aquatic habitat capacity.

5.5 Attraction Flow

An additional consideration relative to fish passage is the presence of the hydro-power station outlet directly downstream of the dam. This station serves as the outlet of an underground transmission main (the Oakdale Shaft) from the Quabbin Reservoir. The water discharge is managed by staff of the Massachusetts Water Resources Authority (MWRA), and is generally operated at full discharge during the summer months, coincident with the lowest flows in the river. The fish passage flows that were assessed ranged from 10 cfs to 120 cfs, which may coincide with times that the discharge of the hydro station is 500 cfs. This will create a much stronger flow that fish will be naturally attracted to, which will lead them do a dead end.

As discussed with NFWS, the channel downstream of the dam and hydro-power station could be configured to add additional separation between the two channels, and a barrier could be provided to prevent fish from attempting to enter the power house channel. Any barrier installed would have to be carefully designed to prevent backwater effects on the hydro-power station. An existing vegetated island downstream of the existing dam would be impacted by such work, but could be relocated to provide a natural barrier between the two channels. Figure 5-1 includes a conceptual sketch of such a channel configuration.



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DATE	JUNE 2016
SCALE	1"=100'
PROJ. NO.	2688-37
DESIGNED	JCM
DRAWN	JCM
CHECKED	JAG

ATTRACTION FLOW - ISLAND RELOCATION

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

PRELIMINARY FEASIBILITY STUDY & ENGINEERING DESIGN

DRAWING NAME:

FIG. 5-1

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Drawing: W:\DESIGN\2688-37-DE\CAD\QP-ALTERNATIVES.DWG Layout: TabALT - ISLAND
Plotted by: JAMESM On this date: Tue, 2016 June 28 - 5:09pm

5.6 Water Control Measures During Construction

The water control plan will need to be carefully considered prior to construction, such that all manner of flow situations can be accounted for and dealt with quickly, without causing a turbidity release into the Wachusett Reservoir that could impact water supply operations.

5.6.1 Low-Flow

Under low-flow conditions, it is recommended that a type of diversion pipe or channel be constructed around the active construction site, with cofferdams at the upstream and downstream ends of construction to divert water through the temporary diversion. This setup should be sized to accommodate as much flow as economically feasible, but at a minimum should be able to sustain median flows during the construction season. According to *USGS StreamStats*, the median flow during the month of August is 13.3 cfs, and the bankfull flow is 829 cfs. The average spring flow was estimated to be approximately 88 cfs. While trying to divert the bankfull flow may be cost prohibitive, low-flow diversion of at least the spring flow of 88 cfs with a freeboard to accommodate an additional 25% would provide the ability to work in the dry during most flow conditions throughout the summer.

5.6.2 High Flow (Flood Contingency Plan)

If a significant precipitation event is forecast to occur during the construction period and flows are elevated above that which the low-flow water control is capable of managing, a flood contingency plan should be available and enacted before the precipitation event occurs. This may involve the modification of the cofferdams or the diversion of the anticipated flows to a stable portion of the site, such that the damage to the site is mitigated and downstream turbidity release is kept to a minimum.

5.6.3 Sediment and Erosion Control

Erosion control on site will be managed through the use of approved Best Management Practices (BMPs) from the Massachusetts Erosion and Sediment Control Guidelines. Work in the channel will be completed under dry conditions, and the watercourse will be protected using silt fence and straw bales, as appropriate. Any dewatering pumps that are necessary to provide dry conditions during excavation will be discharged to a designated settling basin to eliminate turbidity in the water before it is discharged back into the watercourse.

5.7 Construction Timeline

Deconstruction and removal of the dam and restoration of the channel is anticipated to take approximately 4 months. It is anticipated that the construction window will be limited to the months of June, July, August, and September due to lower flow conditions and fish migration concerns. It should also be noted that the Quabbin Interflow Shaft #1 is opened for water supply reasons from June to October, which transfers water from the Quabbin Reservoir to the Wachusett Reservoir, which means flows at the downstream end of the project will be elevated, and water quality will be a primary concern.

6.0 RECOMMENDATIONS

Based on the foregoing analysis and conceptual design, removal of the Quinapoxet dam spillway and creation of a restored channel upstream, while maintaining stable channel morphology and protecting the downstream reservoir from sedimentation, is believed to be feasible. Conceptual design by its nature does not include detailed grading or refined channel design. However, based upon HEC-RAS analysis and conceptual design analysis, both Alternatives #1 and #3 have potential for long-term hydraulic and aquatic habitat restoration in the Quinapoxet River. Critical design features will be adequate channel armoring and creation of a low-flow channel for fish habitat.

Alternative #1 exhibits less flow variability by providing one consistent slope through the reach. The lack of variability and velocity interrupters makes fish passage more difficult to accommodate through the site. Alternative #2 was not further pursued due to the fill required downstream of the dam, which may interfere with the operation of the hydro-power facility. Therefore, if fish passage is chosen as a project goal, it is recommended that Alternative #3 is pursued further. Additionally, the channel work downstream of the existing dam should be considered. Although it will increase the overall impact area, it will provide a more fish-passable channel.

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APPENDIX A

PHOTO LOG AND INDEX PLAN

Appendix A – Photo Log

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
WEST BOYLSTON, MA

APRIL 21, 2015
MMI #2688-37

PHOTOS TAKEN ON APRIL 14, 2015

Figure 1: Looking north along the earthen berm on the southern bank adjacent to the portal from the Quabbin Aqueduct.

Figure 2: Portal and maintenance building from the Quabbin Aqueduct and Quinapoxet Dam.

Figure 3: Looking upstream and the Quinapoxet dam spillway.

Figure 4: Looking east downstream of the Quinapoxet dam approximately 700' downstream.

Figure 5: Looking west upstream of the Quinapoxet dam at a riffle run section approximately 800' upstream.

Figure 6: Looking downstream at the fish bypass structure.

Figure 7: Looking down at Quinapoxet dam spillway.

Figure 8: Looking north across the Quinapoxet dam spillway.

2015-04-14 Photo Log

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REVISIONS

INDEX PLAN

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

PRELIMINARY FEASIBILITY & ENGINEERING DESIGN

JCM	DRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=100'

DATE: JUNE 30, 2015

PROJECT NO.: 2688-37

SHEET NO.: **1 OF 1**

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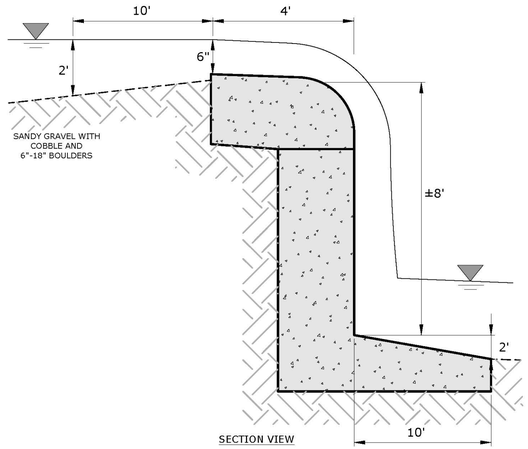
Drawing: W:\DESIGN\2688-37-DX\CAD\NONPLANSET\IEC-EXS SECTIONS AERIALDWG Layout Tab:EX-PLAN
Plotted by DANNE On this date: Fri, 2015 June 19 - 4:54pm

APPENDIX B

EXISTING CONDITIONS SURVEY MAP



TYPICAL DAM CREST SECTION

MAPPING NOTES:

1. TOPOGRAPHIC INFORMATION IS BASED UPON MassGIS Data - LiDar Terrain Data subset: May 6-7, 2011 Nashua River, AND SUPPLEMENTED WITH FIELD SURVEY BY MILONE & MACBROOM, INC., CHESHIRE CT. 4/16 & 4/29/2015. UTILITY INFORMATION FIELD SURVEYED BY MILONE & MACBROOM, INC.
2. ALL CONTOURS AND ELEVATIONS ARE IN PRESENTED IN FEET, AND REFER TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1988 (NGVD 1988).
3. NORTH ARROW, BEARINGS AND COORDINATES ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD 1983) MASSACHUSETTS MAINLAND STATE PLAIN.
4. INFORMATION REGARDING THE LOCATION OF EXISTING UTILITIES HAS BEEN BASED UPON AVAILABLE INFORMATION AND MAY BE INCOMPLETE, AND WHERE SHOWN SHOULD BE CONSIDERED APPROXIMATE. THE LOCATION OF ALL EXISTING UTILITIES SHOULD BE CONFIRMED PRIOR TO BEGINNING CONSTRUCTION. CALL "DIG SAFE", 1-888-344-7233. ALL UTILITY LOCATIONS THAT DO NOT MATCH THE VERTICAL OR HORIZONTAL CONTROL SHOWN ON THE PLANS SHALL IMMEDIATELY BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR RESOLUTION.
5. MILONE & MACBROOM INC. ACCEPTS NO RESPONSIBILITY FOR THE ACCURACY OF MAPS AND DATA WHICH HAVE BEEN SUPPLIED BY OTHERS.
6. WETLANDS DETERMINED, FLAGGED AND FIELD LOCATED BY MILONE & MACBROOM, INC. ON JUNE 29. 2015

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DESCRIPTION	DATE	BY

EXISTING CONDITIONS

QUINAPOXET DAM REMOVAL
QUINAPOXET RIVER AT THE WACHUSETT RESERVOIR

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

DRM	DRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: JUNE 18, 2015

PROJECT NO.: 2688-37

SHEET NO.: 1 OF 1

SHEET NAME: EX-1

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APPENDIX C

FIELD NOTES AND PEBBLE COUNT FORMS

P.65
4/14/15

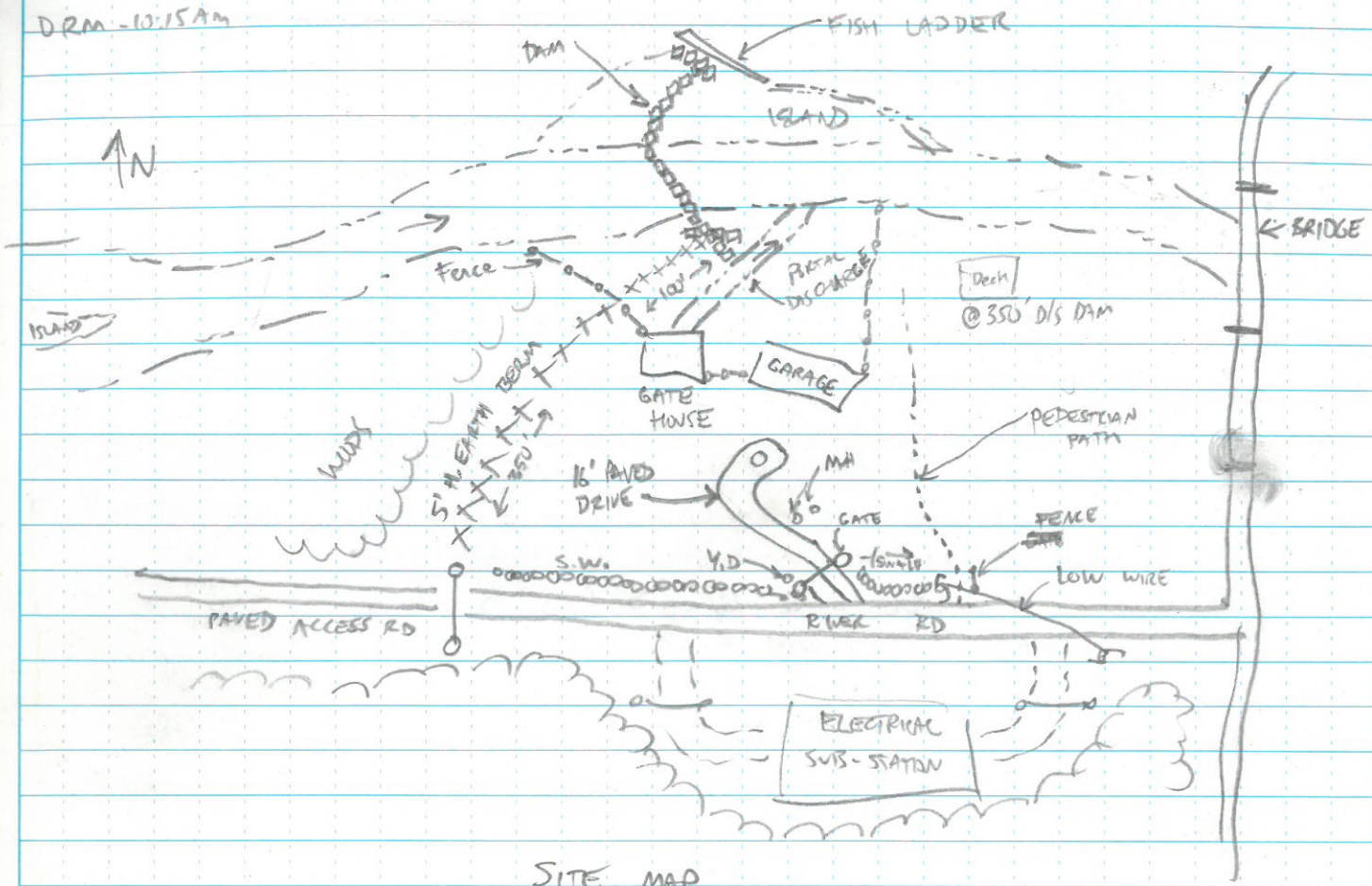
QUINNAPOXET DAM - WEST BOLYSTON, MA

RIVER RD @ QUINAPOXET RIVER, NEAR WACHUSETT RESERVOIR

CLOUDY, 55°

JCM - 9:45 AM

DRM - 10:15 AM



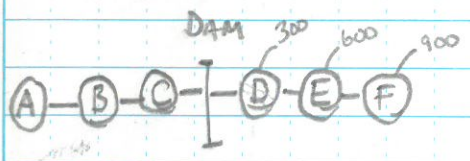
SITE MAP

GEOMORPHIC MEASUREMENTS

- STATIONING RELATIVE TO DAM.

DAM = 0+00 D/S = NEGATIVE U/S = POSITIVE

"LOW-FLOW" REFERS TO DATE OF SURVEY E.O.W.



(F): STA: -9+00: BACKWATER FROM RESERVOIR

LOW FLOW WIDTH = 160 FT DEPTH VARIES BANK FULL WIDTH = 165' DEPTH = +1.0'

SLOPE = 0.0%, V=0 OVERLY WIDE SECTION

BANKS SLOPE = 3:1, GRASS & WILLOW PLANTINGS, HEIGHT = 6.5', STABLE

SANDY GRAVEL BOTTOM, ~~SOME~~ FEW BOULDERS, SOME ORGANICS, STABLE

(E): STA: -6+00: LIMIT OF BACKWATER - TRANSITION FROM FREE FLOWING

LOW-FLOW WIDTH = 115 FT DEPTH = 6"-2' BANKFULL WIDTH = 150' DEPTH = +1.5'

SLOPE D/S = 0.0% U/S = 0.9%, V = 3-5 FT/SEC

BANK SLOPE = 3:1 GRASS & WILLOW, HEIGHT = 8', STABLE

SANDY/GRAVEL/ COBBLE BED, MORE BOULDERS U/S, STABLE

Scale: 1 square = _____ +13.7% / -14.7% → UPHILL ADD 0.5%, DOWNHILL REDUCE BY 0.5%

QUINAPOXET DAM - CTD

(D): STA: -3+00: RUN BETWEEN 2 RIFFLES, D/S OF DAM
LOW FLOW WIDTH = 56', DEPTH 1'-4' BANKFULL WIDTH = 65', DEPTH = +2.5'
SLOPE D/S = 0.9% U/S = 0.9% V = 5 FT/SEC → ARMORED, ~~[illegible]~~ TOO NARROW
BANK SLOPE: 3:1, HEIGHT = 10', BEAVER ACTIVITY, CUTTING WILLOWS, MINOR EROSION
COBBLE / BOULDER BOTTOM, ARMORED / STABLE

DAM - SEE BELOW

(C): STA +2+00: RUN U/S OF DAM
LOW FLOW WIDTH = 67', DEPTH = 2'-3' BANKFULL WIDTH = 72', DEPTH = +1.0'
SLOPE D/S = 0.4% U/S = 0.4% V = 4 FT/SEC
BANKS: LOW (1'), NATURALLY ARMORED W/ BOULDER & WILLOW & TREE ROOTS, STABLE
SANDY COBBLE & BOULDER, NATURALLY ARMORED

B/W B & C → BOULDER ARMORED BANKS, BERM ON RIVER-LEFT
→ RIFFLE, 100' LONG - STA: 2+00 - 3+00
↳ LIKELY HISTORIC DAM, STACKED STONE ABUTMENTS
& EARTHEN EMBANKMENTS / BERMS

HISTORIC DAM STA 4+60, STACKED STONE ABUTMENT REMAINS
ISLAND U/S OF DAM - LIKELY CAUSED BY HISTORIC SEDIMENT AGGRADATION IN IMPOUNDMENT

(B): STA: + 3+75: MIDDLE OF RIFFLE, 25' D/S OF HISTORIC DAM SITE
LOW-FLOW WIDTH = 50' DEPTH = 2'-3' BANKFULL N/A, MANIPULATED BANKS
SLOPE U/S: 1.75% D/S: 0.4% V = 8-10 FT/SEC
BANKS: 4'-7' HIGH STONE ARMORED BERMS, 1:1 → 3:1 SLOPES, MANMADE (V. OLD, STABLE)
BOULDERS: 1'-3' DIA AVG.

(A): STA: + 4+75: 75' U/S OF FORMER DAM, STABLE RUN
LOW-FLOW WIDTH = 75' DEPTH = 1'-2.5' BANKFULL WIDTH = 85' DEPTH = +1.0'
SLOPE: ~~[illegible]~~ 1.5% U/S 1.75% D/S V = 4-5 FT/SEC
BANKS: LOW, VEGETATED, ARMORED W/ ROOTS, 3:1 @ 3'-4' HEIGHT
SANDY COBBLE, SOME 1'-2' BOULDERS
ISLAND DIRECTLY U/S - SEDIMENT FROM OLD DAM?

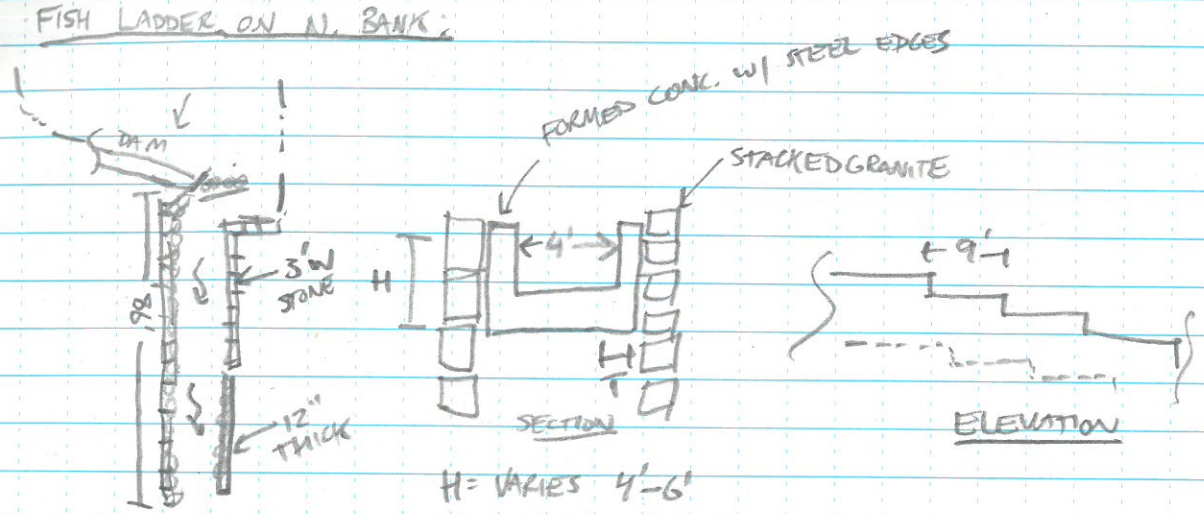
- ANOTHER HISTORIC DAM WAS U/S?
- FLOW SPLIT - BANKFULL WIDTH U/S OF SPLIT = 80'

Rite in the Rain
Scale: 1 square = _____

P.67
4/14/15

QUINAPIXET DAM - DAM MEASUREMENTS

FISH LADDER ON N. BANK:

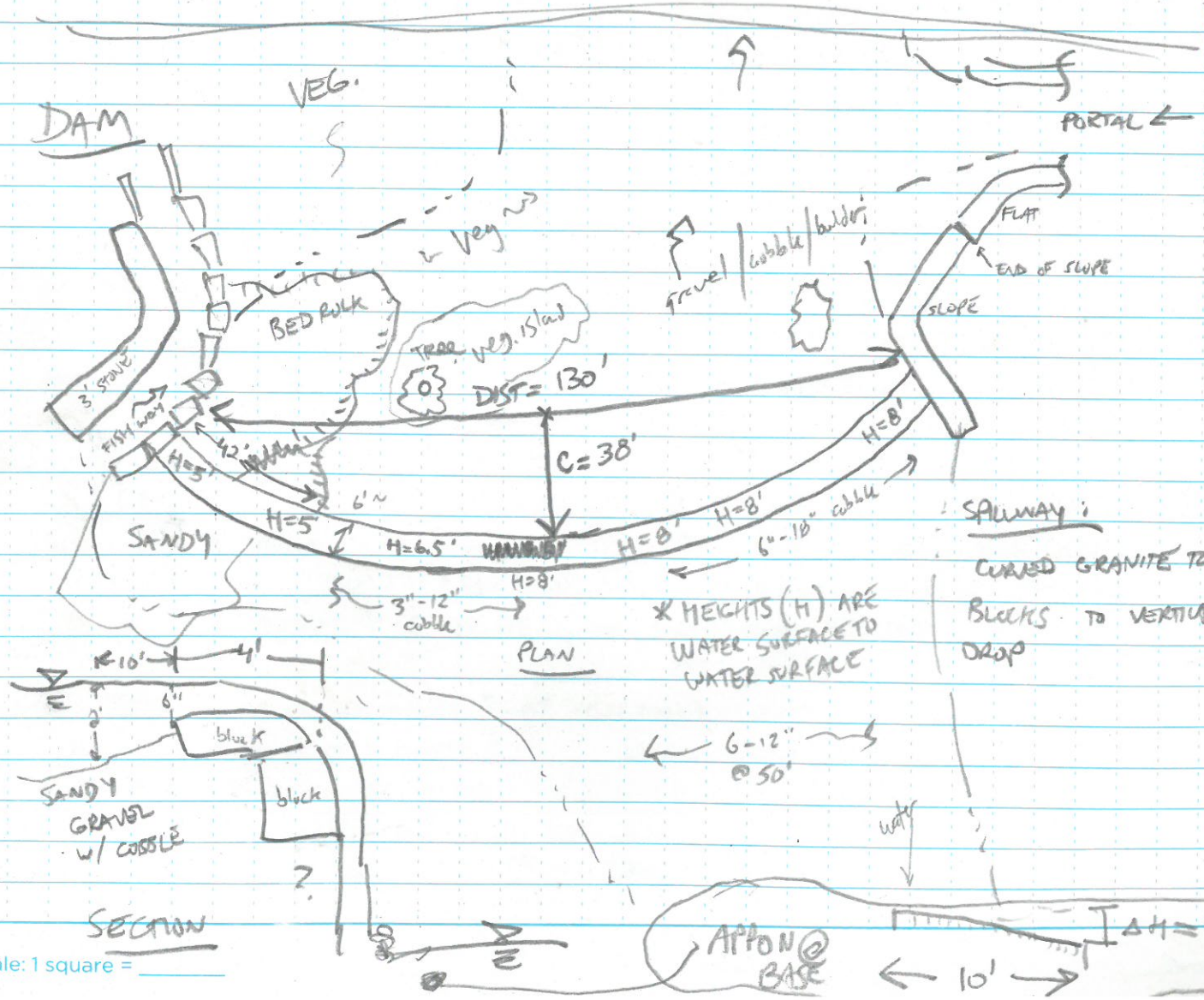


H = VARIES 4'-6'

4' I.D.

T = VARIES 12" CONC. WALL (WHEN ALONE)
~4" WHEN LINING INSIDE STONE
~2' ALONG DAM ABUTMENT

PLAN



Scale: 1 square = _____

Project/Sample Information

Project	Quinapoxet Dam Removal Project
Stream	Quinapoxet River
Location	West Boylston, Mass
Sample ID	Downstream (500'-600' downstream of the dam)
Sample Date	4/14/2015
Sampled By	DRM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	0
sand	0
gravel	29
cobble	44
boulder	27
bedrock	0

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	Approx. water depth 1'-3'

Particle Sizes (mm)

D16	39
D35	77
D50	**121**
D84	322
D95	489

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**		1	2.1	2.1
fine gravel	4	**5.7**		1	2.1	4.2
fine gravel	5.7	**8**			0.0	4.2
medium gravel	8	**11.3**			0.0	4.2
medium gravel	11.3	**16**			0.0	4.2
coarse gravel	16	**22.6**			0.0	4.2
coarse gravel	22.6	**32**		2	4.2	8.3
very coarse gravel	32	**45**		6	12.5	20.8
very coarse gravel	45	**64**		4	8.3	29.2
small cobble	64	**90**		5	10.4	39.6
medium cobble	90	**128**		6	12.5	52.1
large cobble	128	**180**		6	12.5	64.6
very large cobble	180	**256**		4	8.3	72.9
small boulder	256	**362**		8	16.7	89.6
small boulder	362	**512**		3	6.3	95.8
medium boulder	512	**1024**		2	4.2	100.0
large boulder	1024	**2048**			0.0	100.0
very large boulder	2048	**4096**			0.0	100.0
bedrock	4096	**-**			0.0	100.0
			Total	48	100.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	12.4
D5	1.2

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

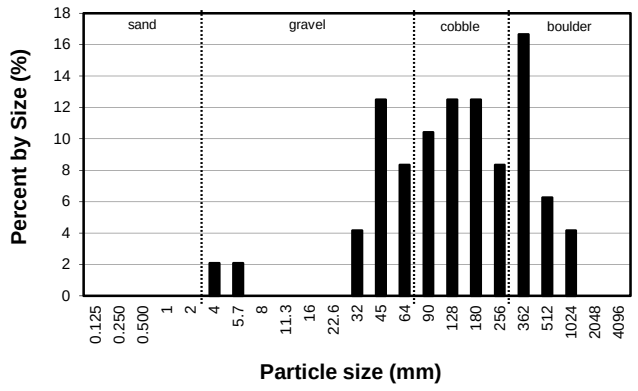
Mean	

Riffle Stability Index (%)

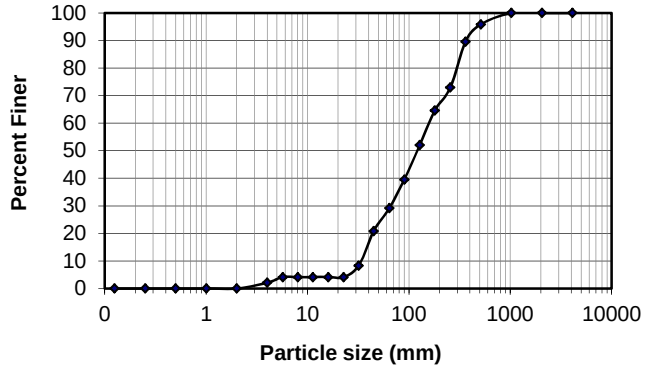
(Kappesser, 2002)

Notes

Particle Size Histogram



Gradation Curve



Project/Sample Information

Project	Quinapoxet Dam Removal Project
Stream	Quinapoxet River
Location	West Boylston, Mass
Sample ID	Upstream (50'-100' upstream of the dam)
Sample Date	4/14/2015
Sampled By	DRM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	0
sand	0
gravel	39
cobble	47
boulder	14
bedrock	0

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	Approx. water depth 2'-3.5'

Particle Sizes (mm)

D16	11
D35	57
D50	**92**
D84	232
D95	581

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**		3	6.1	6.1
fine gravel	4	**5.7**		2	4.1	10.2
fine gravel	5.7	**8**		2	4.1	14.3
medium gravel	8	**11.3**		1	2.0	16.3
medium gravel	11.3	**16**		2	4.1	20.4
coarse gravel	16	**22.6**		1	2.0	22.4
coarse gravel	22.6	**32**		1	2.0	24.5
very coarse gravel	32	**45**		1	2.0	26.5
very coarse gravel	45	**64**		6	12.2	38.8
small cobble	64	**90**		5	10.2	49.0
medium cobble	90	**128**		7	14.3	63.3
large cobble	128	**180**		8	16.3	79.6
very large cobble	180	**256**		3	6.1	85.7
small boulder	256	**362**		3	6.1	91.8
small boulder	362	**512**		1	2.0	93.9
medium boulder	512	**1024**		3	6.1	100.0
large boulder	1024	**2048**			0.0	100.0
very large boulder	2048	**4096**			0.0	100.0
bedrock	4096	**-**			0.0	100.0
			Total	49	100.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	9.5
D5	0.9

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

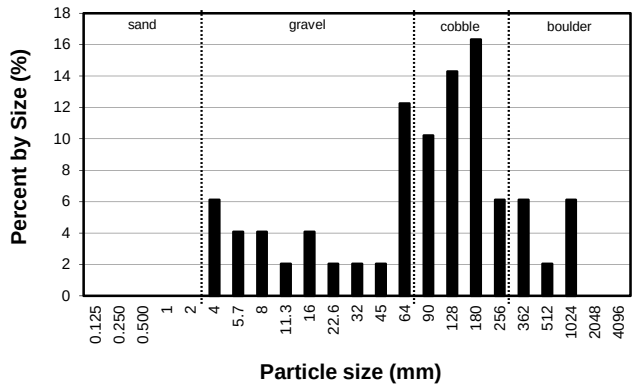
Mean	

Riffle Stability Index (%)

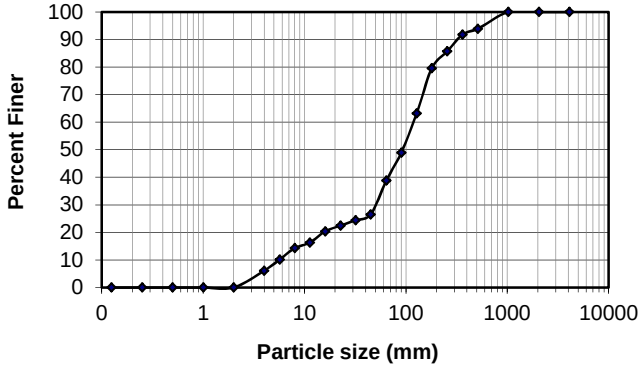
(Kappesser, 2002)

Notes

Particle Size Histogram



Gradation Curve



APPENDIX D

TEST PITS & SEDIMENT SAMPLING INFORMATION

Engineering,
Landscape Architecture
and Environmental Science
MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB	Quinapoxet Dam Removal	MMI#	2688-37
SHEET NO.	1	OF	3
CALCULATED BY	DRM	DATE	5/7/2015
CHECKED BY		DATE	
SCALE	n/a		

GOAL - Calculating total material removed during dam removal process.

Step 1: Calculating areas of material at 50' stations.

Note:
Channel dimensions
Bankfull 65' wide 2.5' deep 2:1 slope
Floodplain dimensions
3:1 slope above bankfull area

Slope

Height

Width

Station 1700

Area 1 floodplain (sediment)
Total depth of material = 7'
Width=84' Height=3' Side slope = 3:1 Area = 279
Depth of sediment = 3'
Area 2 floodplain (Native substrate)
Depth of native substrate = 4'
Width=75' Height=1.5' Side slope = 3:1 Area = 119.25
Area 3 bankfull (Native substrate)
Width=65' Height=2.5' Side slope = 2:1 Area = 175

Station 1750

Area 1 floodplain (sediment)
Total depth of material = 6'
Width=84' Height=2' Side slope = 3:1 Area = 180
Depth of sediment = 2'
Area 2 floodplain (Native substrate)
Depth of native substrate = 4'
Width=75' Height=1.5' Side slope = 3:1 Area = 119.25
Area 3 bankfull (Native substrate)
Width=65' Height=2.5' Side slope = 2:1 Area = 175

Station 1800

Area 1 floodplain (sediment)
Total depth of material = 5.5'
Width=81' Height=2' Side slope = 3:1 Area = 174
Depth of sediment = 2'
Area 2 floodplain (Native substrate)
Depth of native substrate = 3.5'
Width=75' Height=1' Side slope = 3:1 Area = 78
Area 3 bankfull (Native substrate)
Width=65' Height=2.5' Side slope = 2:1 Area = 175

Engineering,
Landscape Architecture
and Environmental Science
MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB	Quinapoxet Dam Removal	MMI#	2688-37
SHEET NO.	2	OF	3
CALCULATED BY	DRM	DATE	5/7/2015
CHECKED BY		DATE	
SCALE	n/a		

Station 1850

Area 1 floodplain (sediment)

Total depth of material = 4.5' Width=79.5' Height=1.25' Side slope = 3:1 Area = 104.1

Depth of sediment = 1.25'

Area 2 floodplain (Native substrate)

Depth of native substrate = 3.25' Width=75' Height=0.75' Side slope = 3:1 Area = 57.9

Area 3 bankfull (Native substrate)

Width=65' Height=2.5' Side slope = 2:1 Area = 175

Station 1900

Area 1 floodplain (sediment)

Total depth of material = 3.25' Width=0' Height=0' Side slope = 0 Area = 0

Depth of sediment = 0'

Area 2 floodplain (Native substrate)

Depth of native substrate = 3.25' Width=75' Height=0.75' Side slope = 3:1 Area = 57.9

Area 3 bankfull (Native substrate)

Width=65' Height=2.5' Side slope = 2:1 Area = 175

Station 1950

Area 1 floodplain (sediment)

Total depth of material = 3' Width=0' Height=0' Side slope = 0 Area = 0

Depth of sediment = 0'

Area 2 floodplain (Native substrate)

Depth of native substrate = 3' Width=75' Height=0.5' Side slope = 3:1 Area = 38.25

Area 3 bankfull (Native substrate)

Width=65' Height=2.5' Side slope = 2:1 Area = 175

Station 2000

Area 1 floodplain (sediment)

Total depth of material = 2.5' Width=0' Height=0' Side slope = 0 Area = 0

Depth of sediment = 0'

Area 2 floodplain (Native substrate)

Depth of native substrate = 2.5' Width=0' Height=0' Side slope = 0 Area = 0

Area 3 bankfull (Native substrate)

Width=65' Height=2.5' Side slope = 2:1 Area = 175

Engineering,
Landscape Architecture
and Environmental Science
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99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB	Quinapoxet Dam Removal	MMI#	2688-37
SHEET NO.	2	OF	3
CALCULATED BY	DRM	DATE	5/7/2015
CHECKED BY		DATE	
SCALE	n/a		

Station 2050

Area 1 floodplain (sediment)

Total depth of material = 1' Width=0' Height=0' Side slope = 0 Area = 0

Depth of sediment = 0'

Area 2 floodplain (Native substrate)

Depth of native substrate = 1' Width=0' Height=0' Side slope = 0 Area = 0

Area 3 bankfull (Native substrate)

Width=65' Height=1' Side slope = 2:1 Area = 67

Totals:

Sediment:

- 279+180+174+104.1 = 737.1sf
- 737.1sf x 50lf = 36,855cf
- 36,855cf = 1,365cy
- **1,365cy**

Native Substrate:

- 67+175+175+38.25+175+57.9+175+57.9+175+78+175+119.25+175+119.25 = 1762.55sf
- 1762.55sf x 50lf = 88,127.5cf
- 88,127.5cf = 3,264cy
- **3,264cy**

CHAIN OF CUSTODY

PAGE 1 OF 2

Date Rec'd in Lab: 6/3/15

ALPHA Job #: L1512249

ALPHA ANALYTICAL
8 Walkup Drive
Westboro, MA 01581
Tel: 508-898-9220

320 Forbes Blvd
Mansfield, MA 02048
Tel: 508-822-9300

Client Information

Client: Milone and MacBroom Inc
Address: 99 Realty Drive
Cheshire, CT 06410
Phone: 203-271-1773
Email: Scott6B@MiloneandMacBroom.com

Project Information

Project Name: Quinapoxet Dam
Project Location: West Boylston
Project #: 2688-37
Project Manager: Andie Greene
ALPHA Quote #:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☒ Same as Client Info PO #:

Regulatory Requirements & Project Information Requirements

☒ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due:

Additional Project Information:

ANALYSIS: VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☐ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST; TPH: ☐ Quant Only ☐ Fingerprint

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	MCP 8260	MCP 6270D	MCP 8082B-Aroclors only	PAHs	EPH - carbon ranges only	Total solids - EPA 3540	HAZ. waste characteristics	PCB congeners 1668	Sample Comments	TOTAL # BOTTLES
12249-01	TP-1	6/3/15	10:25	Soil	DRA, CP	X	X	X	X	X	X				3
02	TP-2	6/3/15	10:50	↓	↓	↓	↓	↓	↓	↓	↓				3
03	SS-1	6/3/15	11:30	↓	↓	↓	↓	↓	↓	↓	↓				3
04	SS-2	6/3/15	11:50	↓	↓	↓	↓	↓	↓	↓	↓				3
05	SS-3	6/3/15	12:35	↓	↓	↓	↓	↓	↓	↓	↓				3
Container Type						G	G	G	P	G	G				
Preservative						A	A	A	A	A	A				

SAMPLE INFO
Filtration
☐ Field
☐ Lab to do
Preservation
☐ Lab to do

Container Type
P= Plastic
A= Amber glass
V= Vial
G= Glass
B= Bacteria cup
C= Cube
O= Other
E= Encore
D= BOD Bottle

Preservative
A= None
B= HCl
C= HNO_3
D= H_2SO_4
E= NaOH
F= MeOH
G= $NaHSO_4$
H= $Na_2S_2O_3$
I= Ascorbic Acid
J= NH_4Cl
K= Zn Acetate
O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
Dan Murto	6/3/15 14:59	[illegible] ARL	6/3/15 1459
[illegible]	6/4/15 0400	[illegible] lab	6/4/15 0400

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 12-Mar-2012)

CHAIN OF CUSTODY

PAGE 2 OF 2

ALPHA ANALYTICAL

8 Walkup Drive, Westboro, MA 01581, Tel: 508-898-9220
320 Forbes Blvd, Mansfield, MA 02048, Tel: 508-822-9300

Date Rec'd in Lab: 6/3/15

ALPHA Job #: L1512249

Client Information

Client: Milone and MacBroom Inc.
Address: 99 Realty Drive, Cheshire, CT 06410
Phone: 203-271-1773
Email: scott68@miloneandmacbroom.com

Project Information

Project Name: Quinapoxet Dam
Project Location: West Boylston
Project #: 2688-37
Project Manager: Andie Greene
ALPHA Quote #:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☐ Same as Client info PO #:

Regulatory Requirements & Project Information Requirements

☑ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due:

Additional Project Information:

ANALYSIS: VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☐ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST

SAMPLE INFO: Filtration ☐ Field ☐ Lab to do; Preservation ☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	Sample Comments	TOTAL # BOTTLES
12249 01	TP-1	6/3/15	10:25	soil	DBM, CP		3
02	TP-2	6/3/15	10:50	↓	↓		3
03	SS-1	6/3/15	11:30	↓	↓		3
04	SS-2	6/3/15	11:50	↓	↓		3
05	SS-3	6/3/15	12:35	↓	↓		3

Container Type	G	G	G	G	P	G	G
Preservative	A	A	A	A	A	A	A

Container Type: P= Plastic, A= Amber glass, V= Vial, G= Glass, B= Bacteria cup, C= Cube, O= Other, E= Encore, D= BOD Bottle

Preservative: A= None, B= HCl, C= HNO_3, D= H_2SO_4, E= NaOH, F= MeOH, G= $NaHSO_4$, H = $Na_2S_2O_3$, I= Ascorbic Acid, J = NH_4Cl, K= Zn Acetate, O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
Stan Mann	6/3/15 14:09	AMC	6/3/15 14:09
	6/4/15 0400	Mansfield Lab	6/4/15 04:00

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 12-Mar-2012)

CHAIN OF CUSTODY

PAGE 1 OF 2

Date Rec'd in Lab: 6/3/15

ALPHA Job #: L1512249

ALPHA ANALYTICAL
8 Walkup Drive
Westboro, MA 01581
Tel: 508-898-9220

320 Forbes Blvd
Mansfield, MA 02048
Tel: 508-822-9300

Client Information

Client: Milone and MacBroom Inc
Address: 99 Realty Drive
Cheshire, CT 06410
Phone: 203-271-1773
Email: Scott68@milone and macbroom.com

Additional Project Information:

Project Information

Project Name: Quinapoxet Dam
Project Location: West Boylston
Project #: 2688-37
Project Manager: Andie Green
ALPHA Quote #:

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)
Date Due:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☒ Same as Client info PO #:

Regulatory Requirements & Project Information Requirements

☑ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

ANALYSIS: VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☐ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST; TPH: ☐ Quant Only ☐ Fingerprint

SAMPLE INFO: Filtration ☐ Field ☐ Lab to do; Preservation ☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	MCP 8270D - PAHs	MCP 8081B - Organochlorine Pest.	EPH - Carbon ranges only	Total Solids - SM 2540	Haz. Waste Characteriz.	PCB Congeners by GC	Sample Comments	TOTAL # BOTTLES
12249-01	TP-1	6/3/15	10:25	Soil	DRM, CP	X	X	X	X	X	X		3
02	TP-2	6/3/15	10:50	↓	↓	↓	↓	↓	↓	↓	↓		3
03	SS-1	6/3/15	11:30	↓	↓	↓	↓	↓	↓	↓	↓		3
04	SS-2	6/3/15	11:50	↓	↓	↓	↓	↓	↓	↓	↓		3
05	SS-3	6/3/15	12:35	↓	↓	↓	↓	↓	↓	↓	↓		3
Container Type						G	G	G	P	G	G		
Preservative						A	A	A	A	A	A		

Container Type
P= Plastic
A= Amber glass
V= Vial
G= Glass
B= Bacteria cup
C= Cube
O= Other
E= Encore
D= BOD Bottle

Preservative
A= None
B= HCl
C= HNO_3
D= H_2SO_4
E= NaOH
F= MeOH
G= $NaHSO_4$
H = $Na_2S_2O_3$
I= Ascorbic Acid
J = NH_4Cl
K= Zn Acetate
O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
Dan Mullen	6/3/15 14:09	[signature] ARL	6/3/15 14:09

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FORM NO: 01-01 (rev. 12-Mar-2012)

CHAIN OF CUSTODY

PAGE 2 OF 2

ALPHA ANALYTICAL
8 Walkup Drive
Westboro, MA 01581
Tel: 508-898-9220

320 Forbes Blvd
Mansfield, MA 02048
Tel: 508-822-9300

Date Rec'd in Lab: 6/3/15

ALPHA Job #: L1512249

Client Information

Client: Milone and MacBroom Inc.
Address: 99 Realty Drive
Cheshire, CT 06410
Phone: 203-271-1773
Email: scott-b@milone and macbroom.com

Additional Project Information:

Project Information

Project Name: Quinapoxet Dam
Project Location: West Boylston
Project #: 2688-37
Project Manager: Andie Greene
ALPHA Quote #:

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)
Date Due:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☐ Same as Client info PO #:

Regulatory Requirements & Project Information Requirements

☑ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

ANALYSIS: VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☐ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST; TPH: ☐ Quant Only ☐ Fingerprint

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	TPH: MCP 7471B - Total mercury	MCP 6010C - Total Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Zinc	Grainsize Analysis	TOC - EPA 9060A - Zpep	Spec. Cond. - EPA 9050	Sample Comments	TOTAL # BOTTLES
12249 01	TP-1	6/3/15	10:25	soil	DBM, CP	X	X	X	X	X	X	X		3
02	TP-2	6/3/15	10:50	↓	↓	↓	↓	↓	↓	↓	↓	↓		3
03	SS-1	6/3/15	11:30	↓	↓	↓	↓	↓	↓	↓	↓	↓		3
04	SS-2	6/3/15	11:50	↓	↓	↓	↓	↓	↓	↓	↓	↓		3
05	SS-3	6/3/15	12:35	↓	↓	↓	↓	↓	↓	↓	↓	↓		3
Container Type						G	G	G	G	P	G	G		
Preservative						A	A	A	A	A	A	A		

Container Type
P= Plastic
A= Amber glass
V= Vial
G= Glass
B= Bacteria cup
C= Cube
O= Other
E= Encore
D= BOD Bottle

Preservative
A= None
B= HCl
C= HNO_3
D= H_2SO_4
E= NaOH
F= MeOH
G= $NaHSO_4$
H = $Na_2S_2O_3$
I= Ascorbic Acid
J = NH_4Cl
K= Zn Acetate
O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
Stan [illegible]	6/3/15 14:09	[illegible] AAL	6/3/15 14:09

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 12-Mar-2012)

I:\Pest15\150623a\15150623a-45.d

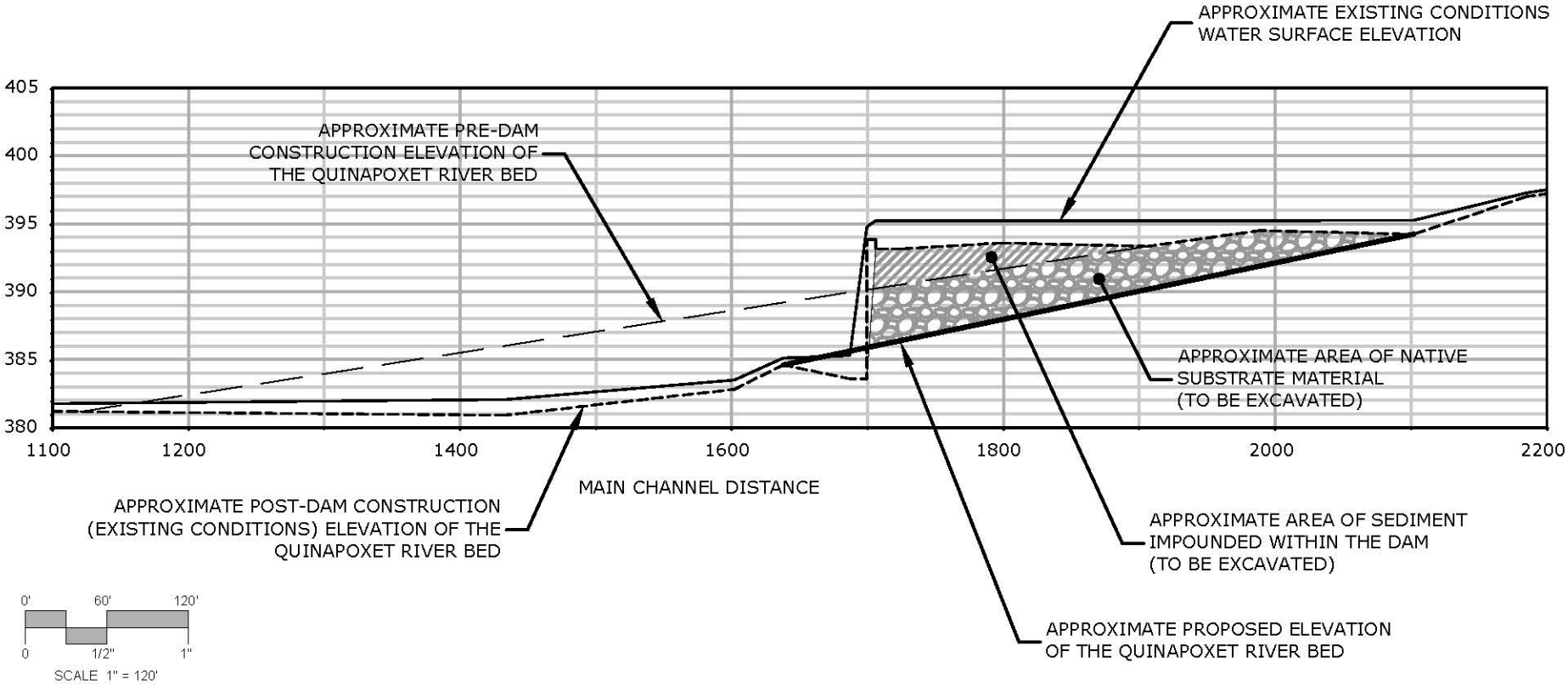
Data File Name	**15150623a-45.d**
Data File Path	**I:\Pest15\150623a**
Operator	**pest15:gpLOADED**
Date Acquired	**6/23/2015 20:52**
Acq. Method File	**PEST.M**
Sample Name	**PEM15150623a02,42ee,,**
Instrument Name	**Pest 15**

Name	Ret Time	Response	
4,4'-DDT	4.59	327081112.1	% Breakdown
4,4'-DDE	3.91	7154721.662	
4,4'-DDD	4.38	6410450.799	3.98%
Endrin	4.30	394962215	% Breakdown
Endrin Aldehyde	4.78	4923475.75	
Endrin Ketone	5.28	4388228	2.30%
1-br-2-nb_Pesticides #2			
4,4'-DDT #2	5.12	124521238.4	% Breakdown
4,4'-DDE #2	4.46	1542864.07	
4,4'-DDD #2	4.90	2460798	3.12%
Endrin #2	4.81	167219070.1	% Breakdown
Endrin Aldehyde #2	5.21	1264897.9	
Endrin Ketone #2	5.76	1612590.25	1.69%

WG794270-1,-2,-3
L1512249-05

LEGEND

- WATER SURFACE ELEVATION
- PRE-DAM CONSTRUCTION RIVER BED ELEVATION
- POST-DAM CONSTRUCTION (EXISTING CONDITIONS) RIVER BED ELEVATION
- PROPOSED CONDITIONS RIVER BED ELEVATION
- IMPOUNDED SEDIMENT (TO BE EXCAVATED)
- NATIVE SUBSTRATE MATERIAL (TO BE EXCAVATED)



SCALE 1" = 120'

MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733
www.miloneandmacbroom.com

DATE	MAY 2015
SCALE	1"=120'
PROJ. NO.	2688-37
DESIGNED	DRM
DRAWN	DRM
CHECKED	JCM

QUINAPOXET RIVER PROFILE

SEDIMENT SAMPLING PLAN
QUINAPOXET DAM

RIVER STREET
WEST BOYLSTON, MASSACHUSETTS

REVISED: ---

PROJECT PHASE: PRELIMINARY DESIGN

DRAWING NAME: FIG. 1

Drawing: C:\USERS\DAIMIE\APPDATA\LOCAL\TEMP\ACPUBLISH_4992\FIGURE 1.DWG Layout Tab:8.5X11H
Plotted by: DAIMIE On this date: Fri, 2015 May 8 - 10:29am

SOURCE(S):
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP,

N

Figure 2: Sediment Sampling Locations

MXD: Y:\2688-37\Maps\Sed Sample Location.mxd

Quinapoxet Dam

LOCATION: West Boylston, Massachusetts

Map By:	DRM
MMI#:	2688-37
Original:	5/1/2015
Revision:	6/17/2015
Scale:	1 in = 83 ft

MILONE & MACBROOM
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

APPENDIX F

COMPILED RESOURCE LIST

Document & Data Collection Index

Quinapoxet Dam Removal

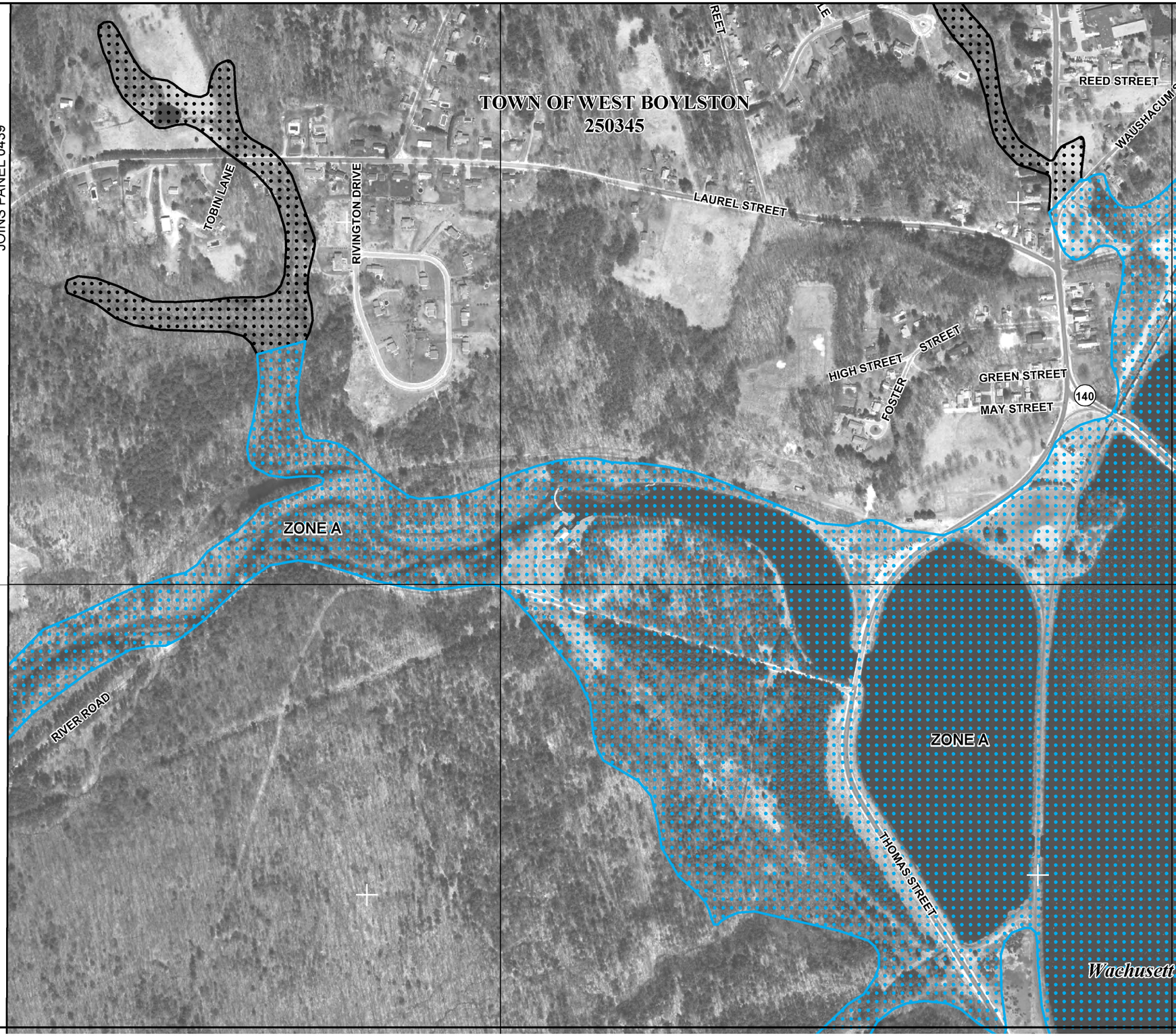
MMI# 2688-37

West Boylston, MA

MMI ID No.	Date	Type	Pages	Title	Author	Source
1	4/15/2015	Notes	3	Field notes from site investigation	MMI personell	MMI
2	4/4/2011	Mapping	1	Flood Insurance Rate Map (FIRM)	FEMA	FEMA website
3	varies	Photos	14	Historic photographs during construction of the Quinapoxet Dam and Wachusett Reservoir	unknown	Massachusetts DER
4	varies	Plans	18	Historic plans of dam construction	unknown, Mass MDC	Massachusetts DER
5	3/5/2015	Report	2	Sanborn Map Report - None Found.	EDR	EDR
6	11/5/1936	Photos	8	Pictures taken by J. Arthur Kitson showing fishway installation	J. Arthur Kitson	Massachusetts DER

APPENDIX G

FEMA DATA & USGS STREAMSTATS OUTPUT



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0443E

FIRM

FLOOD INSURANCE RATE MAP

WORCESTER COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 443 OF 1075

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
STERLING, TOWN OF	250336	0443	E
WEST BOYLSTON, TOWN OF	250345	0443	E

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

MAP NUMBER
25027C0443E

EFFECTIVE DATE
JULY 4, 2011

Federal Emergency Management Agency

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

StreamStats Version 3 Beta

Basin Characteristics Ungaged Site Report

Date: Wed Apr 29, 2015 2:19:01 PM GMT-4
NAD 1983 Latitude: 42.3871 (42 23 14)
NAD 1983 Longitude: -71.8025 (-71 48 09)

Label	Value	Units	Definition
STRMTOT	114	miles	Total length of mapped streams in basin
ACRSDFT	12.7	square miles	Area underlain by stratified drift
DRNAREA	57	square miles	Area that drains to a point on a stream
DRFTPERSTR	0.11	square mile per mile	Area of stratified drift per unit of stream length
MAREGION	0	dimensionless	Region of Massachusetts 0 for Eastern 1 for Western
FOREST	68.5	percent	Percentage of area covered by forest
CRSDFT	22.09	percent	Percentage of area of coarse-grained stratified drift
BSLDEM10M	7.657	percent	Mean basin slope computed from 10 m DEM
BSLDEM250	4.232	percent	Mean basin slope computed from 1:250K DEM
LC11IMP	4.03	percent	Percentage of impervious area determined from NLCD 2011 impervious dataset
LC11DEV	14.4	percent	Percentage of developed (urban) land from NLCD 2011 classes 21-24

Accessibility **FOIA** **Privacy** **Policies and Notices**
U.S. Department of the Interior | U.S. Geological Survey
URL: http://ssdev.cr.usgs.gov/v3_beta/BCreport.htm
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StreamStats Version 3 Beta

Flow Statistics Ungaged Site Report

Date: Wed Apr 29, 2015 2:20:24 PM GMT-4
Site Location: Massachusetts
NAD 1983 Latitude: 42.3871 (42 23 14)
NAD 1983 Longitude: -71.8025 (-71 48 09)
Drainage Area: 57 mi2

Low Flows Basin Characteristics			
100% Statewide Low Flow WRIR00 4135 (57 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	57	1.61	149
Mean Basin Slope from 250K DEM (percent)	4.232	0.32	24.6
Stratified Drift per Stream Length (square mile per mile)	0.11	0	1.29
Massachusetts Region (dimensionless)	0	0	1

Probability of Perennial Flow Basin Characteristics			
100% Perennial Flow Probability (57 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	57 (above max value 1.99)	0.01	1.99
Percent Underlain By Sand And Gravel (percent)	22.09	0	100
Percent Forest (percent)	68.50	0	100
Massachusetts Region (dimensionless)	0	0	1

Warning: Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Bankfull Flows Basin Characteristics			
100% Bankfull Statewide SIR2013 5155 (57 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	57	0.6	329
Mean Basin Slope from 10m DEM (percent)	7.657	2.2	23.9

Low Flows Streamflow Statistics						
Statistic	**Value**	**Unit**	**Prediction Error (percent)**	**Equivalent years of record**	**90-Percent Prediction Interval**	
					Min	**Max**
D50	59	ft3/s	18		32.1	108
D60	43.9	ft3/s	20		22.8	84.3
D70	26.3	ft3/s	24		10.3	66.6
D75	20.4	ft3/s	26		7.92	52.1
D80	16.5	ft3/s	28		6.16	43.3
D85	13	ft3/s	32		4.78	34.6
D90	9.86	ft3/s	37		3.42	27.8
D95	6.44	ft3/s	46		2.03	19.7
D98	4.06	ft3/s	60		1.11	14.1
D99	3.21	ft3/s	65		0.83	11.6
M7D2Y	6.47	ft3/s	50		1.94	20.8
AUGD50	13.3	ft3/s	33		4.86	35.5
M7D10Y	3.02	ft3/s	71		0.74	11.5

http://pubs.usgs.gov/wri/wri004135/ (http://pubs.usgs.gov/wri/wri004135/)

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.

Probability of Perennial Flow Streamflow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
PROBPEREN	1	dim				

http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)
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.

Bankfull Flows Streamflow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
BFWDTH	74.8	ft	21			
BFDPTH	3.07	ft	20			
BFAREA	229	ft2	29			
BFFLOW	829	ft3/s	55			

http://pubs.usgs.gov/sir/2013/5155/ (http://pubs.usgs.gov/sir/2013/5155/)
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._

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URL: http://ssdev.cr.usgs.gov/v3_beta/FTreport.htm
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APPENDIX H

REGRESSION EQUATION AND GAUGE ANALYSIS

Engineering,
Landscape Architecture
and Environmental Science
MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB	Quinapoxet Dam Removal		MMI# 2688-37
SHEET NO.	1	OF	2
CALCULATED BY	JCS	DATE	04/29/2015
CHECKED BY	JCM	DATE	5/1/2015
SCALE	n/a		

GOAL - **Determine flows at the project site for typical low flows, bankfull flows, 5-year, 10-year, and 100-year storm return frequency events using the Wandles Eastern Massachusetts regression equations.**

Compile Flood Flow Data for Coppermine Brook:

A_u= 57.0 square miles → Contributing watershed to Quinapoxet Dam

A_g= 46.3 square miles → Contributing watershed to USGS Gauge 01095375

St = 7.8 % → Storage index: area of swamps, lakes, and ponds expressed as a percentage plus 0.5

USGS Streamstats	
Streamflow exceeded 99 percent of the time	3.21 cfs
7-Day mean low-flow that occurs on average once in 2 years	6.47 cfs
7-Day mean low-flow that occurs on average once in 10 years	3.02 cfs
August streamflow exceeded 50 percent of the time	13.3 cfs
Bankfull flow	829 cfs

Note:

1) No FEMA flows are available as Quinapoxet River was studied by approximate methods.

2) USGS Streamstats Version 3 Beta run on April 29, 2015. Note: drainage area of 57 sq. mi. is above max value 1.99 sq. mi.

Compute 5-year, 10-year, and 100-year Flows:

5-Year Flow

$$Q_{t(g)} = \frac{(Q_{t(s)} * N) + (Q_{t(r)} * E)}{N + E}$$

→ Eq. 19 in "Estimating Peak Discharges of Small, Rural Streams in Massachusetts," S. William Wandle, Jr. 1983

$Q_{t(s)}$ = 1499.4 cfs → Flow from HEC SSP calculations for USGS Gauge 01095375

$Q_{t(r)} = 65.17 * A^{0.751} * St^{-0.139}$

$Q_{t(r)}$ = 872.09 cfs

→ Regression equation for Central Massachusetts, Eq. 8 in Wandle paper, stograge index based on MassDEP Hydro25K shapefile

N = 18 → Number of years of observed peak data for USGS Gauge

E = 11 → Equivalent years of record for the flood-estimating equations, used E=11 for Central region since 5-year flow is not in Table 5

$Q_{t(g)}$ = 1261.46 cfs

$$Q_{t(u)} = \left(\frac{A_u}{A_g}\right)^{0.75} * Q_{t(g)}$$

→ Eq. 20 in Wandle paper using x = 0.75 for Central Mass.

$Q_{t(u)}$ = **1474.32** cfs

Engineering,
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JOB	Quinapoxet Dam Removal		MMI# 2688-37
SHEET NO.	2	OF	2
CALCULATED BY	JCS	DATE	04/29/2015
CHECKED BY	JCM	DATE	5/1/2015
SCALE	n/a		

10-Year Flow

$$Q_{t(g)} = \frac{(Q_{t(s)} * N) + (Q_{t(r)} * E)}{N + E}$$ → Eq. 19 in "Estimating Peak Discharges of Small, Rural Streams in Massachusetts," S. William Wandle, Jr. 1983

$Q_{t(s)} =$ 1788.5 cfs → Flow from HEC SSP calculations for USGS Gauge 01095375

$Q_{t(r)} = 84.98 * A^{0.760} * St^{-0.166}$ → Regression equation for Central Massachusetts,

$Q_{t(r)} =$ 1113.45 cfs Eq. 9 in Wandle paper

N = 18 → Number of years of observed peak data for USGS Gauge

E = 11 → Equivalent years of record for the flood-estimating equations, used E=11 for Central region since 10-year flow is not in Table 5

$Q_{t(g)} =$ 1532.45 cfs

$$Q_{t(u)} = \left(\frac{A_u}{A_g}\right)^{0.75} * Q_{t(g)}$$ → Eq. 20 in Wandle paper using x = 0.75 for Central Mass.

$Q_{t(u)} =$ **1791.04** cfs

100-Year Flow

$$Q_{t(g)} = \frac{(Q_{t(s)} * N) + (Q_{t(r)} * E)}{N + E}$$ → Eq. 19 in "Estimating Peak Discharges of Small, Rural Streams in Massachusetts," S. William Wandle, Jr. 1983

$Q_{t(s)} =$ cfs → Flow from HEC SSP calculations for USGS Gauge 01095375

$Q_{t(r)} = 172.7 * A^{0.797} * St^{-0.237}$ → Regression equation for Central Massachusetts,

$Q_{t(r)} =$ 2253.01 cfs Eq. 12 in Wandle paper

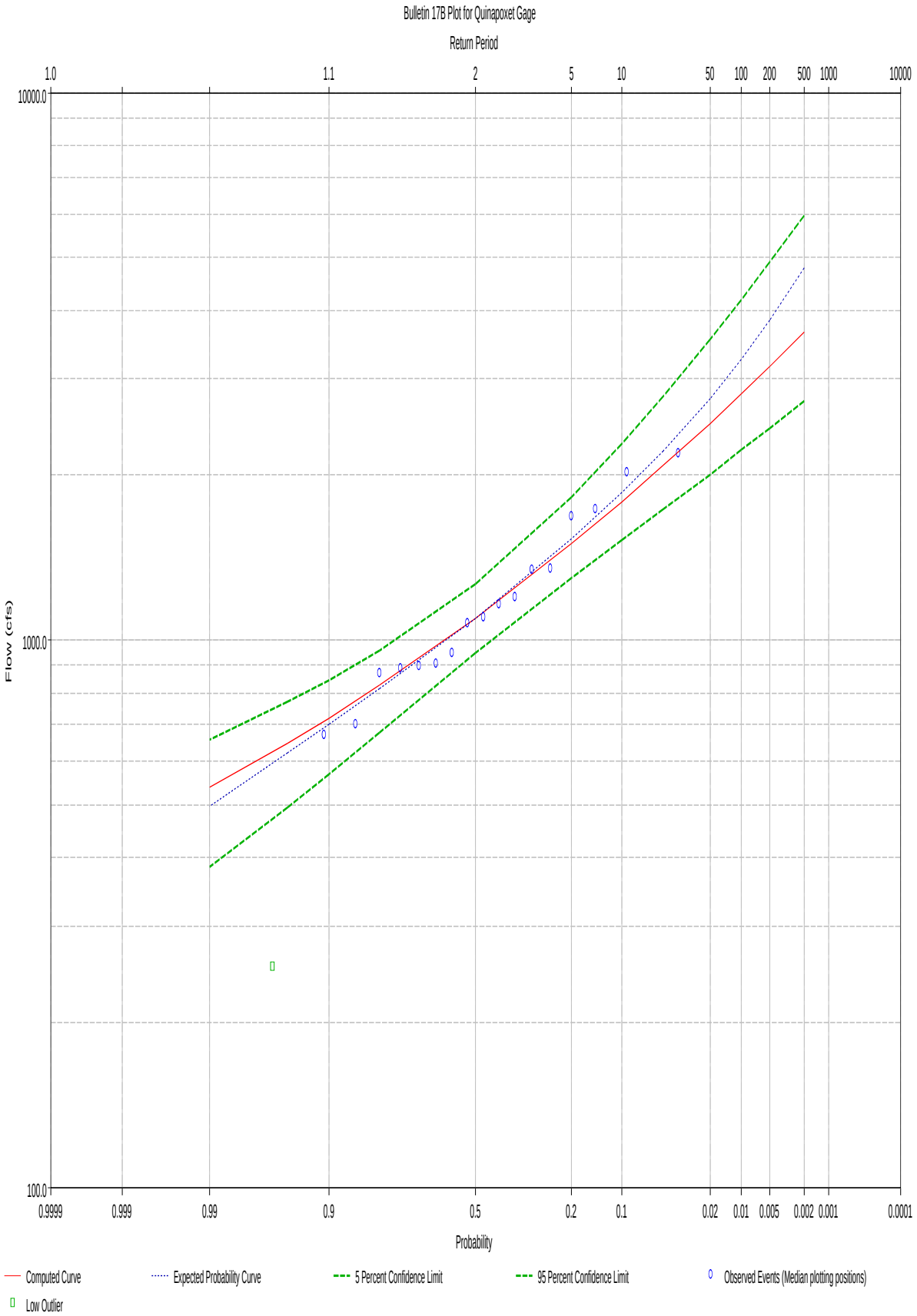
N = 18 → Number of years of observed peak data for USGS Gauge

E = 11 → Equivalent years of record for the flood-estimating equations, used E=11 for Central region from Table 5 in Wandle paper

$Q_{t(g)} =$ 854.59 cfs

$$Q_{t(u)} = \left(\frac{A_u}{A_g}\right)^{0.75} * Q_{t(g)}$$ → Eq. 20 in Wandle paper using x = 0.75 for Central Mass.

$Q_{t(u)} =$ **998.80** cfs


Bulletin 17B Plot for Quinapoxet Gage
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
10000.0
1000.0
100.0
Flow (cfs)
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)
Low Outlier

```
-------------------------------
Bulletin 17B Frequency Analysis
    29 Apr 2015   11:17 AM
-------------------------------


--- Input Data ---

Analysis Name: Quinapoxet Gage
Description:

Data Set Name: Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK
DSS File Name: W:\Design\2688-37-DE\Comps\Hydrology\HEC-SSP\Quinapoxet\Quinapoxet.dss
DSS Pathname: /QUINAPOXET RIVER/CANADA MILLS NEAR HOLDEN, MA/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name:
W:\Design\2688-37-DE\Comps\Hydrology\HEC-SSP\Quinapoxet\Bulletin17bResults\Quinapoxet_Gage\Quinapoxet_Gag
e.rpt
XML File Name:
W:\Design\2688-37-DE\Comps\Hydrology\HEC-SSP\Quinapoxet\Bulletin17bResults\Quinapoxet_Gage\Quinapoxet_Gag
e.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---


<< Skew Weighting >>
-----------------------------------------------------------------
Based on 18 events, mean-square error of station skew =     0.488
Mean-square error of regional skew =                          -?
-----------------------------------------------------------------


<< Frequency Curve >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK
-------------------------------------------------------------------
|  Computed    Expected   |   Percent   |    Confidence Limits    |
|    Curve    Probability |   Chance    |        0.05        0.95 |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS        |
|-------------------------|-------------|-------------------------|
|     2,239.6     2,298.3 |      0.2    |     3,239.3     1,763.3 |
|     2,189.0     2,252.6 |      0.5    |     3,143.4     1,729.2 |
|     2,136.6     2,199.2 |      1.0    |     3,044.8     1,693.5 |
|     2,066.9     2,125.8 |      2.0    |     2,915.5     1,645.7 |
|     1,937.1     1,985.1 |      5.0    |     2,679.5     1,555.3 |
|     1,796.4     1,829.7 |     10.0    |     2,431.4     1,455.0 |
|     1,597.8     1,617.2 |     20.0    |     2,096.0     1,308.4 |
|     1,164.6     1,164.6 |     50.0    |     1,435.6       960.8 |
|       738.1       715.6 |     80.0    |       897.9       570.3 |
|       546.8       510.6 |     90.0    |       685.5       389.2 |
|       412.6       366.0 |     95.0    |       539.7       268.1 |
|       223.2       162.0 |     99.0    |       326.9       116.5 |
|-------------------------|-------------|-------------------------|


<< Systematic Statistics >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK
-----------------------------------------------------------------
|        Log Transform:        |                               |
|          FLOW, CFS           |       Number of Events        |
|------------------------------|-------------------------------|
|  Mean                 3.024  |  Historic Events           0  |
|  Standard Dev         0.213  |  High Outliers          0     |
|  Station Skew        -1.223  |  Low Outliers           0     |
```

Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.223	Systematic Events	18

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 18 events, 10 percent outlier test deviate K(N) = 2.335
Computed low outlier test value = 335.38

1 low outlier(s) identified below test value of 335.38

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Systematic Statistics >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.060	Historic Events	0
Standard Dev	0.151	High Outliers	0
Station Skew	0.380	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.223	Systematic Events	18

<< High Outlier Test >>

Based on 17 events, 10 percent outlier test deviate K(N) = 2.309
Computed high outlier test value = 2,567.76

0 high outlier(s) identified above test value of 2,567.76

Note: Statistics and frequency curve were modified
using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
21 Oct 1996	1,350.0	1	2010	2,190.0	3.80
10 Mar 1998	2,020.0	2	1998	2,020.0	9.24
25 Jan 1999	700.0	3	2005	1,730.0	14.67
22 Apr 2000	1,340.0	4	2011	1,680.0	20.11
22 Mar 2001	869.0	5	1997	1,350.0	25.54
14 May 2002	253.0	6	2000	1,340.0	30.98
23 Jun 2003	895.0	7	2007	1,200.0	36.41
02 Apr 2004	1,100.0	8	2014	1,160.0	41.85
03 Apr 2005	1,730.0	9	2004	1,100.0	47.28
25 Oct 2005	1,070.0	10	2006	1,070.0	52.72
17 Apr 2007	1,200.0	11	2013	945.0	58.15
09 Mar 2008	888.0	12	2009	906.0	63.59
24 Jul 2009	906.0	13	2003	895.0	69.02
14 Mar 2010	2,190.0	14	2008	888.0	74.46
07 Mar 2011	1,680.0	15	2001	869.0	79.89
08 Dec 2011	671.0	16	1999	700.0	85.33
14 Jun 2013	945.0	17	2012	671.0	90.76
31 Mar 2014	1,160.0	18	2002	253.0*	96.20

```
|---------------------------|-------------------------------------|
                                                          * Outlier


<< Skew Weighting >>
-------------------------------------------------------------------
Based on 18 events, mean-square error of station skew =     0.304
Mean-square error of regional skew =                           -?
-------------------------------------------------------------------


<< Frequency Curve >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK
-----------------------------------------------------------------------
|  Computed    Expected   |   Percent   |    Confidence Limits    |
|    Curve    Probability |   Chance    |        0.05        0.95 |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS        |
|-------------------------|-------------|-------------------------|
|     3,652.1     4,779.0 |      0.2    |     5,974.8     2,738.8 |
|     3,161.4     3,834.4 |      0.5    |     4,904.1     2,438.7 |
|     2,815.6     3,255.5 |      1.0    |     4,188.0     2,220.2 |
|     2,489.1     2,763.2 |      2.0    |     3,543.8     2,007.4 |
|     2,082.4     2,214.3 |      5.0    |     2,789.4     1,730.7 |
|     1,788.5     1,855.9 |     10.0    |     2,282.6     1,519.6 |
|     1,499.4     1,526.9 |     20.0    |     1,822.2     1,297.8 |
|     1,095.9     1,095.9 |     50.0    |     1,263.6       946.9 |
|       825.5       813.9 |     80.0    |       954.6       677.1 |
|       720.1       701.6 |     90.0    |       844.6       568.9 |
|       647.1       621.5 |     95.0    |       770.1       494.6 |
|       536.9       496.1 |     99.0    |       658.3       385.7 |
|-------------------------|-------------|-------------------------|


<< Synthetic Statistics >>
Quinapoxet Gage Data-CANADA MILLS NEAR HOLDEN, MA-FLOW-ANNUAL PEAK
-----------------------------------------------------------------
|        Log Transform:        |                               |
|          FLOW, CFS           |       Number of Events        |
|------------------------------|-------------------------------|
|  Mean                 3.049  |  Historic Events           0  |
|  Standard Dev         0.155  |  High Outliers          0     |
|  Station Skew         0.359  |  Low Outliers           1     |
|  Regional Skew          ---  |  Zero Events            0     |
|  Weighted Skew          ---  |  Missing Events         0     |
|  Adopted Skew         0.359  |  Systematic Events        18  |
|------------------------------|-------------------------------|

--- End of Analytical Frequency Curve ---
```

APPENDIX I

HYDRAULIC MODELING INFORMATION

Stable Channel Design Results - Copeland Method

d84(mm) = 230, D50(mm) = 92, D16(mm) = 11

Temperature (F)	55		
Specific Gravity of Sediments	2.65		
Unit Weight of Water (lb/cu ft)	62.385		
Viscosity (sq ft/s)		1.315E-05	
Discharge (cfs)	829 (table 3-2)		

Upstream Channel

Sediment Concentration (ppm)	39.62 (model prediction)		
Base Width (ft)	60 (TRIAL)		
Channel Slope (ft/ft)	0.015 (survey data)		
		Left	Right
Side Slope	1	1	
Roughness Eq	Manning	Manning	
Roughness Value		0.08	0.08

Stable Channel

Median Channel Width (ft)	70 (TRIAL, based on bankfull)		
Valley Slope(ft/ft)	0.015		
		Left	Right
Side Slope	2	2	
Roughness Eq	Manning	Manning	
Roughness Value		0.1	0.1 (woods)

Computed Stable Channels

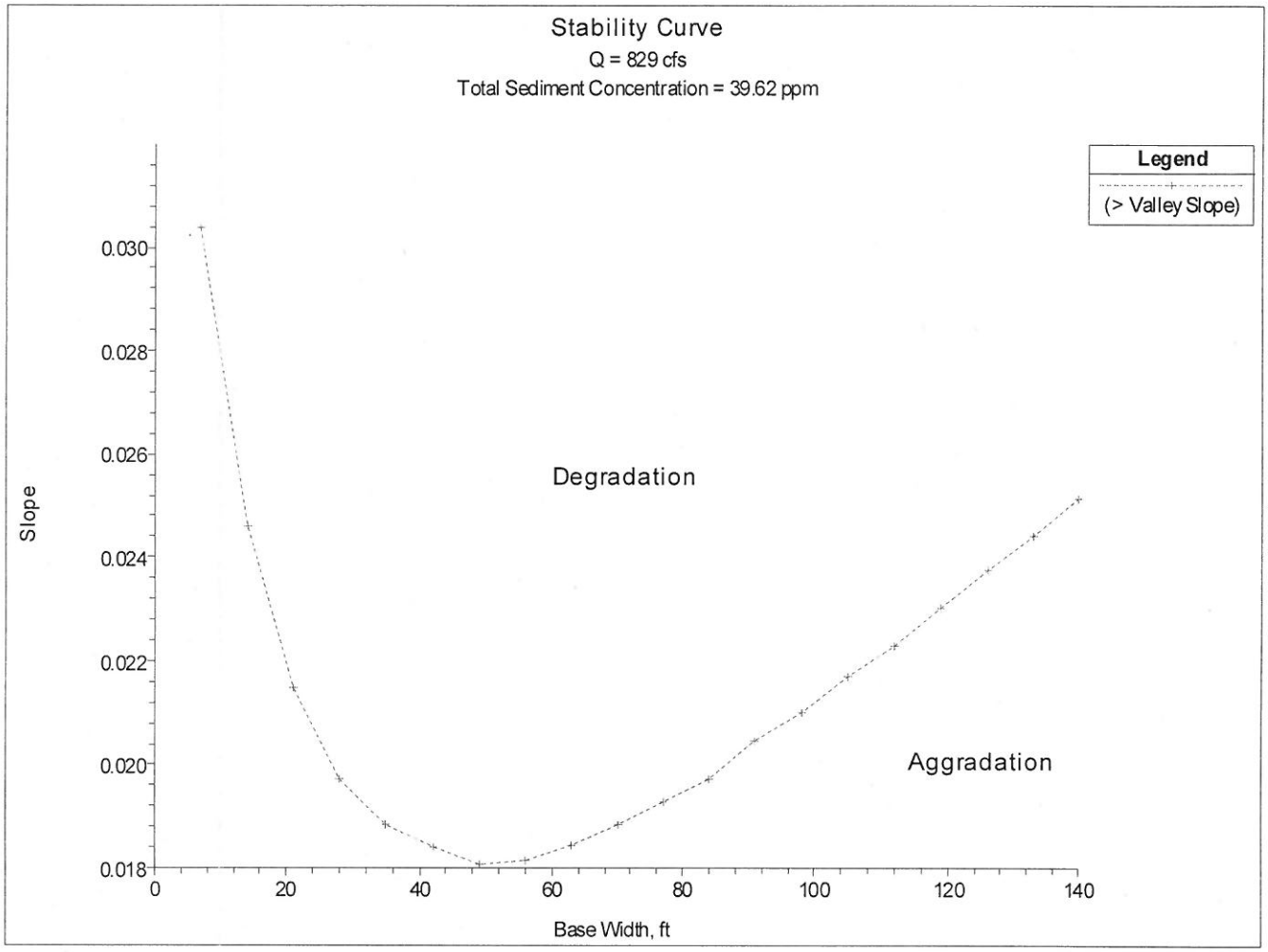
Bottom Width	Depth	Energy Slope	Comp n-Value	Hyd Radius	Velocity	Froude Number	Shear Stress
7.0	6.3	0.030388	0.0898	3.53	6.76	0.48	11.91
14.0	5.1	0.024602	0.0786	3.37	6.69	0.52	7.85
21.0	4.2	0.021489	0.0697	3.13	6.74	0.58	5.62
28.0	3.5	0.019716	0.0616	2.81	6.77	0.64	4.30
35.0	3.0	0.018853	0.0559	2.53	6.80	0.69	3.50
42.0	2.6	0.018385	0.0514	2.28	6.80	0.75	2.96
49.0	2.3	0.018076	0.0477	2.06	6.81	0.80	2.57
56.0	2.0	0.018155	0.0450	1.88	6.79	0.84	2.30
63.0	1.8	0.018429	0.0431	1.73	6.76	0.88	2.12
70.0	1.7	0.018831	0.0417	1.60	6.72	0.91	1.98
77.0	1.5	0.019297	0.0404	1.48	6.68	0.95	1.87
84.0	1.4	0.019707	0.0391	1.38	6.64	0.98	1.77
91.0	1.3	0.020462	0.0383	1.30	6.59	1.00	1.71
98.0	1.3	0.020993	0.0376	1.22	6.55	1.03	1.65
105.0	1.2	0.021690	0.0374	1.16	6.51	1.05	1.61
112.0	1.1	0.022299	0.0365	1.10	6.47	1.08	1.56
119.0	1.1	0.023037	0.0364	1.05	6.43	1.10	1.53
126.0	1.0	0.023746	0.0359	1.00	6.39	1.12	1.50
133.0	1.0	0.024423	0.0357	0.96	6.35	1.14	1.48
140.0	0.9	0.025132	0.0354	0.92	6.31	1.16	1.45

good Solutions

*******Solution for Minimum Stream Power*******

51.1	2.2	0.018037	0.0468	2.01	6.80	0.81	2.47

$51 + (2 \times 2 \times 2.2) = 60$ FT


Stability Curve
Q = 829 cfs
Total Sediment Concentration = 39.62 ppm
Legend
(> Valley Slope)
Degradation
Aggradation
Slope
0.030
0.028
0.026
0.024
0.022
0.020
0.018
0
20
40
60
80
100
120
140
Base Width, ft

Engineering, Planning,
Landscape Architecture
and Environmental Science

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JOB QUINAPOXET DAM
SHEET NO. ____ OF ____
CALCULATED BY JGM DATE 6/15
CHECKED BY ____ DATE ____
SCALE ____

A) REGIONAL BANKFULL GEOMETRY

Watershed Area = 57 SM

$W_b = 15.04 (DA)^{0.4038}$ (Bent, USGS, 2013)

$= 15.04 (57)^{0.4038} = 77$ FT

$D_b = 0.9502 (DA)^{0.2960}$

$= 0.9502 (57)^{0.2960} = 3.14$ FT

B) Pattern

a) $SSP = \gamma Q S$

$= 9800 \left(\frac{829}{35}\right) (0.015) / \frac{77}{3.3} = 149 \ W/m^2$

at this level, predict a mod braided/active channel

b) Church

$Q_{metric} = 23.7$

$S = 0.015$

pattern = wandering, braided

c) Chang $\frac{S}{\sqrt{d}} = \frac{0.015}{\sqrt{92}} = 0.16$

$Q = \frac{829 \text{ CFS}}{35}$

pattern = meander, stable

width = 70

depth = 7.6

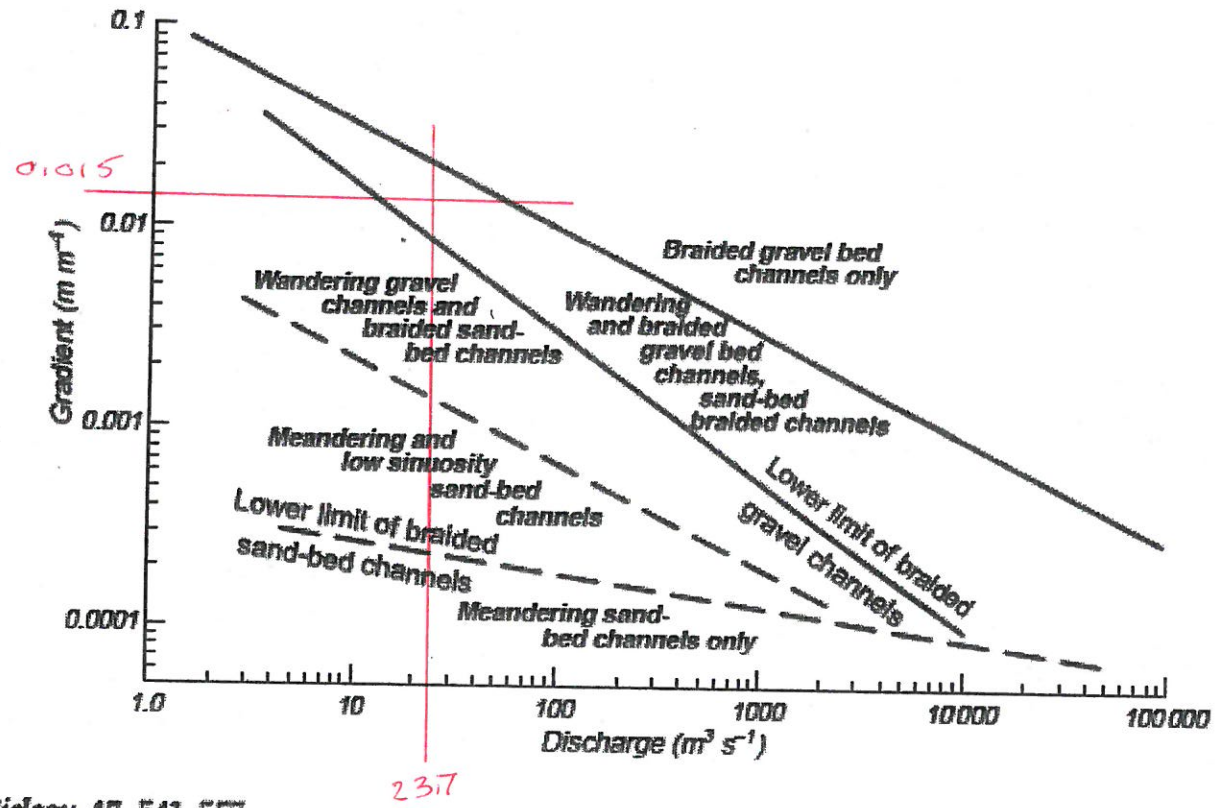

Fig. 4 Fields of river channel morphological pattern within the domain of S versus Q. Q is the 'channel-forming discharge', which is variously interpreted to be bankfull flow or mean annual flood. [partly after Leopold & Wolman (1957)] The different positions of gravel and sand transitions show the effect of sediment calibre, which is not otherwise quantified in this display. Note the distinct plotting positions of 'upward' and 'downward' transitions in channel morphology, the consequence of varying bank constitution and bank strength in the different regimes.

© 2002 Blackwell Science Ltd, *Freshwater Biology*, 47, 541–557

$Q = \frac{829 \text{ CFS}}{35} = 23.7 \text{ CMS}$

$S = 0.015$

Church, 2002

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REVISIONS

EXISTING CONDITIONS: HEC-RAS CROSS SECTION LOCATION MAP

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

PRELIMINARY FEASIBILITY & ENGINEERING DESIGN

--	BAM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=100'

DATE: JUNE 30, 2015

PROJECT NO.: 2688-37

Figure 1

SHEET NO.:

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Drawing: W:\DESIGN\2688-37-DE\CAD\VOYPLANSET\HEC-RAS SECTIONS.DWG Layout: Tab:EX-RAS
Plotted by: DAMME On this date: Fri, 2015 June 19 - 4:38pm

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JOB	Quinapoxet Dam Removal	MMI#	2688-37
SHEET NO.	1	OF	2
CALCULATED BY	BeckyM	DATE	6/12/2015
CHECKED BY		DATE	
SCALE	n/a		

GOAL - EVALUATE CHANNEL SIZE BASED UPON FLOOD CARRYING CAPACITY, CHANNEL BANK STABILITY, AND LOW-FLOW FISH PASSABILITY

Step 1: Evaluate Hydrology

Use USGS StreamStats Application to determine flood flows for channel design, and compare to FEMA published data.

(See attached for USGS Streamstats data)

Drainage Area (DA) = 16.6 square miles

	HEC-SSP Analysis
5-Year	1,474 cfs
10-Year	1,791 cfs
100-Year	3,041 cfs

Channel Slope (S) = 2.07% Note: Slope based on survey performed by MMI in April, 2015

Step 2: Evaluate Channel Capacity For Two Year Flow (Approximate Bank-Full)

Method 1: Reference Reach

Measured cross section at stable, upstream location (at upstream end of proposed restoration, Section F)

Channel Width (W) = 165 feet

Channel Depth (D) = 1 foot

Floodplain Width (FP) = Not mapped

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JOB	Quinapoxet Dam Removal		MMI# 2688-37
SHEET NO.	2	OF	2
CALCULATED BY	BeckyM	DATE	6/12/2015
CHECKED BY		DATE	
SCALE	n/a		

Method 2: Manning's Equation for Bankfull and Summer Low Flow

Size channel to carry (approximate) bankful discharge of 829 cfs, have low flow channel for summer flows (13 cfs)

(See attached for manning's equation calculation)

Bankfull Channel Size:		Low-Flow Channel Size	
Input:	Output:	Input:	Output:
Bottom Width = 60 ft	Depth = 3.24 ft	Bottom Width = 30 ft	Depth = 0.75 ft
Side Slopes = 3:1	Velocity = 4.07 fps	Side Slopes = 1:1	Velocity = 1.57 fps
Depth = 4 ft		Depth = 0.75 ft	
Slope = 0.378%		Slope = 0.378%	
Manning's N-value = 0.03		Manning's N-value = 0.03	
Discharge = 829 cfs		Discharge = 13 cfs	

Step 3: Evaluate Channel Capacity For Maximum Predicted Flow (See Attachment D)

Assess velocities in channel and floodplain during 100-year flow (3,041 cfs)

Input:	Output:
Floodplain Width = 125 ft	Depth = 5.80 ft
Main Channel (See Above)	Wetted Area = 495.46 sf
Slope = 0.378%	Velocity = 5.37 fps
Discharge = 3,041 cfs	
Manning's N-value Channel = 0.03	
Manning's N-value Floodplain = 0.1	

:: Depth of 5.8 feet will lower flood elevations by approximate two feet, and velocities near 5.37 fps can be mitigated through stone armoring of the channel.

APPENDIX J

GEOTECH BORINGS

Memorandum

TO: **Georgeann Keer, Massachusetts Division of Fisheries and Wildlife**
Andrew Greene, Milone & MacBroom, Inc. (MMI)
James Murac, MMI

FROM: **Dan Melnik, MMI**

DATE: **May 13, 2016**

RE: **Quinapoxet River**
West Boylston, Massachusetts
MMI #2688-37-7

Introduction

The goals of the project include restoration of free passage of fish and wildlife, naturalization of riverine hydrology, sediment management, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without causing impact to MWRA and DCR water supply operations to an underground aqueduct connecting the Quabbin Reservoir to the Wachusett Reservoir called "Quabbin Interflow Shaft #1" or the downstream Wachusett Reservoir. In order to locate and characterize bedrock elevations in support of a future dam removal effort, 5 geotechnical borings were performed. Work began on Wednesday, April 27, 2016. Ed Connor from DCR and Dan Melnik from MMI met on site (Quinapoxet River Dam) to coordinate the drilling operation. The following is a description of the results.

Drilling Operation

New England Boring Contractors (NEBC) arrived on site Wednesday morning, April 27, 2016, with the proposed Diedrich D50 track-mounted rig (see photo log attached) to commence exploratory drilling for bedrock within the Quinapoxet River. Terramats were used to protect the existing vegetated berm and gain access to the river. Each night the drilling rig was removed from the river and stored along the southern bank of the river.

Once in the river, NEBC set up on the first hole, B4, on April 27, 2016. B4 is located 40' northwest of the fence post on the right bank (see attached plan of boring locations). An oil boom and silt fence were placed around the rig once in the water. Drilling was completed to a depth of 14 feet, but halted due to turbidity releases. DCR provided one 20' long 12" deep silt curtain to be installed directly downstream of the drilling rig and another 80' long section immediately upstream of the dam spillway to contain/trap/knock down sediment within the river channel. Drilling resumed on April 28, 2016 from 14' to 19'. An additional 4' deep silt curtain spanning the channel was installed approximately 600' downstream of the dam to assist in reducing sediment in the river. All three of these curtains were used for the remainder of the project.

The depth of water at the first hole B4 was approximately 1.9'. To install the boring, first a 10' section of casing was driven approximately 8.1' into the channel bed to ensure that the boring would not collapse on itself. Materials encountered within the boring consisted of river cobble, coarse sand, and gravelly material (see attached boring log). Boring equipment was removed from the hole on April 29, 2016 after reaching 19' without hitting bedrock.

The second hole, B3, was completed on April 29, 2016. B3 is located 30' from the right bank corner of the dam spillway and 40' upstream of the dam spillway. The depth of water at this location was approximately 1.35'. To install the boring, first a 10' section of casing was driven approximately 6.1' into the channel bed to ensure that the boring would not collapse on itself. Materials encountered within the boring consisted of river cobble, coarse sand, and gravelly material (see attached boring log). Boring equipment was removed from the hole on April 29, 2016 after reaching 19' without hitting bedrock.

The third hole, B2, was completed on April 29, 2016. B2 is located 55' from the right bank corner of the dam spillway and 36' upstream of the dam spillway. The depth of water at this location was approximately 2.2'. To install the boring, first a 10' section of casing was driven approximately 7.3' into the channel bed to ensure that the boring would not collapse on itself. Materials encountered within the boring consisted of river cobble, coarse sand, and gravelly material (see attached boring log). Boring equipment was removed from the hole on April 29, 2016 after reaching 18.8' without hitting bedrock.

The fourth hole, B1, was completed on April 29, 2016. B1 is located 83' from the right bank corner of the dam spillway and 50' upstream of the dam spillway. The depth of water at this location was approximately 1.0'. To install the boring, first a 10' section of casing was driven approximately 6.5' into the channel bed to ensure that the boring would not collapse on itself. Materials encountered within the boring consisted of river cobble, coarse sand, and gravelly material (see attached boring log). Boring equipment was removed from the hole on April 29, 2016 after reaching 19' without hitting bedrock.

The fifth hole, B5, was completed on May 2, 2016. B5 is located 85' upstream of boring B4 in the channel. The depth of water at this location was approximately 1.7'. To install the boring, first a 10' section of casing was driven approximately 7.0' into the channel bed to ensure that the boring would not collapse on itself. Materials encountered within the boring consisted of river cobble, coarse sand, and gravelly material (see attached boring log). Boring equipment was removed from the hole on May 2, 2016 after reaching 19' without hitting bedrock.

Table 1

Summary of Boring Results			
ID	Bedrock Elevation	Boring Depth	Proposed Excavation Depth*
B1	< 374.2'	374.2'	386.9'
B2	< 374.1'	374.1'	386.6'
B3	< 374.1'	374.1'	386.5'
B4	< 374.5'	374.5'	388.2'
B5	< 374.3'	374.3'	390.1'

*Proposed Excavation depth based on Design plans dated June 30, 2015

In summation, bedrock was not encountered on site at any of the five borings to depths of approximately 19'. Based on preliminary design plans, the maximum depth of excavation will likely be in the 7' to 10' range or elevations of 386' to 390', significantly higher than ±374' to which all five borings were completed.

Turbidity Releases

Drilling was completed using a hollow stem auger to drill down to the specified depth. During this process, the casing was driven approximately eight feet into the ground below the stream bottom. The material within the casing was then drilled out with the auger and drill bit. The auger cuttings were flushed out of the bore hole through the process of water being pumped down the hollow auger and expelled out the top of the bore hole. Turbidity was created during this boring process when the auger was drilling down to the specified depth and flushing material out as it was cut. This lasted approximately 45 minutes to one hour per hole. Every five feet of drilling and pumping of water, the drill would be stopped in order to add additional lengths of rod to the drill bit. This allowed the turbidity within the channel to disperse before drilling was recommenced. The auger cuttings consisted mostly of pulverized rock and sands which only remain in suspension a short distance (see picture below).

The visible suspended turbidity that was carried downstream by the flow of the river was the finer silts. The previously mentioned turbidity curtains were effective in mitigating turbidity of the larger sands and gravels, and proved unable to filter out the finer silt. Having installed the silt curtains, drilling was allowed (by DCR/MWRA) to continue on site. Oversight was provided by DCR for the remainder of drilling.

Attachments
2688-37-7-m1016-memo

MMI Job No.: 2688-37	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 5
Drilling Co.: New England Boring Contractors	Project Name: Quinapoxet Dam Removal	Hole ID: B1
Operator: Walter	Town: West Boyleston	Date 4/29/2016 Start: 12:50 Finish: 1:45
MMI Inspector: Dan Melnik	Well Location: 83' NW of right bank dam corner and 50' upstream from the dam	Well Type:
Ground Water Obs: DTW: _____ Time: _____ DTW: _____ Time: _____	Drilling Details: Method: IISA Hammer Wt: n/a Sampler: n/a Casing: 6" ST Hammer Fall: n/a Misc.: n/a	

Depth:	Blows: 0-6",6-12",12-18"	Recovery:	Sample:	Coring Time/Ft: (min)	Yield: (gpm)	Moisture:	Field Description:
							Depth of water 1.0' to borehole at channel bottom.
							Note: all drilling depths are from channel bottom.
0'-4'							River cobble material
4'-12'							Coarse sand little silt
12'-14'							Silty sand
14'-14.5'							Sand and gravel
14.5'							Boulder
14.5'-18'							Coarse sand
18'-19'							Coarse sand
							Auger and casing pulled 4/29, deep enough to confirm / deny existance of bedrock.

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MMI Job No.: 2688-37	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410	Sheet: 2 of 5
Drilling Co.: New England Boring Contractors	Project Name: Quinapoxet Dam Removal	Hole ID: B2
Operator: Walter	Town: West Boyleston	Date 4/29/2016 Start: 10:30 Finish: 11:55
MMI Inspector: Dan Melnik	Well Location: 55' NW of right bank dam corner and 36' upstream from the dam	Well Type:
Ground Water Obs: DTW: _____ Time: _____ DTW: _____ Time: _____	Drilling Details: Method: IISA Hammer Wt: n/a Sampler: n/a Casing: 6" ST Hammer Fall: n/a Misc.: n/a	

Depth:	Blows: 0-6",6-12",12-18"	Recovery:	Sample:	Coring Time/Ft: (min)	Yield: (gpm)	Moisture:	Field Description:
							Depth of water 2.2' to borehole at channel bottom.
							Note: all drilling depths are from channel bottom.
0'-5'							River cobble material
5'-7'							Cobble and gravel
7'-9'							Sand
9'-14'							Coarse sand
14'-18.8'							Coarse sand
							Auger and casing pulled 4/29, deep enough to confirm / deny existance of bedrock.

MILONE & MACBROOM®

MMI Job No.: 2688-37	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410	Sheet: 3 of 5
Drilling Co.: New England Boring Contractors	Project Name: Quinapoxet Dam Removal	Hole ID: B3
Operator: Walter	Town: West Boyleston	Date 4/29/2016 Start: 8:20 Finish: 10:00
MMI Inspector: Dan Melnik	Well Location: 30' NW of right bank dam corner and 40' upstream from the dam	Well Type:
Ground Water Obs: DTW: _____ Time: _____ DTW: _____ Time: _____	Drilling Details: Method: IISA Hammer Wt: n/a Sampler: n/a Casing: 6" ST Hammer Fall: n/a Misc.: n/a	

Depth:	Blows: 0-6",6-12",12-18"	Recovery:	Sample:	Coring Time/Ft: (min)	Yield: (gpm)	Moisture:	Field Description:
							Depth of water 1.35' to borehole at channel bottom.
							Note: all drilling depths are from channel bottom.
0'-3'							River cobble material
3'-6.1'							Coarse sand
6.1'-7'							Cobble and gravel
7'-14'							Sand and gravel
14'-16.5'							Coarse sand
16.5'-19'							Compact sand and silt
							Auger and casing pulled 4/29, deep enough to confirm / deny existance of bedrock.

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MMI Job No.: 2688-37	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410	Sheet: 4 of 5
Drilling Co.: New England Boring Contractors	Project Name: Quinapoxet Dam Removal	Hole ID: B4
Operator: Walter	Town: West Boyleston	Date 4/27/2016 - 4/29/2016 Start: 10:40 Finish: 7:30
MMI Inspector: Dan Melnik	Well Location: 40' NW of fence corner	Well Type:
Ground Water Obs: DTW: _____ Time: _____ DTW: _____ Time: _____	Drilling Details: Method: IISA Hammer Wt: n/a Sampler: n/a Casing: 6" ST Hammer Fall: n/a Misc.: n/a	

Depth:	Blows: 0-6",6-12",12-18"	Recovery:	Sample:	Coring Time/Ft: (min)	Yield: (gpm)	Moisture:	Field Description:
							Depth of water 1.9' to borehole at channel bottom.
							Note: all drilling depths are from channel bottom.
0'-5'							River cobble material
5'-8.1'							Coarse sand
8.1'							Cobble and Gravel
8.1'-14'							Coarse sand
							Drilling stopped for the day 4/27 due to turbidity issues.
14'-19'							Coarse sand and angular gravel little silt
							Drilling stopped for the day 4/28 due to turbidity issues.
							Auger and casing pulled 4/29, deep enough to confirm / deny existance of bedrock.

MILONE & MACBROOM®

MMI Job No.: 2688-37	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410	Sheet: 5 of 5
Drilling Co.: New England Boring Contractors	Project Name: Quinapoxet Dam Removal	Hole ID: B5
Operator: Walter	Town: West Boyleston	Date 5/2/2016 Start: 8:25 Finish: 10:00
MMI Inspector: Dan Melnik	Well Location: 85' upstream of B4	Well Type:
Ground Water Obs: DTW: _____ Time: _____ DTW: _____ Time: _____	Drilling Details: Method: IISA Hammer Wt: n/a Sampler: n/a Casing: 6" ST Hammer Fall: n/a Misc.: n/a	

Depth:	Blows: 0-6",6-12",12-18"	Recovery:	Sample:	Coring Time/Ft: (min)	Yield: (gpm)	Moisture:	Field Description:
							Depth of water 1.7' to borehole at channel bottom.
							Note: all drilling depths are from channel bottom.
0'-6'							River cobble material / sand
6'-7'							Silt
7'							Cobble and gravel
7'-12'							Coarse sand
12'-13.5'							Silt with little sand
13.5'-15'							Coarse sand and silt
15'-19'							Coarse sand little gravel and silt
							Auger and casing pulled 5/2, deep enough to confirm / deny existance of bedrock.

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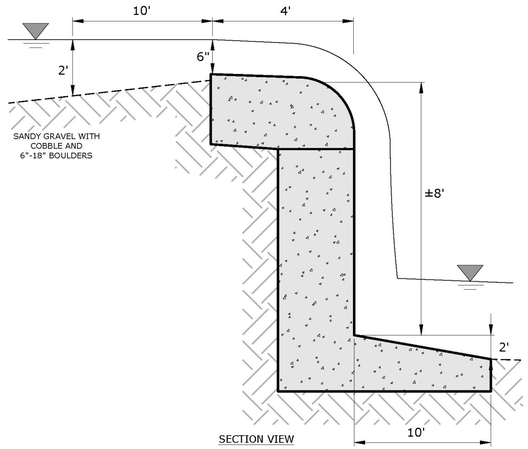
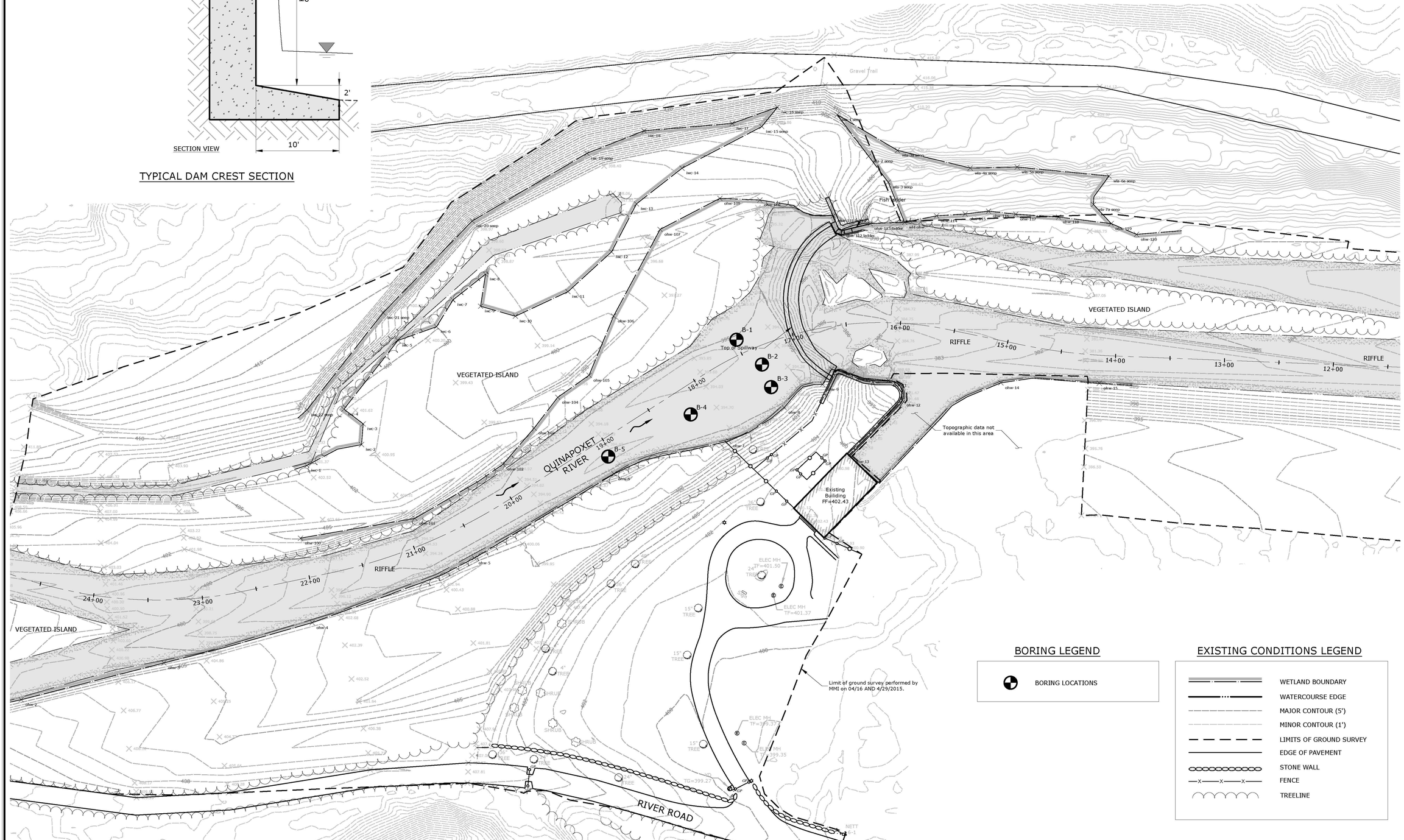


TYPICAL DAM CREST SECTION

MAPPING NOTES:

1. TOPOGRAPHIC INFORMATION IS BASED UPON MassGIS Data - LiDar Terrain Data subset: May 6-7, 2011 Nashua River, AND SUPPLEMENTED WITH FIELD SURVEY BY MILONE & MACBROOM, INC., CHESHIRE CT. 4/16 & 4/29/2015. UTILITY INFORMATION FIELD SURVEYED BY MILONE & MACBROOM, INC.
2. ALL CONTOURS AND ELEVATIONS ARE IN PRESENTED IN FEET, AND REFER TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1988 (NGVD 1988).
3. NORTH ARROW, BEARINGS AND COORDINATES ARE BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD 1983) MASSACHUSETTS MAINLAND STATE PLAIN.
4. INFORMATION REGARDING THE LOCATION OF EXISTING UTILITIES HAS BEEN BASED UPON AVAILABLE INFORMATION AND MAY BE INCOMPLETE, AND WHERE SHOWN SHOULD BE CONSIDERED APPROXIMATE. THE LOCATION OF ALL EXISTING UTILITIES SHOULD BE CONFIRMED PRIOR TO BEGINNING CONSTRUCTION. CALL "DIG SAFE", 1-888-344-7233. ALL UTILITY LOCATIONS THAT DO NOT MATCH THE VERTICAL OR HORIZONTAL CONTROL SHOWN ON THE PLANS SHALL IMMEDIATELY BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR RESOLUTION.
5. MILONE & MACBROOM INC. ACCEPTS NO RESPONSIBILITY FOR THE ACCURACY OF MAPS AND DATA WHICH HAVE BEEN SUPPLIED BY OTHERS.
6. WETLANDS DETERMINED, FLAGGED AND FIELD LOCATED BY MILONE & MACBROOM, INC. ON JUNE 29. 2015



BORING LEGEND

BORING LOCATIONS

EXISTING CONDITIONS LEGEND

- WETLAND BOUNDARY
- WATERCOURSE EDGE
- MAJOR CONTOUR (5')
- MINOR CONTOUR (1')
- LIMITS OF GROUND SURVEY
- EDGE OF PAVEMENT
- STONE WALL
- FENCE
- TREELINE

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DESCRIPTION	DATE	BY

BORING LOCATION MAP

QUINAPOXET DAM REMOVAL
QUINAPOXET RIVER AT THE WACHUSETT RESERVOIR

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

DRM	DRM	WAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: NOVEMBER 25, 2015

PROJECT NO.: 2688-37

SHEET NO.: 1 OF 1

SHEET NAME: PR-1

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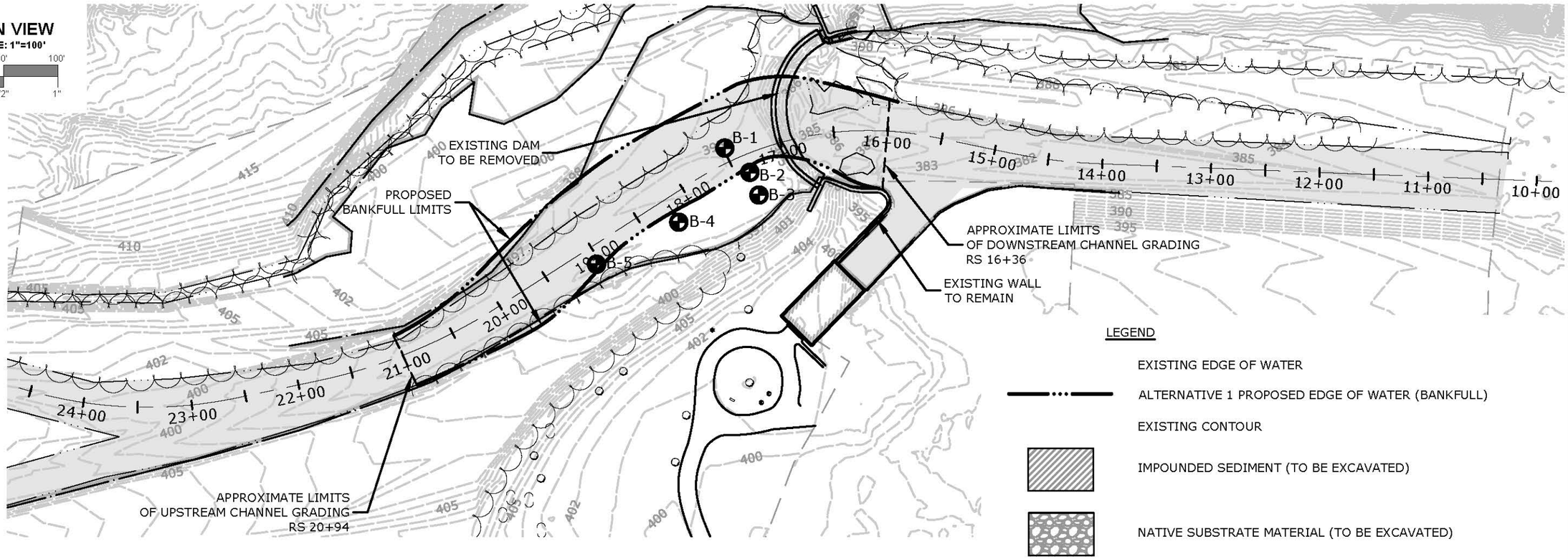

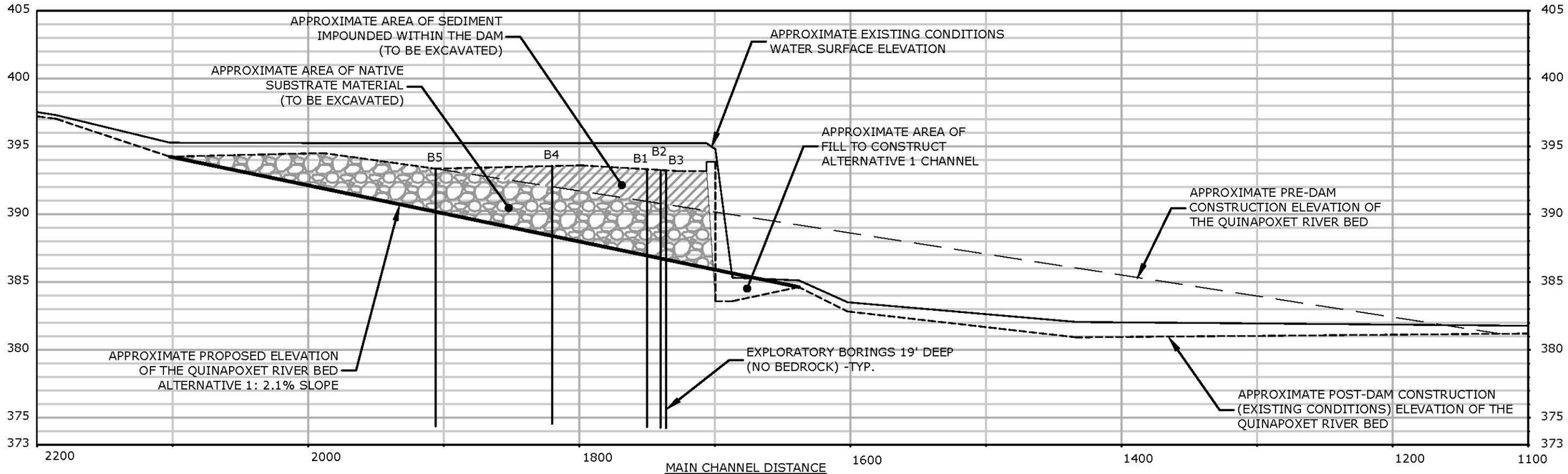

PROFILE
SCALE: 1"=80' H
1"= 8' V

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REVISIONS

ALTERNATIVE 1: CONCEPT PLAN AND PROFILE

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER

WEST BOYLSTON, MASSACHUSETTS

PRELIMINARY FEASIBILITY & ENGINEERING DESIGN

--	BAM	JAG
DESIGNED	DRAWN	CHECKED

SCALE: 1"=100'

DATE: JUNE 30, 2015

PROJECT NO.: 2688-37

Figure 4-1

SHEET NO.

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Drawing: W:\DESIGN\2688-37-DE\CAD\QP-ALTERNATIVE1.DWG Layout: tab:ALT1-PROFILE
Plotted by: DAVME On this date: Tue, 2016 May 3 - 10:09am

APPENDIX K

FISH PASSAGE INFORMATION

Quinapoxet Dam Removal **DRAFT** B.Towler, USFWS, 10/5/2015

85% Daily Exceedance (Approximate Low Fish Passage Design Flow) **REVISED JCM 5/13/2016**

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 1 : 85% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	2.22														
2094	1.47	83	1.845	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
2048	2.68	46	2.075	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1985	0.89	63	1.785	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1897	2.67	88	1.78	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1789	0.88	108	1.775	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1718	2.67	71	1.775	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1679	0.92	39	1.795	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1636	2.57	43	1.745	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1599	2.86	37	2.715	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1433	0.54	166	1.7	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 2 : 85% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	2.18														
2094	0.15	83	1.165	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
2048	0.05	46	0.1	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1985	0.13	63	0.09	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1980	1.25	5	0.69	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1897	2.22	83	1.735	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1789	0.1	108	1.16	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1761	0.05	28	0.075	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1718	0.11	43	0.08	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1711	0.13	7	0.12	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1706	1.03	5	0.58	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1679	2.2	27	1.615	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1636	1.22	43	1.71	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1599	2.12	37	1.67	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1433	0.54	166	1.33	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 3 : 85% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	0.07														
2159	0.15	18	0.11	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2154	2.5	5	1.325	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2094	1.62	60	2.06	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
2054	2.64	40	2.13	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1980	0.08	74	1.36	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1949	0.05	31	0.065	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1897	0.12	52	0.085	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1892	2.55	5	1.335	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1789	1.58	103	2.065	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1718	1.86	71	1.72	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1679	1.53	39	1.695	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1636	1.96	43	1.745	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1599	2.86	37	2.41	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1433	0.54	166	1.7	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

Quinapoxet Dam Removal
15% Daily Exceedance (Approximate High Fish Passage Design Flow)

DRAFT B.Towler, USFWS, 10/5/2015
REVISED JCM 5/13/2016

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 1 : 15% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	4.25														
2094	3.73	83	3.99	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
2048	4.41	46	4.07	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1985	2.15	63	3.28	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1897	4.43	88	3.29	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1789	2.18	108	3.305	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1718	4.42	71	3.3	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1679	2.07	39	3.245	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1636	4.51	43	3.29	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1599	5.14	37	4.825	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1433	1.94	166	3.54	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 2 : 15% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	4.25														
2094	0.89	83	2.57	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
2048	0.45	46	0.67	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1985	0.95	63	0.7	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1980	3.21	5	2.08	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1897	4.22	83	3.715	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1789	0.69	108	2.455	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1761	0.46	28	0.575	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1718	0.83	43	0.645	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1711	0.92	7	0.875	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1706	2.8	5	1.86	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1679	3.96	27	3.38	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS
1636	3.27	43	3.615	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1599	4	37	3.635	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1433	1.94	166	2.97	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

Fish Passage Assessment				12" long landlocked salmon						18" long landlocked salmon					
Alternative 3 : 15% Daily Exceedance				Swim Speed (fps)			Distance (ft)			Swim Speed (fps)			Distance (ft)		
				1.8	5.5	11	INF	3300	27.5	2.8	8.25	16.5	INF	4950	41.25
STA (ft)	V (ft/s)	Distance (ft)	Avg. V (ft/s)	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue	Cruising Speed	Prolng. Speed	Burst Speed	Cruising Fatigue	Prolng. Fatigue	Burst Fatigue
2177	0.52														
2159	0.96	18	0.74	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2154	4.3	5	2.63	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2094	3.41	60	3.855	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
2054	4.52	40	3.965	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1980	0.57	74	2.545	FAIL	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1949	0.4	31	0.485	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS
1897	0.78	52	0.59	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL
1892	4.5	5	2.64	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1789	3.25	103	3.875	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1718	3.48	71	3.365	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1679	3.1	39	3.29	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1636	3.93	43	3.515	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
1599	4.74	37	4.335	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
1433	1.94	166	3.34	FAIL	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
		744	TOTAL												

APPENDIX B

ENGINEERING DESIGN PLANS
UNDER SEPARATE COVER

APPENDIX C

FLOW ESTIMATES FOR CONSTRUCTION

MMI No 4673-03 Quinapoxet Dam Removal, West Boylston, MA
Flow Statistics for Construction Dewatering
USGS 01095375 QUINAPOXET RIVER AT CANADA MILLS NEAR HOLDEN, MA
Watershed Area = 46.3 sq. mi.
Project Site Watershed Area = 57 sq. mi.

Unadjusted Discharge Values at USGS Gauge:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
80% Exceedance	**24**	**30**	**57**	**70**	**41**	**20**	**8**	**5**	**3**	**6**	**11**	**15**
Mean Monthly Discharge (CFS)	**72**	**76**	**138**	**162**	**85**	**65**	**26**	**17**	**17**	**32**	**49**	**81**
20% Exceedance	**107**	**109**	**192**	**220**	**115**	**92**	**36**	**23**	**19**	**46**	**75**	**135**

Watershed Ratio Transfer Equation Qu = Qg x (Au/Ag)^0.75
Discharge Values Adjusted by Watershed Area to Project Site:

Statistical Flows by Month (CFS)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20th Percentile	28	36	67	82	48	24	9	6	4	7	12	18
Mean Monthly Discharge	84	89	161	189	99	76	30	20	20	37	57	95
80th Percentile	125	127	224	257	134	108	42	26	22	53	88	158

Statistical Flows by Month (GPM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20th Percentile	12,400	16,000	29,900	36,800	21,600	10,600	4,100	2,500	1,800	2,900	5,500	7,900
Mean Monthly Discharge	37,800	39,900	72,400	85,000	44,600	34,100	13,600	8,900	8,900	16,800	25,700	42,500
80th Percentile	56,100	57,100	100,600	115,300	60,200	48,300	18,700	11,800	9,900	23,900	39,400	70,800

Flood Flows by Recurrence Interval (CFS)

	Bankfull	5-Year	10-Year	100-Year
20th Percentile	830	1,500	1,800	3,000

APPENDIX D

WETLAND DELINEATION REPORT

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

QUINAPOXET DAM REMOVAL: FEASIBILITY STUDY

July 16, 2015
MMI #2688-37

At the request of the Massachusetts Division of Ecological Restoration (DER), Milone & MacBroom, Inc. (MMI) completed a wetland delineation and field assessment on the wetlands associated with the Quinapoxet dam impoundment. This work was completed to provide information for future federal, state, and local permitting efforts for this project.

On June 29, 2015, a MMI wetland scientist delineated wetlands and watercourses within the immediate vicinity of the dam subject to the provisions of the Rule and Regulations of the Massachusetts Wetlands Protection Act and Section 404 of the Clean Water Act. Wetlands were delineated using the methodology provided in the *U.S. Army Corps of Engineers (USACOE) Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region.* The resource area boundaries and wetland flags were collected using a hand-held GPS device and incorporated into project base mapping (see drawing EX-1).

Figure 1 depicts the wetland delineation with the USACOE plot locations. The Natural Resources Conservation Service (NRCS) web soil survey mapping is attached and shows the following soil types within the project wetland delineation area:

- Limerick
- Merrimac

The field investigation was consistent with the NRCS soil survey mapping with minimal bordering vegetated wetlands along the right bank descending of the Quinapoxet River upstream and downstream of the impoundment. Bordering vegetated wetlands were located on the north side of the Quinapoxet River within the forested area. An unnamed intermittent watercourse was located within this forested area that was primarily fed by seeps observed along the northern hillside parallel to the watercourse. The intermittent watercourse was approximately two-feet wide and six-inches deep flowing from west to east. The watercourse dissipated to a relatively flat low-lying area where it likely discharges to groundwater and eventually to the Quinapoxet River.

The bordering vegetated wetlands that were delineated upstream and downstream of the impoundment consisted of palustrine scrub shrub. The bordering vegetated wetland within the floodplain upstream of the dam associated with the forested floodplain upstream and downstream of the dam consisted of palustrine forested system. The Quinapoxet River is classified as a palustrine unconsolidated bottom system. Figure 2 illustrates the wetland vegetation communities mapped at the site and are described below.

Palustrine Unconsolidated Bottom (PUB)

PUB Wetland System

The unconsolidated bottom includes all wetland and deepwater habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. The system is dominated by a cobble-gravel bottom with varying water depths that range from 6 inches of water to as much as 3 feet, approximately. Depths of water within the open water wetland are variable based on seasonal flow regimes. The open water system provides a cold-water fishery habitat; however, the amount of viable habitat varies depending upon seasonal flow regime.

A functional evaluation of the PUB wetland based on MMI field observations is summarized in Table 1. The first column lists the functions generally ascribed to wetlands; the second column summarizes the rationale used to determine whether these functions are being performed within the subject wetland and/or watercourse.

TABLE 1
Functions and Values Assessment – PUB Wetland

	Functions and Values	Comments
	Ground Water Recharge / Discharge	Yes – PUB riverine habitats receive ground water.
	Flood flow Alteration (Storage & Desynchronization)	Yes – PUB mapped by the Federal Emergency Management Agency (FEMA) does provide localized flood flow alteration.
	Fish & Shellfish Habitat	Yes – PUB has the potential to support cold-water fishery resource.
	Sediment / Toxicant Retention	Yes – Sediment deposition was observed upstream of the impoundment.
	Nutrient Removal / Retention / Transformation	No – PUB wetland system has little submerged or floating aquatic vegetation that would provide nutrient removal/retention.

	Functions and Values	Comments
	Production Export (Nutrient)	Yes – Bordering shrubs and trees deposit allochthonous material that is transported to downstream habitats.
	Sediment / Shoreline / Stream Bank Stabilization	Yes – PUB system is bordered by vegetation that keeps shoreline stable.
	Wildlife Habitat	Yes – PUB does provide valuable wildlife habitat for waterfowl, passerine birds, mammals, fish and insects.
	Recreation (Consumptive & Non-Consumptive)	Yes – PUB does provide a readily accessible river system open for recreational use including valuable fishing and/or canoeing area.
	Educational Scientific Value	No – PUB wetland does not provide any educational/scientific value.
	Uniqueness / Heritage	No
	Visual Quality / Aesthetics	Yes – PUB wetland system provides high visual quality.
ES	Endangered Species	No

The principal functions and values of the wetland system at this location include the following:

- Fish habitat
- Local wildlife habitat
- Floodflow alteration
- Recreation (Consumptive & Non-Consumptive)
- Sediment/Shoreline/Stream Bank Stabilization

Palustrine Scrub Shrub

The scrub shrub wetland system is located along the periphery of the PUB wetland community. This system is dominated by shrubby and herbaceous vegetation including speckled alder, silky dogwood, sensitive fern, jewelweed and tussock sedge. Many of the plants are growing on hummocks with low-lying areas with standing water and soils consisting of sandy loam.

Scrub Shrub Wetland System

A functional evaluation of the scrub shrub wetland based on MMI field observations is summarized in Table 2. The first column lists the functions generally ascribed to wetlands; the second column summarizes the rationale used to determine whether these functions are being performed within the subject wetland and/or watercourse.

TABLE 2
Functions and Values Assessment – Scrub Shrub Wetland

	Functions and Values	Comments
	Ground Water Recharge / Discharge	Yes – ground water recharge and discharge was observed with shallow water table within 6 inches of grade and standing water observed between low-lying areas.
	Flood flow Alteration (Storage & Desynchronization)	Yes – Scrub shrub wetland is mapped by FEMA and does provide localized flood flow alteration.
	Fish & Shellfish Habitat	No – Scrub shrub wetland does not support fishery resources.
	Sediment / Toxicant Retention	Yes – Sediment deposition was observed within the scrub shrub wetland system.
	Nutrient Removal / Retention / Transformation	Yes – Dense scrub shrub vegetation provides nutrient removal/retention.
	Production Export (Nutrient)	Yes – Vegetation does deposit allochthonous material that is transported to downstream habitats.

	Functions and Values	Comments
	Sediment / Shoreline / Stream Bank Stabilization	Yes – Existing shrubby vegetation stabilizes shoreline.
	Wildlife Habitat	Yes – Scrub shrub system does provide valuable wildlife habitat for passerine birds, reptiles, amphibians, and insects.
	Recreation (Consumptive & Non-Consumptive)	No – Scrub shrub wetland system is not readily accessible.
	Educational Scientific Value	No – Scrub shrub wetland does not provide any educational/scientific value.
	Uniqueness / Heritage	No
	Visual Quality / Aesthetics	No – Scrub shrub wetland system does not provide high visual quality.
ES	Endangered Species	No

The principal functions and values of the wetland system at this location include the following:

- Local wildlife habitat
- Nutrient removal
- Floodflow alteration

Palustrine Forested Wetland

The forested wetland system is the largest community type found within the project reach. This community comprises the floodplain of Quinapoxet River and the unnamed intermittent tributary. Groundwater seeps along the banks of the floodplain to the Quinapoxet River were observed upstream and downstream of the impoundment. This system has a dense overstory consisting of red maple, American beech and yellow birch. The understory varies in density and consists of silky dogwood, interrupted fern, sensitive fern, jewelweed, cinnamon fern, jack and the pulpit, false solomon seal, and scouring rush.

Forested Wetland System

A functional evaluation of the forested wetland based on MMI field observations is summarized in Table 3. The first column lists the functions generally ascribed to wetlands; the second column summarizes the rationale used to determine whether these functions are being performed within the subject wetland and/or watercourse.

TABLE 3
Functions and Values Assessment – Forested Wetland

	Functions and Values	Comments
	Ground Water Recharge / Discharge	Yes – Groundwater discharge was observed in a few places along the corridor.
	Flood flow Alteration (Storage & Desynchronization)	Yes – The forested wetland is mapped by FEMA and does provide localized flood flow alteration.
	Fish & Shellfish Habitat	No – Forested wetland does not support fishery resources.
	Sediment / Toxicant Retention	Yes – Sediment deposition was observed within the forested wetland system.
	Nutrient Removal / Retention / Transformation	Yes – Forested vegetation provides nutrient removal/retention.

	Functions and Values	Comments
	Production Export (Nutrient)	Yes – Vegetation does deposit allochthonous material that is transported to downstream habitats.
	Sediment / Shoreline / Stream Bank Stabilization	Yes – Existing forested vegetation stabilizes stream banks.
	Wildlife Habitat	Yes – Forested wetland system does provide valuable wildlife habitat for passerine birds, reptiles, amphibians, and insects.
	Recreation (Consumptive & Non-Consumptive)	No – The forested wetland system does not provide recreational uses.
	Educational Scientific Value	No – Forested wetland does not provide any educational/scientific value.
	Uniqueness / Heritage	No
	Visual Quality / Aesthetics	No – The forested wetland system does not provide high visual quality.
ES	Endangered Species	No

The principal functions and values of the wetland system at this location include the following:

- Local wildlife habitat
- Nutrient removal
- Floodflow alteration

2688-37

USDA-NRCS Soil Survey Map

Soil Map—Worcester County, Massachusetts, Northeastern Part
(Quinapoxet Dam)

Map Scale: 1:2,180 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 30 60 120 180

Feet: 0 100 200 400 600

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 1:20,000.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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: Worcester County, Massachusetts, Northeastern Part
Survey Area Data: Version 9, Sep 19, 2014

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

Date(s) aerial images were photographed: Apr 8, 2011—Apr 9, 2011

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

Worcester County, Massachusetts, Northeastern Part (MA613)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Water	1.8	12.5%
8A	Limerick silt loam, 0 to 3 percent slopes	1.0	7.4%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	11.3	80.1%
Totals for Area of Interest		**14.1**	**100.0%**

Wetland Delineation and USACE Plot Location Map

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

MILONE & MACBROOM
Cornerstone Corporate Center
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.milone-macbroom.com

DESCRIPTION	DATE	BY

WETLAND DELINATION MAP

QUINAPOXET DAM REMOVAL
QUINAPOXET RIVER AT THE WACHUSETT RESERVOIR

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

PAS	PAS	MS
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 80'

DATE: JULY 16, 2015

PROJECT NO.: 2688-37

FIGURE 1

SHEET NAME

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Wetland Vegetation Community Map

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

MILONE & MACBROOM
Cornerstone Corporate Center
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.milone-macbroom.com

DESCRIPTION	DATE	BY

WETLAND VEGETATION COMMUNITY MAP

QUINAPOXET DAM REMOVAL
QUINAPOXET RIVER AT THE WACHUSETT RESERVOIR

RIVER ROAD
WEST BOYLSTON, MASSACHUSETTS

PAS	PAS	MS
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 80'

DATE: JULY 16, 2015

PROJECT NO.: 2688-37

FIGURE 2

SHEET NAME

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United States Army Corps of Engineer Delineation Transect Forms

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Quinapoxet River City/County: West Boylston Sampling Date: 6/29/15

Applicant/Owner: DER State: MA Sampling Point: USACE-U1

Investigator(s): Pete Shea Section, Township, Range: _____

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): Convex Slope (%): 5

Subregion (LRR or MLRA): Northeast ~~Lat:~~ Long: 71°48'14.938"W ~~Long:~~ Lat: 42°23'13.393"N Datum: WAD83

Soil Map Unit Name: Merrimac fine sandy loam NWI classification: None

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

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X 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 X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes _____	No X	

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

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)

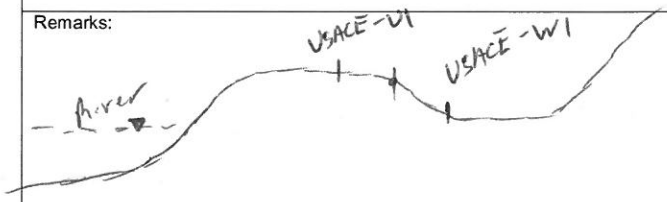
Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes X	No _____	Depth (inches): 22"
Saturation Present? (includes capillary fringe)	Yes X	No _____	Depth (inches): 22"

Wetland Hydrology Present? Yes _____ No X

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

Remarks:



VEGETATION – Use scientific names of plants.

Sampling Point: VSACE-U1

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Fagus Grandifolia	20	N	FACU
2. Betula Lutea	10	N	FAC
3. Acer Rubrum	30	Y	FAC
4. Carpinus Caroliana	120	N	FAC
5.			
6.			
7.			
	180 = Total Cover		

Sapling/Shrub Stratum (Plot size: 15')	Absolute % Cover	Dominant Species?	Indicator Status
1. Multiflora Rose	5	N	FACU
2. Betula Lutea	5	N	FAC
3. ~~Osmunda Claytoniana~~	~~10~~	~~Y~~	~~FAC~~
4.			
5.			
6.			
7.			
	10 = Total Cover		

Herb Stratum (Plot size: 5')	Absolute % Cover	Dominant Species?	Indicator Status
1. ~~None~~			
2. Osmunda Claytoniana	5	N	FAC
3. Euthamia Graminifolia	15	Y	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	20 = Total Cover		

Woody Vine Stratum (Plot size: 15')	Absolute % Cover	Dominant Species?	Indicator Status
1. Toxicodendron Radicans	5	~~FAC~~ N	FAC
2.			
3.			
4.			
	5 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	
FACW species	5	x 2 =	10
FAC species	75	x 3 =	225
FACU species	5	x 4 =	20
UPL species	0	x 5 =	0
Column Totals:	80 (A)		255 (B)

Prevalence Index = B/A = 2.81

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: Upte-Plot1

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

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-.5	10YR/3/2		None				SiCL/O	O;
.5-14"	7.5YR/4/4		None				SiC	A
14"-22"	7.5YR 5/4		None				SiC	Bw

[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** X

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Quinapoxet River City/County: West Boylston Sampling Date: 6/29/15

Applicant/Owner: DER State: MA Sampling Point: USACE-W1

Investigator(s): [illegible] Section, Township, Range: _____

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): Concave Slope (%): 5

Subregion (LRR or MLRA): NE Lat: 71°48'14.938W Long: 42° 33 13.393"N Datum: NAD83

Soil Map Unit Name: Merrimac FSL NWI classification: None

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

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X 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 X No _____	**Is the Sampled Area within a Wetland?** Yes X No _____	
Hydric Soil Present? Yes X No _____		
Wetland Hydrology Present? Yes X No _____	If yes, optional Wetland Site ID: _____	

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

HYDROLOGY

Wetland Hydrology Indicators:

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

- __ Surface Water (A1)
- __ High Water Table (A2)
- X Saturation (A3)
- __ Water Marks (B1)
- X 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)
- X 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)
- X 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 X	Depth (inches): _____	
Water Table Present?	Yes X	No _____	Depth (inches): 10"	
Saturation Present? (includes capillary fringe)	Yes X	No _____	Depth (inches): 8"	**Wetland Hydrology Present?** Yes X No _____

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

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: USACE-W1

Tree Stratum (Plot size: 30)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer Rubrum	~~40~~	Y	FAC
2. Betula lutea	20	Y	FAC
3. Fagus Grandifolia	5	N	FAC
4. Carpinus Caroliana	5	N	FAC
5.			
6.			
7.			
	70	= Total Cover	

Sapling/Shrub Stratum (Plot size: 15)			
1. ~~Onoclea Sens.~~			
2. Cornus Amomum	5	N	FACW
3. Acer Rubrum	5	N	FAC
4.			
5.			
6.			
7.			
	10	= Total Cover	

Herb Stratum (Plot size: 5)			
1. Onoclea Sensibilis	15	N	FACW
2. Impatiens Capensis	20	~~N~~ Y	FACW
3. Arisaema triphyllum	5	N	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	~~40~~	= Total Cover	

Woody Vine Stratum (Plot size: 15)			
1. Vitis Sp.	5		FACW
2.			
3.			
4.			
	5	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ~~40~~ 2 (A)

Total Number of Dominant Species Across All Strata: ~~40~~ 2 (B)

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

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	5	x 2 =	10
FAC species	5	x 3 =	15
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	10 (A)		25 (B)

Prevalence Index = B/A = 2.5

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: USACE-W1

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

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-.5"	10YR 3/2						SL	A
.5-9.5"	2.5YR 4/8	50					SiC	Water Present
	10YR 3/1	50					SiC	
9.5-20"	10YR 3/2						SiC	

[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)
- X 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)
- X 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** X **No** ___

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Q.-River City/County: West Boylston Sampling Date: 6/29/15

Applicant/Owner: DEP State: MA Sampling Point: USACE-U2

Investigator(s): Pete Shea Section, Township, Range: n

Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): Concave Slope (%): 5

Subregion (LRR or MLRA): NE Lat: 42°33'10.35N Long: 71°48'15.01 Datum: NAD83

Soil Map Unit Name: Merrimac FSL NWI classification: None

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

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X 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 X	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	If yes, optional Wetland Site ID: _____
Wetland Hydrology Present?	Yes _____	No X	

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

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)

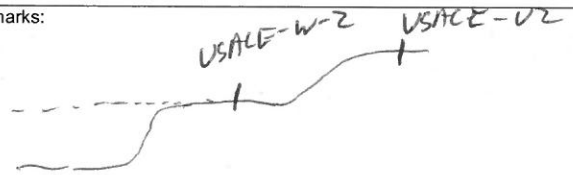
Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes X	No _____	Depth (inches): 26"
Saturation Present? (includes capillary fringe)	Yes X	No _____	Depth (inches): 24"

Wetland Hydrology Present? Yes _____ No X

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

Remarks:



VEGETATION – Use scientific names of plants.

Sampling Point: VMCE-W2

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. ACER Rubrum	10	N	FAC
2. Carpinus Caroliniana	40	Y	FAC
3.			
4.			
5.			
6.			
7.			
	50 = Total Cover		

Sapling/Shrub Stratum (Plot size: 15)			
1. ACER Rubrum	5	N	FAC
2.			
3.			
4.			
5.			
6.			
7.			
	5 = Total Cover		

Herb Stratum (Plot size: 5)			
1. Osmunda Claytoniana	10	N	FAC
2. Euthamia Graminifolia	5	N	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	15 = Total Cover		

Woody Vine Stratum (Plot size: 15)			
1. Toxicodendron Radicans	15	Y	FAC
2.			
3.			
4.			
	15 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

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

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 = 0
FACW species		x 2 = 0
FAC species	6	x 3 = 18
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	6 (A)	18 (B)

Prevalence Index = B/A = 3.0,33

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: USACE-U2

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

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-.4"	10YR 3/2						FSL	A
.4"-24"	7.5YR 4/4						SiClay	BW

[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** X

Remarks:

WETLAND DETERMINATION DATA FORM – Northcentral and Northeast Region

Project/Site: Q-River City/County: West Boylston Sampling Date: 6/29/15

Applicant/Owner: DEP State: MA Sampling Point: USACE-W2

Investigator(s): Peter Sh Section, Township, Range: _____

Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): Hummocky Slope (%): 0

Subregion (LRR or MLRA): NE Lat: 42°41'33.13.5 Long: 71°49'15.1 Datum: NAD83

Soil Map Unit Name: Merrimack FSL NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X 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 X	No _____
Hydric Soil Present?	Yes X	No _____
Wetland Hydrology Present?	Yes X	No _____

Is the Sampled Area within a Wetland? Yes X No _____

If yes, optional Wetland Site ID: _____

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

HYDROLOGY

Wetland Hydrology Indicators:

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

- X Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- X 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)
- X 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)
- X 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 X	No _____	Depth (inches): 0
Water Table Present?	Yes X	No _____	Depth (inches): 2"
Saturation Present? (includes capillary fringe)	Yes X	No _____	Depth (inches): 0"

Wetland Hydrology Present? Yes X No _____

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

Remarks:

VEGETATION – Use scientific names of plants.

Sampling Point: USACE-Plot W-2

Tree Stratum (Plot size: 30)	Absolute % Cover	Dominant Species?	Indicator Status
1. None	0		
2.			
3.			
4.			
5.			
6.			
7.			
	= Total Cover		

Sapling/Shrub Stratum (Plot size: 15)			
1. Acer Rebrum	10	N	FAC
2.			
3.			
4.			
5.			
6.			
7.			
	10 = Total Cover		

Herb Stratum (Plot size: 5)			
1. Onoclea Sensibilis	35	Y	FACW
2. Osmunda Cinnamomea	10	N	FACW
3. Impatiens Capensis	5	N	FACW
4. Arisaema triphyllum	5	N	FACW
5. Carex Stricta	15	Y	OBL
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	55 = Total Cover		

Woody Vine Stratum (Plot size: 15)			
1. None			
2.			
3.			
4.			
	= 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: 2 (B)

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

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	1	x 1 = 1
FACW species	4	x 2 = 8
FAC species	1	x 3 = 3
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	6 (A)	12 (B)

Prevalence Index = B/A = 2.0

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: VSMCE-W2

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

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-,4"	10YR 3/2						SiC	BW
.4-10"	2.5YR 4/8	40					SiC	BG
	10YR 3/1	60					SiC	BG
10-20"	10YR 3/2						SiC	C

[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:

APPENDIX E

HISTORICAL AND ARCHAEOLOGICAL RESOURCES CORRESPONDENCE

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

MASSACHUSETTS WATER RESOURCES AUTHORITY

Charlestown Navy Yard
100 First Avenue, Building 39
Boston, MA 02129

Frederick A. Laskey
Executive Director

Telephone: (617) 242-6000
Fax: (617) 788-4899
TTY: (617) 788-4971

October 6, 2020

Brona Simon, Executive Director
Massachusetts Historical Commission
22 Morrissey Boulevard
Boston, MA 02125

Subject: Quinapoxet Dam Removal Project, West Boylston, MA

Dear Ms. Simon:

Pursuant to M.G.L. Ch. 9. ss. 26 and 27, the Massachusetts Water Resources Authority (MWRA) in consultation with the Department of Conservation and Recreation (DCR) and the Department of Fish and Game Division of Ecological Resources (DER) would like to notify the Massachusetts Historical Commission (MHC) of plans to consider the controlled removal of the Quinapoxet Dam on the Quinapoxet River in West Boylston. Goals of the Project include restoration of free passage of fish and wildlife, naturalization of the riverine hydrology, sediment management and protection of water supply.

As explained in the attached Project Notification Form (PNF), the Quinapoxet Dam is listed on the National Register of Historic Places as an Inventoried Property (WBY.905) and is adjacent to The Quabbin Aqueduct Outlet Chamber (WBY.907), which is also listed as an Inventoried Property. Additionally, the Dam is located within and adjacent to two Inventoried Areas (WBY.G and WBY.C)

MWRA is working with AHS Inc., which has identified the Project's Area of Potential Effect (APE) to be within an area of both pre-colonial and historic period archeological sensitivity. To supplement this PNF, PAL will also be submitting an application to conduct an archeological field investigation on behalf of MWRA for the Project.

On behalf of MWRA, thank you for the opportunity to submit this PNF. Please do not hesitate to contact me at 1 (617) 788-4958 with any questions or concerns.

Sincerely,

Beth Card
Director
Environmental and Regulatory Affairs

cc: David Leslie, AHS
John Gregoire, MWRA

APPENDIX A
MASSACHUSETTS HISTORICAL COMMISSION
220 MORRISSEY BOULEVARD
BOSTON, MASS. 02125
617-727-8470, FAX: 617-727-5128

PROJECT NOTIFICATION FORM

Project Name: Quinapoxet Dam Removal Project

Location / Address: Quinapoxet River

City / Town: West Boyston, MA

Project Proponent

Name: Massachusetts Water Resource Authority (MWRA)

Address: 100 First Ave

City/Town/Zip/Telephone: Charlestown, MWRA, 02129

Agency license or funding for the project (list all licenses, permits, approvals, grants or other entitlements being sought from state and federal agencies).

Note: Both State and Federal funding sources are anticipated; to be identified though future grant applications.

Agency Name	Type of License or funding (specify)
MA DEP	401 Water Quality Certification and Chapter 91 Dredge Permit
MA DCR ODS	Chapter 253 Dam Alteration Permit
West Boylston Conservation Commission	Notice of Intent – for Ecological Restoration Project
US Army Corps of Engineers	Section 404 Permit

Project Description (narrative):

The goals of the project include restoration of free passage of fish and wildlife, naturalization of riverine hydrology, sediment management, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without causing impact to MWRA and DCR water supply mission, the operations of the Quabbin Interflow Shaft #1, or the downstream Wachusett Reservoir.

Does the project include demolition? If so, specify nature of demolition and describe the building(s) which are proposed for demolition.

This project will involve the controlled removal of the 1905 Quinapoxet Dam spillway. The dam is listed on the MA DCR inventory of dams as "Quinapoxet Accretion Dam" (MA#02523). Its MA ODS rating is non-jurisdictional.

Does the project include rehabilitation of any existing buildings? If so, specify nature of rehabilitation and describe the building(s) which are proposed for rehabilitation.

No buildings will be rehabilitated as part of this project.

Does the project include new construction? If so, describe (attach plans and elevations if necessary).

No new construction is proposed for this project.

APPENDIX A (continued)

To the best of your knowledge, are any historic or archaeological properties known to exist within the project's area of potential impact? If so, specify.

The project area lies within an area of both pre-colonial and historic-period archaeological sensitivity.* The dam (WBY.905) is in WBY.G and adjacent to WBY.C. Quabbin Aqueduct Outlet Chamber (Shaft #1) (WBY.907) is adjacent to the dam. About 400 feet upstream of the dam are un-inventoried stone bridge abutments.

What is the total acreage of the project area?

Woodland	acres	Productive Resources:	
Wetland 3.83	acres	Agriculture	acres
Floodplain	acres	Forestry	acres
Open space 3.98	acres	Mining/Extraction	acres
Developed 1.05	acres	Total Project Acreage	acres

What is the acreage of the proposed new construction? Area of disturbance is 8.86 acres acres

What is the present land use of the project area?

The area is overseen by the MA Department of Conservation and Recreation. Within the project area, the Quabbin Aqueduct Outlet Chamber (Shaft #1) serves as the Oakdale power station, transferring water from Quabbin Reservoir to the Wachusett Reservoir and generating hydropower. The water-related structures and facilities are under the jurisdiction of MWRA.

Please attach a copy of the section of the USGS quadrangle map which clearly marks the project location.

Please see attached map.

This Project Notification Form has been submitted to the MHC in compliance with 950 CMR 71.00.

*Historic maps suggest that the APE may have been developed for industrial activities during the historical period, although portions of the APE were undoubtedly disturbed by the construction of the dam and associated structures. Based on regional models of Native American land use, undisturbed portions of the proposed project area (a well-drained terrace adjacent to a large river) have the potential to contain Native American archaeological materials. The most likely site types for this area include large, semi-permanent village or camp sites related to seasonal inland resource extraction activities. Historic maps indicate that the project area may have potential to contain historical-period archaeological materials related to the 19th century industrial activity.

Signature of Person submitting this form _____ Date: 10/6/2020

Name: Bethany Card

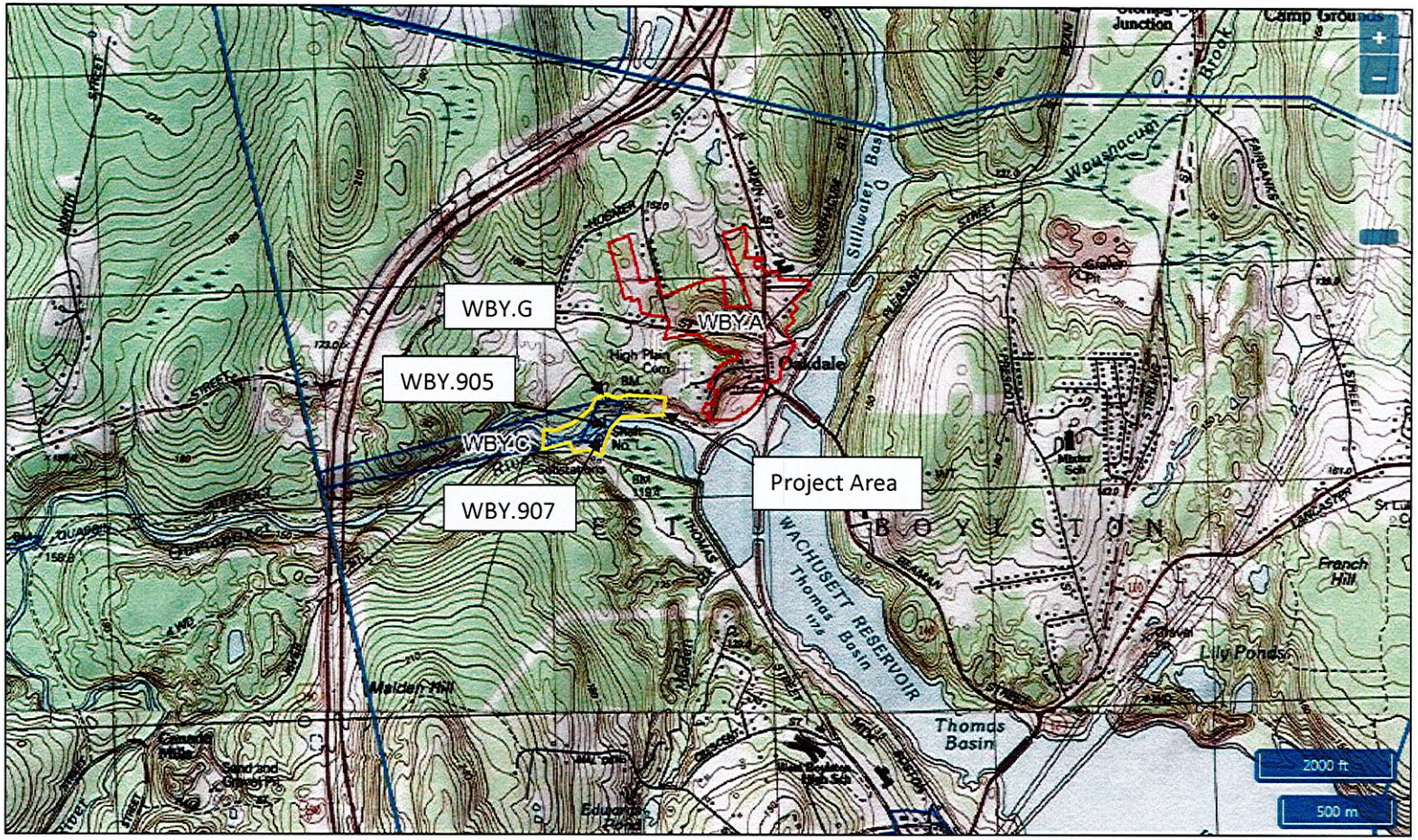
Address: 100 First Ave

City/Town/Zip: Charlestown, MA, 02129

Telephone: Office: 617-788-4958 Cell: 857-320-0908

REGULATORY AUTHORITY

950 CMR 71.00: M.G.L. c. 9, §§ 26-27C as amended by St. 1988, c. 254.



USGS map displaying project area (yellow) and National Register-listed (red) and State Register-listed (blue) districts within the project vicinity.

APPENDIX F

PHOTOGRAPHIC LOG

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

Appendix A – Photo Log

QUINAPOXET DAM REMOVAL PROJECT
QUINAPOXET RIVER
WEST BOYLSTON, MA

MAY 10, 2016
MMI #2688-37

PHOTOS TAKEN BETWEEN APRIL 27 and MAY 2, 2016

Figure 1: NEBC Diedrich D50 drilling rig on trailer.

Figure 2: Looking North at NEBC Diedrich D50 rig in the Quinapoxet River set up on boring B4 with oil boom around right.

Figure 3: Looking upstream at NEBC Diedrich D50 rig set up on B4 with oil boom and silt curtain deployed downstream of set up, turbidity plume is visible on left side of the picture.

Figure 4: Looking downstream of the Quinapoxet dam approximately some turbidity is visible in the rapids immediately downstream of the spillway.

Figure 5: Looking upstream at the rig (currently off) set up on B4, oil boom and two silt curtains have been deployed.

Figure 6: Looking upstream at the rig set up on B3 with oil boom and silt curtain deployed downstream of set up, turbidity plume is visible in the center of the picture.

Figure 7: Looking downstream at the rig set up on B1 with oil boom, silt curtain deployed downstream of set up, and 1 silt curtain deployed upstream of the set up to divert water around rig.

Figure 8: Looking downstream at the rig set up on B5 with oil boom and silt curtain deployed downstream of set up.

Figure 9: Looking downstream at the rig set up on B5 with oil boom and silt curtain deployed downstream of set up, turbidity plume is visible in the center of the picture and left of the rig.

Figure 10: Looking north at the existing berm protecting MWRA structures, visible in the center of the photo is limited disturbance to the grass by terramats used by NEBC.

APPENDIX G

EXPANDED ENVIRONMENTAL NOTIFICATION FORM CIRCULATION LIST

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

Quinapoxet Dam Removal Project

Expanded ENF Distribution List

Secretary Kathleen A. Theoharides Executive Office of Energy and Environmental Affairs Attn: MEPA Office 100 Cambridge Street, Suite 900 Boston, MA 02114 MEPA@mass.gov
Department of Environmental Protection Commissioner's Office One Winter Street Boston, MA 02108 helena.boccadoro@mass.gov
Department of Environmental Protection Central Regional Office Attention: MEPA Coordinator 8 New Bond Street Worcester, MA 01606 Andrea.briggs@mass.gov
Massachusetts Department of Transportation (DOT) Public/Private Development Unit 10 Park Plaza, Suite #4150 Boston, MA 02116-3969 MassDOTPPDU@dot.state.ma.us
MassDOT - District #3 Attention: MEPA Coordinator 499 Plantation Parkway Worcester, MA 01605 Jeffrey.r.gomes@dot.state.ma.us
Massachusetts Historical Commission The MA Archives Building 220 Morrissey Boulevard Boston, MA 02125
Massachusetts Board of Underwater Archaeological Resources Attn: David Robinson 251 Causeway Street – Suite 800 Boston, MA 02114-2136 david.s.robinson@mass.gov
Central Massachusetts Regional Planning Commission Attn: Trish Settles, AICP, Deputy Director One Mercantile Street, Suite 520 Worcester, MA 01608 tsettles@cmrpc.org

West Boylston Select Board Attn: Nancy Lucier 140 Worcester Street Worcester, MA 01583 nlucier@westboylston-ma.gov
West Boylston Planning Board Attn: Melanie Rich 140 Worcester Street West Boylston, MA 01583 planningboard@westboylston-ma.gov
West Boylston Conservation Commission Attn: Toby Goldstein 140 Worcester Street West Boylston, MA 01583 tgoldstein@westboylston-ma.gov
West Boylston Board of Health Attn: Margaret Lee 140 Worcester Street West Boylston, MA 01583 MLee@westboylston-ma.gov
West Boylston Historical Commission Attn: Nancy Barakian 140 Worcester Street West Boylston, MA 01583 historical.society@wbhistory.org
Department of Conservation & Recreation Office of Dam Safety Attn: Nat Tipton, MEPA Coordinator, and David Ouellette 180 Beaman Street West Boylston MA 01583 nathaniel.tipton@state.ma.us david.ouellette@state.ma.us
Massachusetts Water Resource Authority Attn: MEPA Coordinator 100 First Avenue Charlestown Navy Yard Boston, MA 02129 katherine.ronan@mwra.com

Quinapoxet Dam Removal Project

Expanded ENF Distribution List

Wampanoag Tribe of Gay Head (Aquinnah)
Attn: Bret Streans, Natural Resources Director, and Lee Anne Wander, Chief of Staff
20 Black Brook Road
Aquinnah, MA 02535-1545
isa@wampanoagtribe-nsn.gov
cos@wampanoagtribe.net

Mashpee Wampanoag Tribe
Attn: Chuckie Green, Natural Resources Director
483 Great Neck Road South
Mashpee, MA 02649
chuckie.green@mwtribe-NSN.gov

APPENDIX H

SEDIMENT MANAGEMENT PLAN

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

QUINAPOXET DAM REMOVAL

Sediment Management Plan

Prepared for:

Massachusetts Water Resources Authority

May 2021

global **environmental** and **advisory** solutions

SLR

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Appendix C Quinapoxet Dam Removal: Basis of Design Report
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ACRONYMS

BMP	Best Management Practice
CAP	Corrective Action Plan
CFS	Cubic Feet per Second
CY	Cubic Yard
DCR	Massachusetts Department of Conservation and Recreation
E&S	Erosion and Sediment
EPA	Environmental Protection Agency
HDPE	high density polyethylene
ISO	International Organization for Standardization
MA DEP	Massachusetts Department of Environmental Protection
MADER	Massachusetts Division of Ecological Restoration
MCP	Massachusetts Contingency Plan
MMI	Milone & MacBroom, Inc.
MWRA	Massachusetts Water Resources Authority
ND	not detected
NTU	nephelometric turbidity units
QAQC	quality assurance and quality control
QA	quality assurance
QC	quality control
SLR	SLR International Corporation
SMP	Sediment Management Plan
TMP	Turbidity Monitoring Plan
USGS	United States Geological Survey

1. INTRODUCTION

This Sediment Management Plan (SMP) has been developed by SLR International Corporation (SLR) in support of the Quinapoxet Dam Removal Project. This project is a collaboration between the Massachusetts Water Resources Authority (MWRA), the Massachusetts Department of Conservation and Recreation (DCR), and the Massachusetts Division of Ecological Restoration (MADER) to remove aging infrastructure and achieve restoration and naturalization of the associated riverine basin.

1.1 PURPOSE

This SMP seeks to protect MWRA's critical water supply infrastructure adjacent to and downstream of the project site during and following construction activities. The purpose of this SMP is to identify sediment and erosion control mitigation measures and features of the designed channel that will protect the water quality of the downstream Wachusett Reservoir, a drinking water reservoir for the Greater Boston Metropolitan Area.

A detailed management and monitoring plan is required to assure flow velocities during construction and within the restored river reach will not cause downstream turbidity releases or erosive damage to the adjacent water supply infrastructure. It is of the utmost importance to MWRA to assure that the water quality in the Wachusett Reservoir will not be compromised as part of this project. This goal will be achieved through the implementation of a comprehensive erosion and sediment control plan and a Turbidity Monitoring Plan (TMP).

1.2 OBJECTIVES

The objectives of this SMP are to:

- Summarize the project goals and known existing conditions;
- Identify the importance of protecting MWRA's water supply infrastructure;
- Describe the construction phasing and water control plan;
- Describe the sediment and erosion control management practices;
- Outline the comprehensive TMP; and
- Address long-term sediment management.

2. BACKGROUND

The MWRA has retained SLR to design, permit, and assist in the construction of a dam removal project for the Quinapoxet Dam in West Boylston, Massachusetts. The dam is located on the Quinapoxet River, upstream of the Wachusett Reservoir as shown in Figure 1.

2.1 PROJECT OVERVIEW

Aside from removing the dam that is no longer in use, the goals of the project include the restoration of free passage of fish and wildlife, naturalization of riverine hydrology, management of sediment during and after construction, and protection of water quality. These goals are to be met by removing the dam and modifying the channel without impacting the MWRA and DCR water supply mission, the operations of the Quabbin Interflow Shaft #1, or the downstream Wachusett Reservoir.

The DCR Oakdale Power Station and Quabbin Aqueduct outlet channel are located immediately behind the earthen embankment of the dam and discharge to the Quinapoxet River below the dam. The Quabbin Aqueduct transfers water from Quabbin Reservoir to Wachusett Reservoir and is part of the water supply infrastructure for the city of Boston.

Figure 1 Quinapoxet Dam Removal Location Map

2.2 BACKGROUND DATA

2.2.1 FEASIBILITY STUDY

A substantial amount of data collection and preliminary analysis was performed in 2016 as part of a feasibility study conducted by SLR, previously Milone & MacBroom, Inc. (MMI), to determine if removal of the dam will meet the stated project goals (MMI, 2016). MMI was retained by the MADER to conduct the feasibility study and provide conceptual-level hydraulic modeling for the removal of the Quinapoxet Dam. The 2016 Feasibility Study is included in Appendix B.

2.2.2 SEDIMENT ANALYSES

Despite the purpose of dam removal projects to restore free-flowing streams and provide long-term improvements in water quality and ecological conditions, there is potential for short-term impacts on water quality and designated uses during or after dam removal (EPA, 2016). There is potential for sediment that was stored behind the dam to be released during the dam removal, causing potential damages to aquatic life and impairment of water quality. To mitigate this and understand the volume and quality of sediment behind the dam, analyses of the impounded sediment were performed.

2.2.2.1 Impounded Sediment Quality

As part of the 2016 Feasibility Study, chemical analyses of sediment were performed at five locations behind the dam, three in the river and two in adjacent overbank areas. The sediment analyses were performed on both the native (predam) substrate as well as the impounded sediment. The sediment was analyzed according to the Massachusetts Department of Environmental Protection (MA DEP) criteria associated with the management of dredged material. These criteria are specified in the 401 Water Quality Certification Regulations and are codified at 314 CMR 9.07. This regulation, together with a December 2007 guidance document published by the MA DEP entitled "Dam Removal and the Wetland Regulations," incorporate by reference certain provisions of the Massachusetts Contingency Plan (MCP) (310 CMR 40).

All of the chemical analyses results were "not detected" (ND) and/or were less than the MCP Reportable Concentrations or any ecological effects thresholds. In general, all chemical concentrations were ND, and the noted concentrations of metals were at levels that are considered indicative of natural background concentrations. The sampling indicated that submerged sediments can be expected to comply with the limits established by the MCP for contaminated soils once the Quinapoxet Dam is removed and the sediments are exposed. Contaminant levels, or the lack thereof, appeared consistent upstream, within, and downstream of the impoundment.

Based on this analysis it is assumed that the sediments will not require special handling or provisions to limit exposure. Onsite and offsite reuse appears to be possible. Similarly, the soils in the upland area to the north of the impoundment appear to be absent of anthropogenic contaminants and representative of naturally occurring soil. Construction can be initiated without the need for additional sampling or special disposal criteria.

2.2.2.2 Impounded Sediment Reuse and Disposal

The existing channel upstream of the Quinapoxet Dam does not contain an impoundment with accumulated sediment like typical dams due to its construction type. This was explained in further detail in the 2016 Feasibility Study. However, a relatively small layer of accumulated sediment where the bed has aggraded slightly appears to have settled upstream of the dam. Additionally, removal of the dam will require excavation of native material to construct the proposed channel as filling in the downstream is not feasible due to the adjacent Quabbin Interconnect.

Uncontrolled sediment releases are not permissible as the eroded sediment would begin filling the downstream reservoir. Similarly, stabilizing the sediment in place would not allow for a sloped channel to be constructed to overcome the 9-foot drop held in place by the existing dam. Relocation of the sediment to the banks and floodplain is possible for a portion of the impounded sediment, but the problem of armoring the sediment from future mobility adds significant cost and complication. The recommended approach is to transport the sediment off site and dispose of it in a non-flood-prone location. Site inspections and sediment testing reveal minimal silt and clay; therefore, a limited total volume of sediment exists that can likely be reused on site or off site.

2.2.3 SITE HYDROLOGY AND HYDRAULICS

As part of the project design, detailed hydrologic and hydraulic analyses of flood flows and low flows at the project site were conducted. The 2020 Basis of Design Report developed by SLR describes the methodology used to determine historical and predicted flows at the project site and will not be repeated in this report. The 2020 Basis of Design Report is included in Appendix C.

The flow rates at the project site are critical to the design and implementation of the water control plan and management of sediment and turbidity in the vicinity of the project site both during and after construction. Site hydrology, watershed characteristics, and runoff velocity and concentration are major factors that influence the potential for erosion (MA DEP, 2003). Additionally, in-channel flow rates, velocities, and shear stresses substantially affect channel and floodplain erosion, especially during construction when surfaces are unvegetated and unprotected. Knowing the predicted flow rates at the project site can better prepare the contactor to prevent erosion and manage sedimentation. Table 1 provides a summary of typical monthly flows at the project site, and Table 2 provides a summary of estimated peak flood discharge rates.

Table 1 Summary of Low Flows at Project Site

Month	20th-Percentile Duration Flow (cfs)	Mean Monthly Discharge Flow (cfs)	80th-Percentile Duration Flow (cfs)
January	28	84	125
February	36	89	127
March	67	161	224
April	82	189	257
May	48	99	134
June	24	76	108
July	9	30	42
August	6	20	26
September	4	20	22
October	7	37	53
November	12	57	88
December	18	95	158

Notes: Shaded cells represent anticipated construction window.
cfs = cubic feet per second

Table 2 Summary of High Flows at Project Site

Flood Recurrence Interval	Flow Rate (cfs)
100-Year Flood	3,000
10-Year Flood	1,800
5-Year Flood	1,500
Bankfull Flood	830

2.3 WATER QUALITY IMPACTS

Because the Quinapoxet River feeds the Wachusett Reservoir, a drinking water reservoir for the Greater Boston Metropolitan Area, water quality is of the utmost importance.

Suspended sediment in a water body is a primary indicator of overall water quality. Furthermore, turbidity is used as a surrogate measurement for quantifying entrained sediment. Turbidity is an optical measurement that indirectly measures the particle density in the water and can be an indication of total suspended solids. Critical to monitoring of water quality at the project site and maintaining pristine water conditions in the downstream Wachusett Reservoir, turbidity readings can measure the approximate levels of sediment suspension and likelihood of released contaminants in real time (Fondriest, 2020).

The sediment and erosion control measures and TMP outlined in this report will help pre-emptively manage and mitigate water quality impacts to the downstream drinking water source.

2.3.1 BACKGROUND TURBIDITY DATA

Background turbidity data downstream of the project site at permanent monitoring locations has been provided by MWRA and DCR and is provided in Appendix A. Two MRWA turbidity monitoring locations were provided: one at the Route 12 Causeway and the other at the Cosgrove Intake. The Route 12 Causeway monitoring location is located within the Quinapoxet River prior to entering the Wachusett Reservoir (Figure 1), approximately 1.8 miles downstream of the project site. The monitoring location at the Cosgrove Intake is located at the downstream end of the Wachusett Reservoir, approximately 7.6 miles downstream of the project site.

Turbidity data at the Route 12 Causeway was provided for a period of 1 year (2020-2021) at intervals of 2.5 minutes. At this location, the average turbidity was .67 nephelometric turbidity units (NTU), with a maximum recorded reading of 9.87 NTU and 99 percent of readings below 3.33 NTU. At the Cosgrove Intake, turbidity readings were provided for a 5-year period (2016 to 2021) at 15-minute intervals, reporting an average reading of 0.35 NTU, a maximum of 6.0 NTU, and 99 percent of readings below 0.84 NTU.

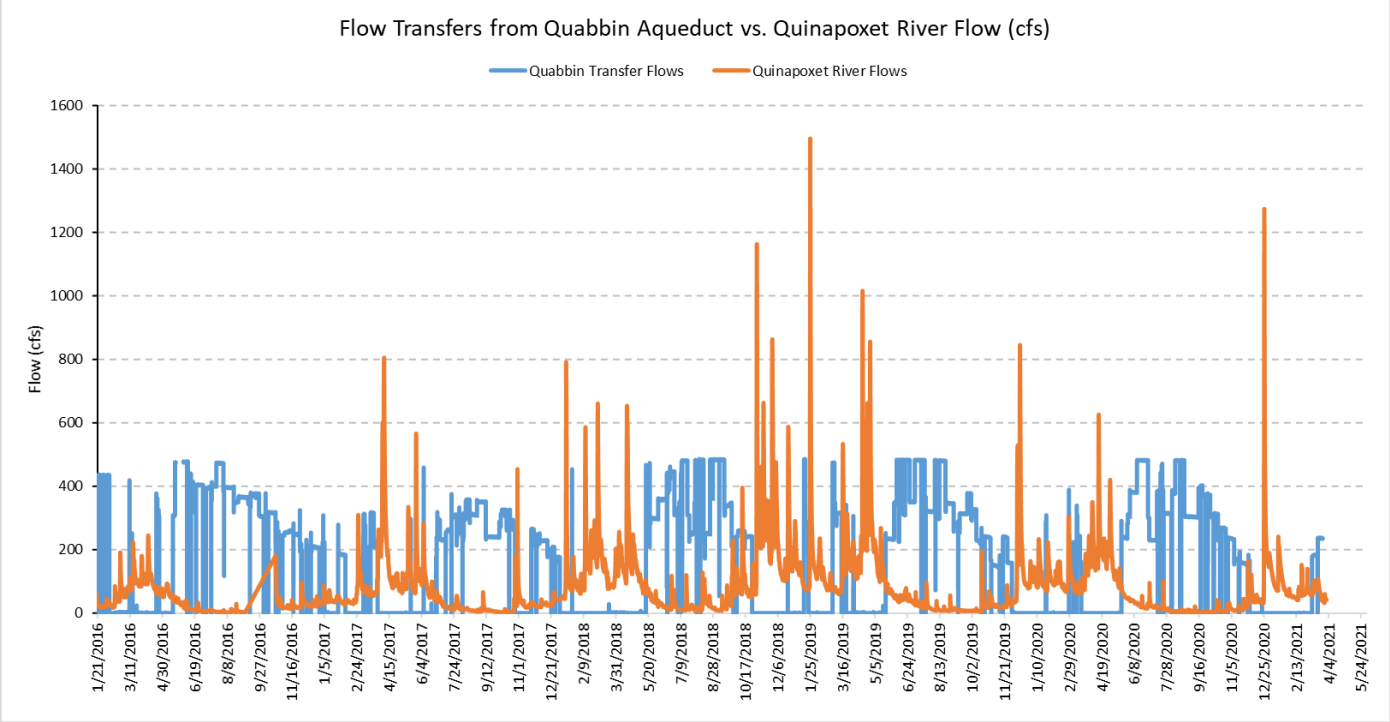
As confirmed by the data, the turbidity at the Cosgrove Intake is expected to be lower than that at the Route 12 Causeway due to the location downstream within a much larger body of water where sediment has already partially settled. The existing turbidity data provides a background of what is expected at these permanent monitoring locations. This turbidity data was also used to inform the turbidity monitoring thresholds at the project site that will be presented later in this report.

2.3.2 QUABBIN RESERVOIR TRANSFERS

The Quabbin Aqueduct is used to transfer water from MWRA's Quabbin Reservoir to the Wachusett Reservoir, eventually feeding the City of Boston's drinking water supply. Transfers from Quabbin Reservoir may occur any time of the year but are typically continuous from May to October for water quality reasons. After passing through a hydroelectric turbine, or a bypass when the turbine is not operational, water is discharged to an outlet channel that joins the Quinapoxet River approximately 100 feet downstream of the dam. The juxtaposition of the dam and Oakdale Station and the proximity of Wachusett Reservoir present practical challenges for this project. The design and water control must consider MWRA operational practices, including the transfer of water from Quabbin to Wachusett Reservoir, which can discharge flows as high as 560 cubic feet per second (cfs).

MWRA and DCR provided data on the flow transfers from Quabbin Aqueduct within a 5-year period (2016 to 2021) at 15-minute intervals. During periods of flow transfer, the average flow rate was reported as 167 cfs, the maximum flow rate was 486 cfs, and the 80th percentile flow was 330 cfs. Under normal low-flow conditions, the flow from the Quabbin Aqueduct transfers exceeds the flow in the Quinapoxet River, in which the 80th percentile flows range between 42 to 257 cfs (Table 1). The expected flow rates and mixing at the confluence of the Quinapoxet River and Quabbin Aqueduct were used to inform the turbidity monitoring thresholds that will be presented in this report. Figure 2 presents the

Quabbin transfer flows from 2016 to 2021, with the flows in the Quinapoxet River over the same time period plotted for comparison.



Note: Quinapoxet River flows represent the flow rates recorded at United States Geological Survey (USGS) Gauge 01095375 in the Quinapoxet River, transferred to the project drainage area per the methodology described in the Preliminary Design Report.

Figure 2 Quinapoxet River Flows vs. Quabbin Transfer Flows (2016 to 2021)

2.4 REGULATORY CONTEXT

Applicable local, state, and federal regulations for the project work were reviewed, and all pertinent permits will be obtained prior to the start of work. The SMP and TMP will comply with all regulatory requirements and issued permits. Due to the sensitive nature of the downstream water body, this SMP dictates more stringent sediment control and turbidity monitoring than is required by the issued permits.

3. CONSTRUCTION PHASING AND WATER CONTROL PLAN

The water control plan has been carefully considered prior to construction such that both low-flow and high-flow situations can be controlled without allowing turbidity releases downstream into the Wachusett Reservoir. The contractor will be required to take extra precautions before, during, and after construction to effectively mitigate the risk of untreated sediment-laden stormwater runoff from flowing into the downstream receiving waters or of any turbid waters from the construction site leaving the controlled area and discharging downstream.

The construction and water control plan laid out in this SMP and on the design plans is the recommended procedure to manage flows during construction. The final water control plan submitted by the contractor will need to be approved and carefully reviewed prior to construction, such that all manner of flow situations can be accounted for and dealt with quickly, without causing a turbidity release into the Wachusett Reservoir that could impact water supply operations.

3.1 CONSTRUCTION TIMING

Deconstruction and removal of the dam and restoration of the channel are anticipated to take approximately 4 months. Typically, the construction window for riverine projects will be limited to the months of June, July, August, and September due to lower flow conditions and fish migration concerns. For this project, the outflow from Quabbin Inflow Shaft No. 1 will dictate the construction window. The Quabbin Aqueduct is opened for water supply reasons from May to October, which transfers water from the Quabbin Reservoir to the Wachusett Reservoir, which means flows at the downstream end of the project will be elevated, and water quality will be a primary concern. The period of May through October is a firm operational period when no construction can take place. Construction is aimed to occur between October 2022 and May 2023. Should a transfer be required during active construction, extra care must be taken to ensure that transfers from Quabbin Reservoir are unimpeded, addressed through the appropriate sizing of temporary infrastructure to convey expected flows and the protection of sensitive areas.

3.2 CONSTRUCTION PHASING

The design plans have been prepared with three phases of bypass water control to divert the flow of the Quinapoxet River around the active work area, depending upon the construction activities taking place during that time. It is important to note that all work will be required to occur in dry conditions, which will limit sedimentation and turbidity levels. Construction route locations will be finalized with MWRA prior to start of construction but are preliminarily depicted on the design plans. One access is proposed to allow construction equipment to access the area upstream of the dam, which will use existing lawn and paved areas on MWRA property. A second construction access is proposed downstream of the dam, utilizing an existing pedestrian walking path. Temporary construction access roads, staging, and stockpile areas will be limited to MWRA-owned property or roadway rights-of-way, as depicted on the design plans.

3.2.1 PHASE 1

The first construction phase involves the coffer damming of low flows around the southern portion of the dam. The removal of a portion of the dam shall be completed once the work area is isolated from active flow in the Quinapoxet River and fully dewatered. Removal of this portion of the dam will provide space for a passive, gravity bypass of the Quinapoxet River to be installed in Phase 2.

3.2.2 PHASE 2

The second phase involves coffer damming and diverting water through gravity-fed bypass pipes around the work area, with smaller sumps and groundwater pumps installed throughout the work site as needed to maintain completely dry conditions. Phase 2 will also require a culvert crossing under the temporary construction road to allow access to the work area while maintaining flow from the Quabbin Aqueduct, as needed. Disassembling of the remaining dam, fish ladder, and appurtenances; removal of existing islands; and construction of the new channel can be completed in dry conditions during the second phase of construction. Once the main channel is complete, water can be transitioned into the reconstructed riverbed, as will be described in Section 4.2.

3.2.3 PHASE 3

The third phase of water control will require temporary diversion of any flow from the Oakdale Power Station outlet channel to maintain completely dry conditions. As soon as the exit channel is fully dewatered, installation of fish-deterrent features on the side channel can be performed. All discharges from temporary bypass pipes shall end in a plunge pool designed to provide a soft landing for out-migrating fish. Once the channel is complete, floodplain work outside the wetted portion of the channel can be constructed.

3.3 LOW-FLOW WATER CONTROL

Low-flow water control considers all flows less than or equal to the bankfull flow rate, as outlined in Table 2 and provided on the design plans. Low-flow control will be of primary importance for Phase 2, in which the main portion of the channel will be under construction and the flow bypass will occur via passive, gravity flow around the work area. During Phases 1 and 3, low flows conveyed through the main channel have access to the majority of the existing or constructed channel and floodplain.

3.3.1 FLOW BYPASS SYSTEM

Under low-flow conditions, it is recommended that two temporary bypass pipes be installed to divert the active flow of the Quinapoxet River around the dewatered construction site, with cofferdams at the upstream and downstream ends of construction to fully isolate the work area. The gravity bypass pipes are shown on the plans schematically, but the final location should be laid out in the contractor's approved Erosion and Sediment Control Plan. This setup should be sized to accommodate as much flow as economically feasible up to the bankfull flow but at a minimum should be able to pass 500 cfs. Pumping should not be used for low-flow bypass. The bypass pipes should be released to a clean water splash pad, as detailed on the plans, to prevent scour of the downstream streambed.

3.4 HIGH-FLOW WATER CONTROL (FLOOD CONTINGENCY PLAN)

The project site is located within the 1% annual chance floodplain zone and is subject to flooding. If a significant precipitation event is forecast to occur during the construction period and flows are elevated above that which the low-flow water control is capable of managing, a flood contingency plan should be available and enacted before the precipitation event occurs. This may involve the modification of the cofferdams or the diversion of the anticipated flows to a stable portion of the site, such that the damage to the site is mitigated and downstream turbidity release is kept to a minimum. The contractor will be required to prepare and submit a Flood Contingency Plan prior to construction commencement.

3.4.1 WEATHER TRACKING AND RECOMMENDED MITIGATION MEASURES

Weather reports provided by the National Weather Service shall be diligently monitored on a daily basis. If a significant precipitation event is forecast to occur during the construction period and flows are expected to exceed that which the low-flow bypass is capable of conveying, the contractor shall stop work, remove equipment from the floodplain, and secure the project site as needed to accommodate the elevated flows.

A significant precipitation event shall be defined as more than 1 inch of rainfall predicted within any 24-hour period (50 percent or higher chance) by the National Weather Service. Work shall be halted until precipitation stops and chances of precipitation fall below 50 percent.

3.4.2 FLOOD MITIGATION MEASURES

Equipment and materials must be available on site to allow a rapid response to stabilize disturbed construction areas and to evacuate workers, equipment, and stockpiled material from potentially impacted areas. The specific measures to relocate equipment and materials should be outlined in detail in the contractor's Flood Contingency Plan. The level of action before a predicted flood event should be relative to the volume of predicted precipitation. It is of primary importance that the site is protected during flood events, which pose the most risk to sediment entrainment and turbidity. SLR and MWRA shall approve the contractor's Flood Contingency Plan prior to the start of construction.

Following a flood event, no equipment and materials should be moved back to the site until flood levels have receded to low-flow conditions. In general, work shall be performed during as low water as possible.

3.5 REUSE AND DISPOSAL OF SOIL

Soil and other materials excavated from the project site should be carefully handled within dry work areas to prevent erosion and downstream sedimentation. Under no circumstances shall excavation, grading, and moving of materials occur in the wet. The dry work area shall be designed to allow the proper transport of soil within the work zone, to designated soil stockpile areas, and off site.

Due to the nature of the dam construction and nearby infrastructure, significant volumes of soil will be excavated upstream of the dam. Approximately 3,950 cubic yards (CY) of material will be excavated over the three project phases, about 2,530 of which will be reused on site for proposed design features. The

design considered reuse of soil on site to the maximum extent practicable due to conditions discussed previously. The proposed design limits the amount of soil to be reused on site as it would present more sedimentation risk and would be cost prohibitive to stabilize excess soil to be kept on site. Exporting excess earthworks, approximately 860 CY, will prevent erosion and sedimentation after construction is complete, protecting the water quality of the downstream water bodies.

4. EROSION AND SEDIMENT CONTROL PLAN

Turbidity reduction practices and technologies at construction sites include both erosion controls to minimize entrainment of sediment and structural sediment controls to reduce concentrations of sediment after particles have become entrained. Some of the generalized principles that underly the selection of the most appropriate sediment and erosion control practices are as follows:

- Minimizing the footprint of disturbance and retaining natural vegetation to the extent practical;
- Scheduling construction to minimize soil exposure during the wet season or to limit exposure times overall;
- Promptly stabilizing denuded areas that are not actively being worked;
- Designing site drainage features to minimize the development of concentrated flows;
- Diverting runoff away from steep slopes, highly erosive soils, and sensitive habitat areas;
- Minimizing the steepness and length of cut slopes by using benches, terraces, contour furrows, or diversion ditches;
- Utilizing channel linings or temporary structures in drainage channels to slow discharge velocities and avoid channel downcutting;
- Retaining sediment on site by using sediment trapping devices (e.g., silt fences, basins, traps, etc.) and equipment tracking controls (e.g., stabilized gravel entrances/exits, shaker plates, wheel wash facilities, etc.);
- Regularly maintaining all site controls; and
- Inspecting sites frequently and correcting problems promptly. (Geosyntec, 2012)

The detailed sediment erosion and control plans developed for this project consider methods to best implement and enforce these practices given the high level of water quality required downstream of the project. To achieve low turbidity concentrations, these practices must be strictly adhered to and should be considered at all times by the contractor.

4.1 SEDIMENT AND EROSION CONTROL MEASURES

Erosion and sediment control on site will be managed through the use of approved Best Management Practices (BMPs) from the Massachusetts Erosion and Sediment Control Guidelines (MA DEP, 2003). All vegetative and structural erosion and sediment control practices shall be constructed and maintained according to the standards and specifications in the Massachusetts Erosion and Sediment Control Guidelines and as directed in the design plans and specifications.

The BMPs discussed herein are the minimum to be implemented, and the contractor should employ additional measures to meet the TMP. The erosion and sediment (E&S) control plan was developed to provide redundancy with multiple lines of defense, and the final E&S control plan submitted by the contractor should address all of the above practices.

4.1.1 SITE ACCESS AND UPLAND AREAS

4.1.1.1 Construction Entrance Pads

Construction entrance pads should be utilized as designated on the design plans or at any locations where vehicles enter or exit the project site. The construction entrance should be installed on any unpaved areas and should be the first item of work on the site. Construction entrance pads should be maintained to the specified dimensions and to the capacity to remove sediment from vehicle tires.

4.1.1.2 Temporary Construction Access Roads

Temporary construction access roads should be constructed and maintained according to locations on the plans and details. Proper grading, stabilization, and alignment of the roads will reduce sediment problems on site. If additional access roads are required, thought should be given to the construction and layout of the roads, considering steep slopes, surface waters, soil types, and potential hazards. Access road surfaces should be sloped for drainage (MA DEP, 2003). All temporary construction access roads shall be surrounded with the perimeter controls described below. Roadways shall be inspected weekly and after each runoff event, and damaged roadways shall be repaired immediately. When construction is complete, temporary access roads shall be stabilized, capped, and vegetated according to the details.

4.1.1.3 Temporary Soil Stockpile and Staging

Soil should be stockpiled at the locations designated on the design plans or as approved by the engineer or MWRA. Soil stockpile locations are isolated so that they do not interfere with work on the site and located outside of the floodway. Side slopes of stockpiles should not exceed 3:1, and heights should not exceed 35 feet. When work is not occurring, stockpiles should be stabilized with seed, mulching materials, or clear plastic. The contractor should maintain the protective covering on stockpiles until needed for access.

Areas for staging should be located as shown on the plans or at additional locations approved by the engineer or MWRA. Staging areas should be located at least 50 feet from the 100-year floodplain line. All soil stockpile and staging areas shall be surrounded with the perimeter controls described below.

4.1.1.4 Perimeter Controls

Proper perimeter protection within the work area and upstream areas is essential to prevent sediment from entering the water body. Perimeter protection shall consist of both straw bales and silt fence, placed parallel to each other. Perimeter protection should be placed along all temporary access roads, around all soil stockpile and staging areas, and at the downstream extent of places in the upland work area where there is potential for runoff to enter the riverine basin or leave the site. The design plans show anticipated locations of the perimeter controls, and the contractor should provide final locations on the approved E&S plan and as directed in the field by the engineer or MWRA.

Straw bale barriers are constructed with bales of straw staked in place, according to the detail on the design plans. Tying the bales to stakes with wire will provide additional stability. Permeability through straw bales is less than that of the adjacent silt fences; therefore, straw bales should be placed downstream of the silt fence acting as the second line of defense against sedimentation, as shown on the details. Bales should be placed in a single row lengthwise along a contour, and the ends of the rows should flare upstream. Each bale should be securely anchored with two stakes, and the gaps between bales should be chinked with straw to prevent water and sediment from escaping. Straw barriers should be inspected immediately after each runoff event, and necessary repairs to bales should be accomplished immediately. Sediment deposits along bales should be removed, and bales should be replaced if not functioning as desired.

Silt fences shall be placed according to the locations on the plans and at any locations to prevent sediment from leaving the site and entering the river channel. Silt fences, or sediment fences, are capable of intercepting and detaining small to medium amounts of sediment and reducing runoff velocity down a slope. Silt fences should be placed upstream of straw bales as their low permeability enhances sediment trapping. The fence line should be located at least 10 feet from the toe of slopes, and the fence line should be nearly level to provide sediment storage and access for cleanout. Support posts shall be installed according to the details, and the fence shall be embedded at least 12 inches. The expected life of a silt fence is approximately 6 months, but fences should be inspected and maintained regularly for proper performance. Silt fences should be checked for tears, excess sedimentation, or other signs of overuse and replaced immediately.

4.1.2 IN-STREAM AND FLOODPLAIN DRY WORK AREAS

The primary mechanism of preventing sedimentation during construction is to construct all work in dewatered areas. This section details the water control methods and sediment control methods that will maintain a dry work area during the three phases of construction. Under no circumstances should any work occur in the wet. If the work area becomes inundated or contains a significant amount of ponded water, work must stop and water be removed from the dry work area before proceeding.

4.1.2.1 Lined Cofferdams

Lined cofferdams are recommended as the primary mechanism to keep the channel dry during construction activities. For construction Phases 1 and 3, the lined cofferdams will create a perimeter around the proposed work area, with the main channel being utilized for flow diversion. During Phase 2, the cofferdams will block the main channel, with gravity diversion pipe installed to bypass the main channel flow. The lined cofferdams for each phase should be placed according to the design plans and as approved by SLR and MWRA. Cofferdams should be constructed from sandbags, concrete block barriers, sheet piling, or other nonerosive material but cannot be constructed of earth fill. Cofferdams should be constructed to a height sufficient to retain the flows as depicted on the design plans.

Cofferdams should be lined with an impermeable liner on the upstream side. Both the cofferdam and the liner should be embedded a minimum of 12 inches to prevent seepage into the work area. It is the responsibility of the contractor to implement and maintain the selected method of coffer damming to

keep the work area completely dry. Cofferdams should be inspected daily to check for leakage or subsurface seepage and be repaired or modified as soon as possible to keep the work area dry.

4.1.2.2 Temporary Turbid Water Pump and Settling Basins

If site dewatering within the dry work zone becomes necessary due to leakage or seepage, temporary turbid water sumps, pumps, and settling basins should be used. The temporary sump, water pump, and turbidity settling basin are shown on the plans schematically but should be located and quantified based on the dewatering needs. Sump pits should be located at a low point within the work area and should be sized depending on the amount of water that must be pumped. Turbidity settling basins should be located outside of the active work zone and within a vegetated area to the maximum extent possible. Any pumped water from sumped areas must enter a turbidity settling basin prior to discharging back to surface waters. Sediment settling basins should be sized to handle the amount of water pumped to them and should be used in conjunction with other practices to remove as much sediment as possible.

Within the dry work area, the contractor should locate designated staging areas for the bypass pump and power packs to limit disturbance and maintain a dry area for equipment. The temporary pumping staging areas should also be relocated based on dewatering needs. Temporary turbid water pumps and associated power packs should be maintained according to the details and the manufacturer's recommendations and to meet the TMP standards.

4.1.2.3 Soil Stabilization

Temporary or permanent stabilization should occur as soon as any channels or disturbed areas reach final grade. Cessation of activity for at least 2 days or if precipitation is anticipated requires temporary stabilization. Permanent stabilization via the means shown on the restoration plans should occur as soon as possible, but if permanent stabilization has not yet been achieved, temporary stabilization can occur through surface roughening, vegetative stabilization, or erosion control blankets. Erosion control blankets are the preferred method of temporary stabilization and should be installed on any slopes greater than 3:1 (H:V) according to the details provided and according to the manufacturer's recommendations.

4.1.2.4 Temporary Stream Crossings

A temporary stream crossing will be required during Phase 2 to provide access to the main channel dry work area. The temporary crossing will be under the construction access road across the channel outlet from the Quabbin Aqueduct. The stream crossing does not need to convey the main channel flow but does need to convey the flow anticipated from the Quabbin Aqueduct Shaft #1, which is known to release flows as high as 560 cfs. Although it is not likely that flow transfers will occur during the construction period or be of this magnitude, the temporary stream crossing must be designed to convey a flow of 560 cfs. The recommended design is using four 4-foot-diameter high density polyethylene (HDPE) pipes in parallel sloped at 1 percent as shown on the plans. The schedule of transfers from Quabbin Reservoir should be discussed with MWRA prior to the construction period to see what the scheduled transfers will be.

The temporary stream crossing is shown on the design plans, but the final location should be approved by SLR and MWRA. The minimum width of the stream crossing should be 12 feet and be aligned perpendicular to flow. For a crossing with multiple pipes, the spacing between each pipe should be at least half the pipe diameter. Only clean rock fill may be used around the pipes and on the roadway surface. Construction entrance pads shall be used at the entrance and exit of the stream crossing to avoid mud falling into the water. Suitable outlet protection, such as a temporary clean water splash pad, should be used to prevent scour at the pipe outlet. The temporary crossing should be designed to be structurally stable and to withstand and safely convey the transfer flows from Quabbin Aqueduct.

4.1.3 DOWNSTREAM MANAGEMENT

As a last line of defense against any sediment leaving the work site during construction, two rows of turbidity curtains should be installed downstream of the work area. Turbidity curtains should be installed perpendicularly to the river, at least 50 feet downstream of the downstreammost cofferdam and any limit of work from the three phases of construction. Turbidity curtains shall be installed in an area of impounded or slow-moving water. The turbidity curtains should be the first E&S measures installed before any work begins. The curtain should be tied into the banks and anchored to the bottom of the stream channel so sediment cannot escape beneath. Care should be taken when installing the turbidity curtain not to agitate and entrain channel bed sediment. The turbidity curtains should be maintained by occasionally removing accumulated sediment. The curtain should be removed prior to any predicted storm events as part of the flood contingency plan and should be inspected and repaired weekly. Maintenance of the turbidity curtains should be according to the manufacturer's specifications.

4.1.4 MITIGATION PRACTICES

Should turbidity levels be exceeded according to the TMP as described in the following section, additional structural practices should be implemented. Below is a list of additional mitigation and enhanced sediment control practices that should be implemented by the contractor. This list is not exhaustive, and it is the responsibility of the contractor to install other methods to meet the turbidity threshold requirements laid out in the TMP.

- Stop-work implementation
- Repair and/or replacement of existing sediment practices
- Additional sedimentation basins
- Frac tanks
- Additional turbidity curtains
- Temporary check dams or baffles
- Coagulation and flocculation technologies

4.2 REINTRODUCTION OF FLOW

Removing cofferdams and reintroducing flow into dry work areas presents one of the largest risks for entraining sediment. Flow should be reintroduced to dry work areas in a slow and controlled manner. After each phase of construction is complete, the contractor shall remove sections of upstream coffer

damming in small sections, reintroducing flow in small quantities to prevent excess turbidity and to "wash" fine materials out of the postconstruction channel slowly. Upon initiation of reintroducing flow, the contactor should remove a section of coffer damming no greater than 1 foot in width to slowly divert flow back into the dry work area while still maintaining passive bypass for larger flows. The first flush of water back into the newly constructed channel is expected to be the most sediment laden. The contractor shall pump this sediment-laden first flush into a sedimentation basin outside of the work area so that any sediment can be settled out before re-releasing downstream. The process of removing portions of the cofferdam to the newly constructed area should occur slowly with additional sections removed only when the previously opened section(s) runs clear, and turbidity measurements meet the standards in the TMP. This process should be continued until flow is completely reintroduced to the constructed channel. This process is of utmost importance for Phase 2, which presents the largest risk for sedimentation during reintroduction of flow. SLR is required to be on site during reintroduction of flow after each construction phase to monitor the procedure and the downstream turbidity. Reintroduction of flow should be explicitly addressed in the contractor's approved E&S plan.

5. TURBIDITY MONITORING PLAN (TMP)

Due to the sensitive nature of the downstream waterbodies, a formal TMP will be implemented during the construction phases of the Quinapoxet Dam Removal. The TMP will serve to quantify successful implementation and maintenance of the E&S controls and inform the decision of any corrective actions.

The successful implementation of the TMP will ensure there are no adverse water quality impacts on the downstream drinking water source. Specifically, the contractor must maintain project controls resulting in turbidity no greater than 2 NTU as measured by MWRA at its permanent downstream sampling stations. Turbidity monitoring and reporting will be the responsibility of the contractor at all times during construction. It is recommended that the selected contractor employ an experienced and qualified environmental testing agency to ensure the proper implementation of this TMP.

5.1 ANALYTICAL METHOD AND INSTRUMENTATION

Turbidity is an optical measurement requiring a light source and a photodetector. Nephelometry is a common type of photodetector that is considered the most accurate method for measuring turbidity and is approved by both the Environmental Protection Agency (EPA) and the International Organization for Standardization (ISO). Turbidity sampling during construction must consist of both continuous monitoring and discrete grab sampling within the water column, compliant with EPA and ISO methods, at various points of compliance.

5.1.1 CONTINUOUS SAMPLING

Continuous monitoring of turbidity is required as the primary means of ensuring compliance with this TMP. Continuous monitoring should be performed with a turbidity sensor that is permanently submerged in the body of water. Turbidity sensors allow for the measurement of in-situ, real-time data and most accurately represent surface water conditions. Turbidity sensors should be connected to a buoy-based sonde or a data logger to record and report data in real time. The data logger must be capable of transmitting live data via wireless communication to a web-based or cloud-based platform where the turbidity data can be viewed in real time.

The primary components required for the continuous turbidity monitoring system are as follows:

- Turbidity sensor
    - The selected turbidity sensor must be ISO 7027 compliant and report data at a frequency of 15 minutes or more frequently.
    - If the water depth at the sampling location is greater than 3 feet, multiple sensors must be provided for depth sampling. One turbidity sensor must be provided for every 3-foot depth of the water column (a 3-foot channel depth requires one sensor, a 6-foot channel depth requires two sensors, etc.). Locations that require multiple depth sensors should be daisy chained from the same buoy.

    - The sonde must contain a wiper to prevent fouling and sediment accumulation on the sensor.
    - Recommended turbidity sensor is the YSI EX02, or approved equal.
- Data Buoy and Data Logger
    - A data buoy, or floating platform, must be provided that supports the real-time monitoring sensor selected.
    - The data buoy must serve to house the monitoring equipment and supply power to the monitoring equipment via solar-powered battery packs.
    - The data buoy and housed data logger must be capable of transmitting sensor data in real time, either via radio, cellular, or satellite-based wireless communication.
    - The data buoy must be anchored with a two-point mooring system including a stainless-steel mooring line, bottom chain, and anchor system to ensure that it remains stationary and is capable of handing the anticipated flow rates in the channel.
    - Recommended data buoy is NexSens CB-450 Data Buoy, or approved equal.
- Live Data Platform
    - Live turbidity data via a web-based or cloud-based platform must be made available to MWRA, DCR, and SLR at all times during construction.
    - The live data platform must be capable of reporting data in real time at 15-minute intervals for immediate viewing.
    - The data platform and associated software must be password protected, with credentials for login provided as requested by MWRA.
    - The data platform must be capable of providing automated alerts when turbidity levels exceed predefined limits.
    - The data platform must be capable of archiving historical data for future download.
    - Recommended data platform is NexSens WQData Live Web Datacenter, or approved equal.

This component list is not exhaustive of all appurtenant equipment and materials required for continuous monitoring. The contractor is responsible for installing, maintaining, and providing access to real-time turbidity data throughout the life of the project. Under no circumstances can work proceed without the turbidity data being available to MWRA, DCR, and SLR. MWRA reserves the right to issue a stop-work order if real-time continuous monitoring data is not available.

It is highly recommended that the selected contractor employ an experienced environmental testing agency that is qualified to install, maintain, and operate all components of the continuous turbidity monitoring system. Prior to the start of construction, the contractor shall provide product data as a formal submittal for the selected equipment, documenting compliance with ISO 7027. The contractor shall also provide a submittal of the qualifications for the testing agency that will oversee the turbidity monitoring during construction.

5.1.2 GRAB SAMPLING

Grab samples will be used as a secondary means of measuring turbidity, with the intent to verify readings from the continuous sampling, provide a backup method for sampling if equipment

malfunctions, and provide spot readings at the direction of MWRA or SLR during sensitive work phases. The frequency of grab sampling is detailed in Section 5.2.3.

Grab samples from the water column shall be analyzed via a portable turbidity meter or turbidimeter. Turbidity meters use a water sample retrieved from a water column rather than measuring in the water directly. Turbidity meters are a cost-effective and accurate measurement of current water quality conditions. Manual grab samples allow for the ability to adapt to problems that arise on site or changing flow locations.

Instrumentation quality standards for measuring turbidity in nephelometric turbidity units (NTU) via turbidimeters are regulated through EPA Method 180.1. Turbidimeters are recommended for grab samples with turbidities less than 40 NTU, which is expected for samples from this project. Recommended turbidity meters are the Hach 2100Q Portable Turbidity Meter, Thermo Scientific AQ4500 Handheld Turbidity Meter, or approved equal. Prior to the start of construction, the contractor shall provide product data as a formal submittal for the selected portable turbidity meter, documenting compliance with EPA Method 180.1.

Grab samples should be retrieved at roughly the middle of the water column, at least 1 foot below the water surface but not within 6 inches of the channel bed. The contractor should avoid stirring the bottom sediments to the maximum extent practicable during sampling. It is of critical importance to have well-trained personnel taking water samples and to minimize sampling personnel changes during a project. To the maximum extent practicable, consistency in sampling personnel should be maintained to reduce result variability. Sampling personnel should receive training in using the equipment prior to the start of sampling.

5.1.3 CALIBRATION AND MAINTENANCE

All continuous monitoring equipment and handheld turbidity meters should be calibrated prior to use according to the manufacturer's instructions. Calibration procedures and frequency vary per product and must comply with both ISO 7027 and EPA Method 180.1. Proof of calibration for all equipment according to the manufacturer's procedure should be provided as a formal submittal to SLR prior to construction and sampling.

The equipment shall be maintained and inspected daily according to the manufacturer's recommendations. Depending on the equipment, periodic maintenance and calibration are usually required. The complete continuous turbidity monitoring system (sensors, data logger, telemetry, software) should be tested with the data platform prior to being put in the water.

In case of failure or damage to the sensor on either the continuous or handheld monitoring equipment, the contractor should have a spare turbidimeter on site. Construction cannot continue without any form of turbidity monitoring, so having a backup on site is important. The contractor will not be compensated for lost work time due to turbidity equipment failure.

5.1.4 VISUAL TURBIDITY INSPECTIONS

In addition to measurements taken with the continuous monitoring system and portable turbidity meter, visual monitoring should take place throughout construction. The contractor should visually assess the turbidity downstream of the project site and compare it to the turbidity of the upstream and receiving waters. The contractor should report any visual changes to the water immediately to MWRA and mitigate them as soon as possible.

Should a turbidity plume be observed visually, the contactor should provide photographs of receiving waters at SLR's or MWRA's request and report a turbidity reading from the middle of the plume, which will prompt further action at the direction of MWRA.

5.2 MONITORING REQUIREMENTS

This section outlines the specific monitoring plan that the contractor should implement during construction, including monitoring locations, sampling and reporting frequency, required thresholds to be met, and any required corrective action measures.

5.2.1 MONITORING LOCATIONS

Turbidity monitoring locations were selected based on the anticipated construction phasing and water control plan. One location upstream of the project site will be utilized as a background sample location to establish the baseline turbidity values at the project site. The background sample location is designated WQ-B-1 and should be located approximately 100 feet upstream of the project site. The background sample location must be located sufficiently upstream of any construction work occurring within the channel or floodplain. The background monitoring site location will remain constant throughout the duration of construction and shall be field approved by MWRA and SLR prior to commencing sampling.

Two monitoring locations downstream of the project site, known as points of compliance, will serve to measure turbidity downstream of the work area and to compare to the background sampling location. One location (WQ-C-1) will be located approximately 100 feet downstream of the project site, and another location (WQ-C-2) will be approximately 3,000 feet downstream of the project site at the Thomas Street Bridge (Figure 1). The downstream monitoring locations will be constant for all phases of construction. Table 3 summarizes the points of compliance and background sample identification numbers. All sampling points are shown on the construction sheets (CP-1 and CP-2) of the design plans. Sampling locations shown on the design plans are approximate and should be field approved by MWRA or SLR based on the actual limits of water and sediment control devices, channel flow dynamics, and other factors. The contractor or contractor's representative should not deploy any monitoring equipment without the approval of the final sample locations.

Table 3 Turbidity Sampling Location Identifiers

Sample Type	Construction Phase	Sample ID	Sample Location
Background (Upstream)	All	WQ-B-1	Center of wetted width
Points of Compliance (Downstream)	All	WQ-C-1	100 feet downstream of downstreammost turbidity curtain, center of wetted width
		WQ-C-2	Upstream of Thomas Street bridge, center of wetted width

5.2.2 SAMPLING AND REPORTING FREQUENCY

Turbidity monitoring via the continuous sampling system should be active throughout the entire duration of construction. The continuous monitoring system must report turbidity at 15-minute intervals, which are available to be viewed in real time through the live web platform.

Turbidity monitoring via the handheld turbidity meters should occur at least once daily to spot check the continuous monitoring equipment and more frequently as requested by MWRA or during sensitive stages of construction. Table 4 outlines the sampling frequency that the contractor must take turbidity grab samples and the frequency that those turbidity results must be communicated to SLR and MWRA. Grab samples from the upstream and downstream locations should be taken within a maximum period of 30 minutes from each other.

Table 4 Sampling and Reporting Frequency for Grab Samples

Site Condition	Sampling Frequency	Sample Locations	Reporting Form	Reporting Frequency
Normal Conditions	Daily (Once daily during a typical construction day to spot check continuous monitoring equipment)	Three sampling locations during each sampling 'event': • Upstream Background (WQ-B-1) • Downstream Point of Compliance 1 (WQ-C-1) • Downstream Point of Compliance 2 (WQ-C-2)	Turbidity Monitoring Form – Daily	Email scanned "Daily" forms weekly unless requested daily by MWRA. Report and email forms daily if turbidity reading (NTU) measured with the handheld turbidity meter is NOT within 10 percent of the continuous reading (NTU).
Increased Frequency Conditions	During the circumstances described below, sampling should occur at a minimum of once every hour or the frequency directed by SLR or MWRA • After visual observation of a turbidity plume • During switching of construction phases and moving of cofferdams • During reintroduction of flow into a dry work area • At the direction of SLR or MWRA	At the direction of MWRA or SLR. (Sample locations to represent sensitive work areas, turbidity plumes, or any other areas of concern)	Turbidity Monitoring Form – Increased Frequency	Communicate results immediately to SLR or MWRA representative on site. Email scanned "Increased Frequency" forms weekly unless requested daily by MWRA.

All grab sample turbidity measurements should be reported to MWRA via the Turbidity Monitoring Forms provided in Appendix E. The "daily" form should be utilized under normal monitoring conditions, and the "increased frequency" form should be used when more frequent testing is required. The contractor should report all information required on the form and provide the form electronically to SLR and MWRA once weekly (or as required for increased frequency monitoring via email). The contractor will be provided the appropriate email address and contact information for distribution of the Turbidity Monitoring Forms. For increased frequency monitoring conditions, the contractor can report turbidity measurements to an SLR or MWRA staff member on site or by phone.

In addition to sending Turbidity Monitoring Forms via email and continuous monitoring through the live web platform, the contractor should also maintain an electronic database of all turbidity readings and calibration readings for the handheld turbidity meter for the duration of the project. The turbidity database should include all information reported on the Turbidity Monitoring Forms for that day and any additional pertinent information. The contractor is responsible for delivering the grab sample turbidity monitoring database to SLR or MWRA at the end of construction or as requested throughout construction.

The web platform used for the continuous monitoring should be capable of archiving past readings from the project, such that an electronic database of the data can be downloaded and archived at the end of the project or as desired during construction.

5.2.3 TURBIDITY THRESHOLDS AND CORRECTIVE ACTIONS

The contractor must maintain project E&S controls as described in Section 4 such that the turbidity is no greater than 2 NTU as measured by MWRA at its permanent downstream sampling location at the outlet of the Wachusett Reservoir.

Increases above background turbidity will be defined as the difference in NTU between the background (upstream) turbidity sample (WQ-B-1) and the turbidity at any of the two points of compliance downstream (WQ-C-1 and WQ-C-2). The thresholds at each of the two points of compliance differ based on the expected mixing with Quabbin transfer flows and other hydrodynamic processes occurring just downstream of the project site. The historical turbidity data was used to help inform the selected thresholds above the measured background turbidity. SLR or MWRA reserves the right to modify the turbidity thresholds at any point during the project to meet the required water quality goals should the established compliance thresholds prove insufficient. Table 5 documents the required turbidity thresholds and the associated corrective action required by the contractor.

Table 5 Turbidity Thresholds and Corrective Actions

Downstream Point of Compliance	Warning	Stop Work
WQ-C-1	Increase above background turbidity ≥ 1.5 NTU	Increase above background turbidity ≥ 20 NTU
WQ-C-2	Increase above background turbidity ≥ 5 NTU	Increase above background turbidity ≥ 5 NTU
MWRA Permanent Turbidity Monitoring Locations	NA	≥ 2 NTU at MWRA permanent downstream sampling locations (as measured by MWRA)

The following corrective actions should be enacted if either the "Warning" or "Stop Work" thresholds are reached. These designations can be triggered by either the continuous monitoring or grab sample readings:

- Warning
  - Triggers increased frequency grab sampling at locations designated by SLR or MWRA, as outlined in Table 4.
  - Contactor to discuss E&S mitigation measures to be implemented with SLR and MWRA.
- Stop Work
  - Contractor to stop all work immediately.
  - Contractor to draft and implement Corrective Action Plan (CAP).
  - Work cannot continue until approved by SLR or MWRA.

5.2.4 CORRECTIVE ACTION PLAN

If an increase above background turbidity triggers the Stop Work threshold, the contractor must immediately stop work and submit a formal CAP to SLR and MWRA. The CAP must clearly detail the measures that will be taken to modify or enhance the current E&S controls to meet the required turbidity levels. The contractor cannot continue work until the CAP is reviewed and signed by SLR and MWRA. SLR or MWRA reserves the right to request a CAP at any stage of the project if water quality goals are not met. The required CAP is provided in Appendix F.

5.3 QUALITY ASSURANCE AND QUALITY CONTROL

It is ultimately the contractor or contractor's representative's responsibility to implement the TMP as outlined to protect the downstream drinking water source with the overall goal of maintaining turbidity levels no greater than 2 NTU at the outlet of the Wachusett Reservoir. SLR will serve as a Quality Assurance and Quality Control (QAQC) manager throughout the life of the project.

5.3.1 SLR QAQC

Prior to and during the beginning stages of construction, SLR will provide oversight of turbidity monitoring. During the initial stages of construction, SLR will be on site to designate appropriate sampling locations, approve E&S measures, and approve turbidity readings.

Quality Assurance (QA) should be achieved by following the protocols laid out in this TMP and adhering to the prescribed sampling and monitoring frequency and protocols. It is recommended that the selected contractor employ an experienced and qualified environmental testing agency to assure the requirements of this TMP are met.

Quality Control (QC) will be implemented by the SLR representative on site through periodic measurements of turbidity at frequencies requested by MWRA. SLR will also provide QC through daily review of the real-time data through the web platform, weekly review of submitted Turbidity Monitoring Forms, and review of any CAPs. Should turbidity monitoring and reporting not meet the requirements of this TMP or result in multiple instances of noncompliance, SLR and MWRA reserve the right to enforce third-party turbidity monitoring, to be funded by the contractor.

5.3.2 MWRA CONTINUOUS MONITORING

MWRA should report any exceedance readings above 2 NTU at the permanent turbidity monitoring stations within the Wachusett Reservoir to SLR and the contractor to gauge the success of this TMP. If downstream turbidity measurements exceed desired levels, MWRA, SLR, and the contractor should meet to discuss if it is related to the project work and discuss mitigation measures.

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APPENDICES

APPENDIX A

EXISTING FLOW AND TURBIDITY DATA

Sediment Management Plan

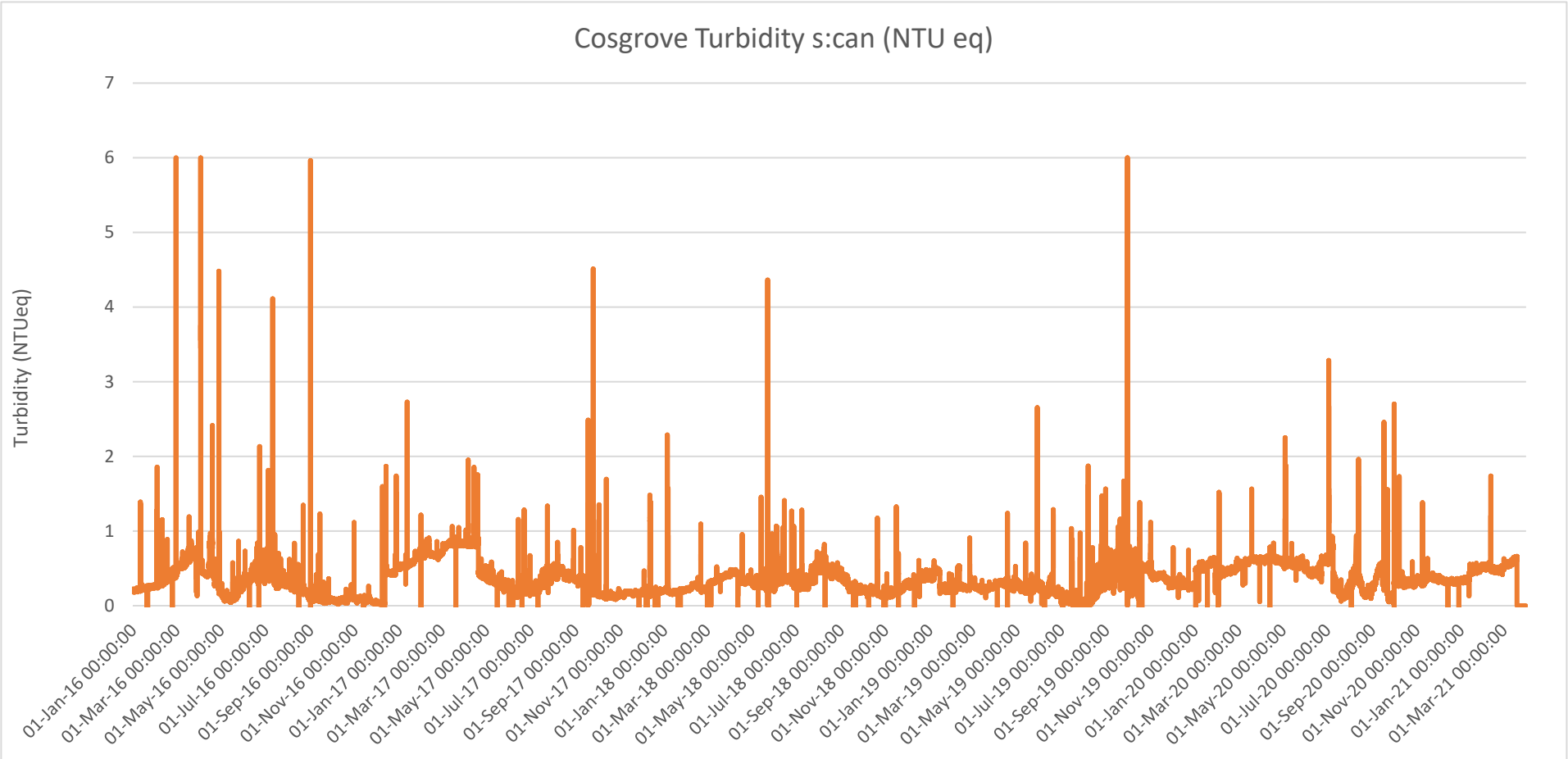
Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, MA 02129

May 2021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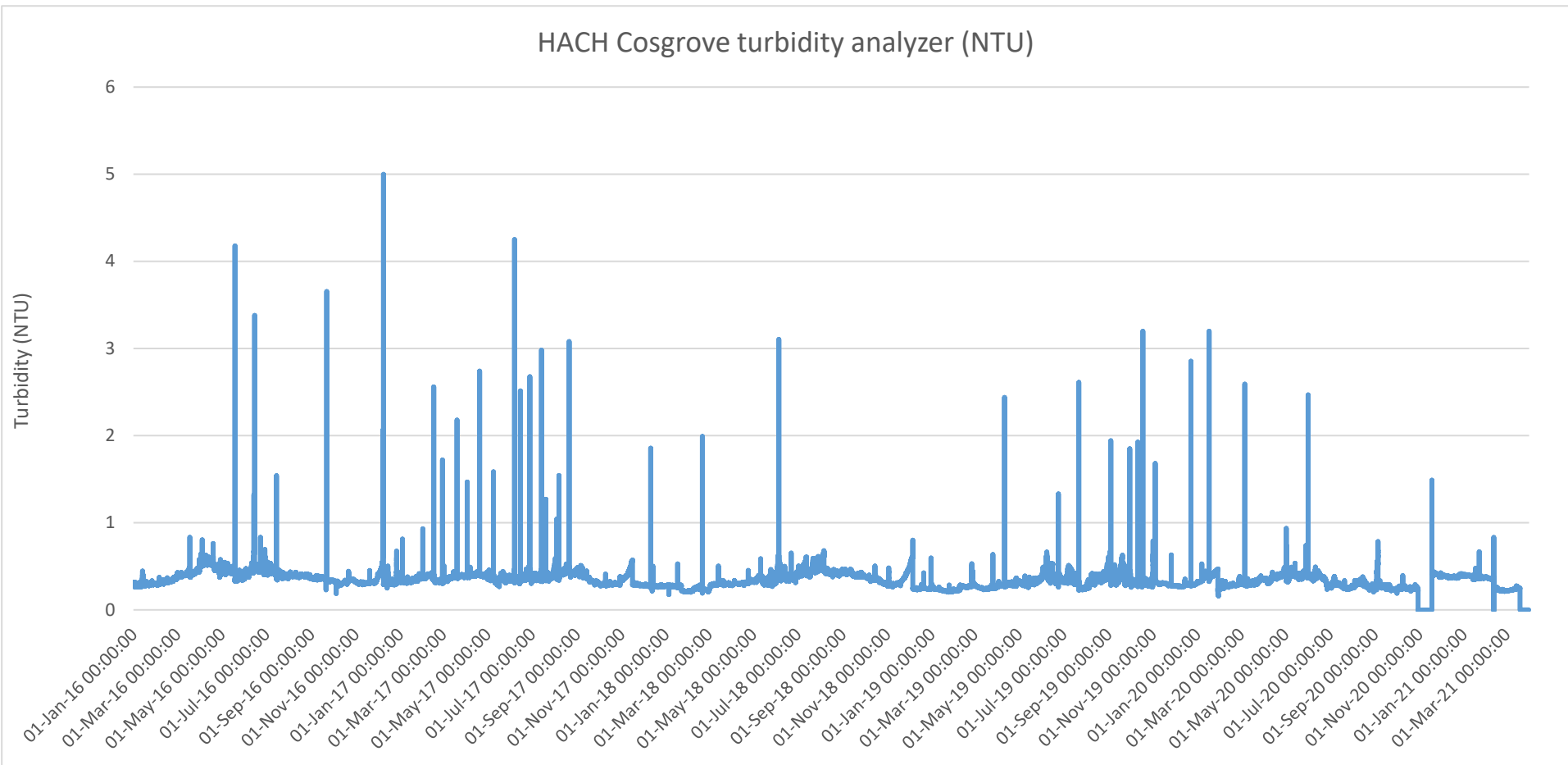
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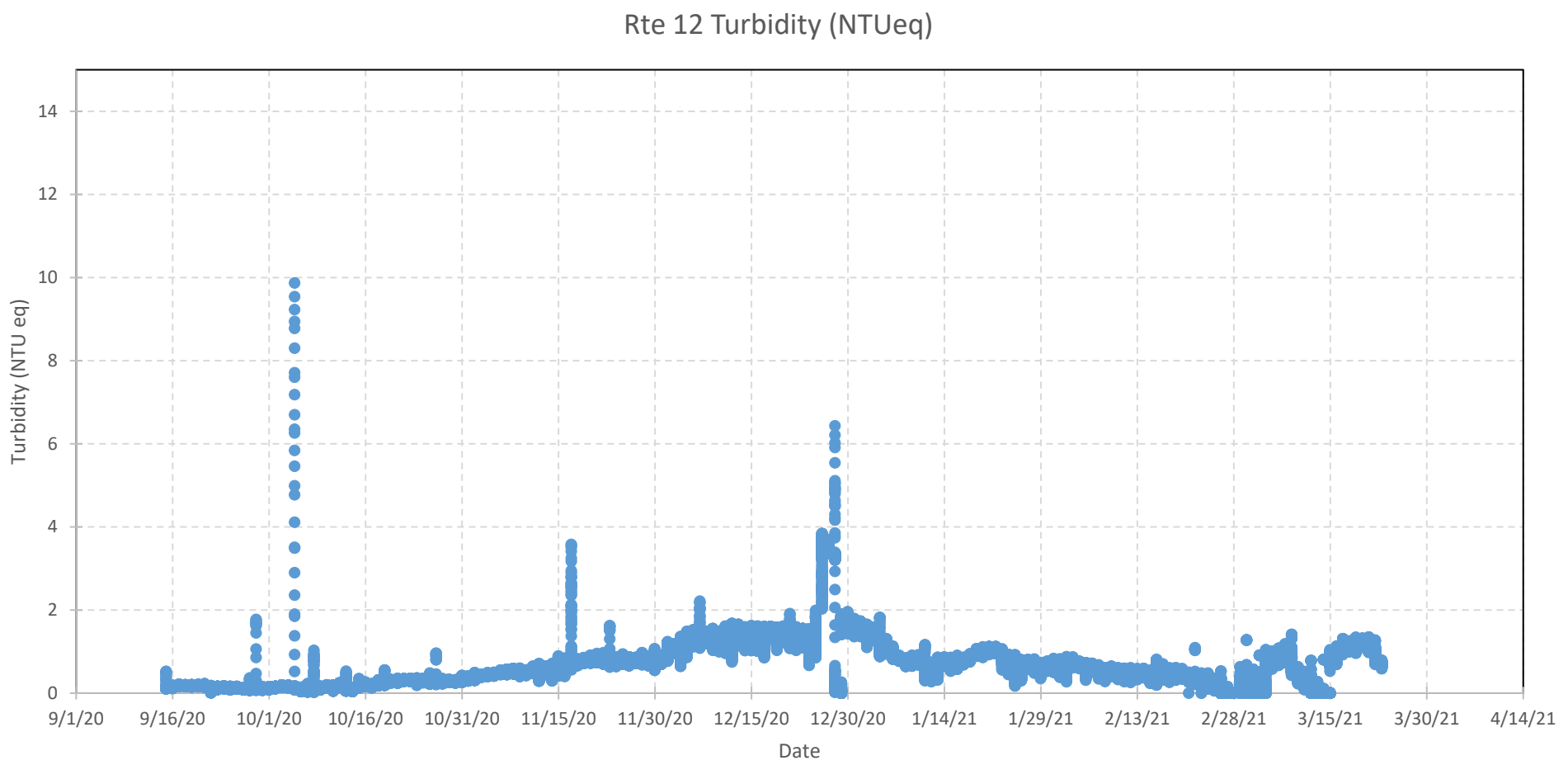
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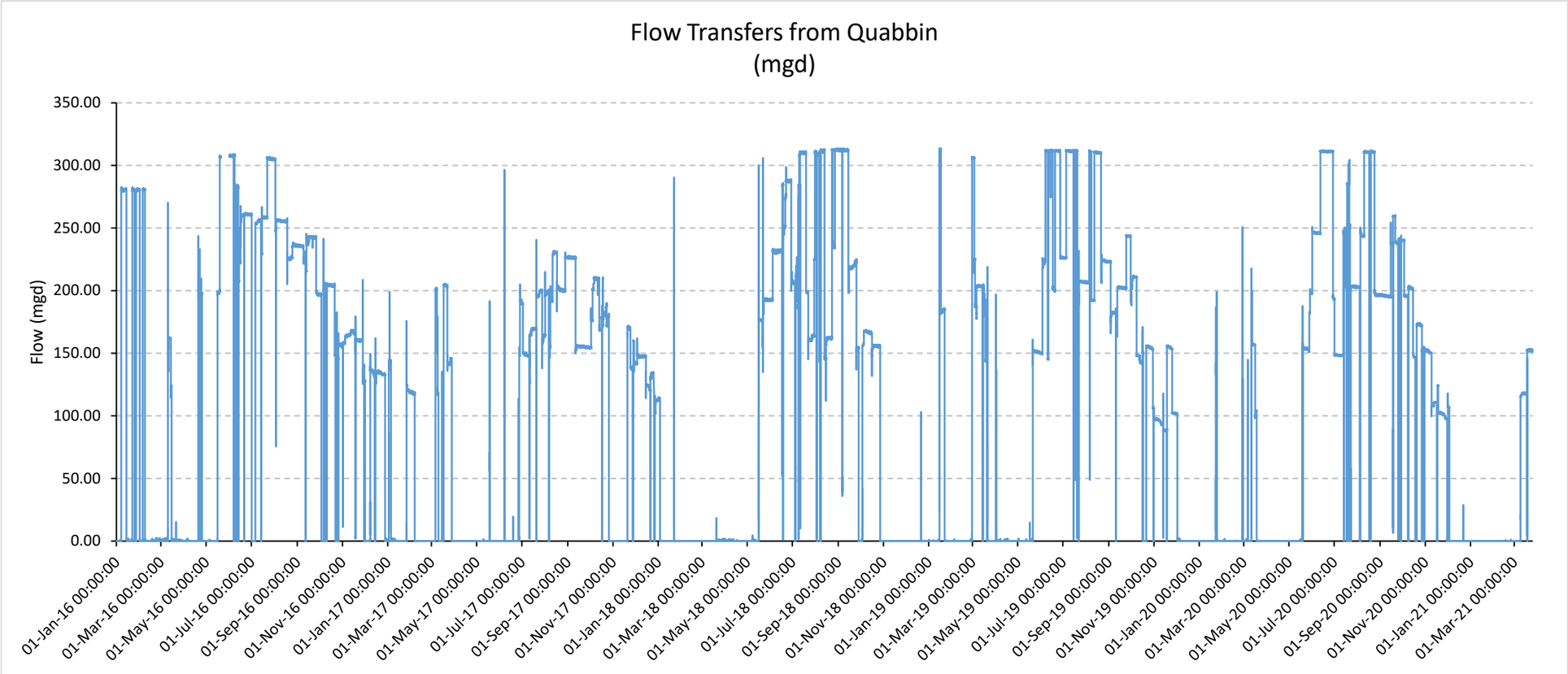
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APPENDIX B

QUINAPOXET DAM REMOVAL: FEASIBILITY STUDY

(Provided in Appendix C - 2020 Basis of Design, Appendix A)

Sediment Management Plan

Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

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May 2021

APPENDIX C

QUINAPOXET DAM REMOVAL: BASIS OF DESIGN REPORT

(Provided in Appendix C - 2020 Basis of Design Report)

Sediment Management Plan

Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, MA 02129

May 2021

APPENDIX D

EPA METHOD 180.1

Sediment Management Plan

Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, MA 02129

May 2021

United States Environmental Protection Agency

www.epa.gov August 1993

Method 180.1: Determination of Turbidity by Nephelometry

METHOD 180.1

DETERMINATION OF TURBIDITY BY NEPHELOMETRY

Edited by James W. O'Dell
Inorganic Chemistry Branch
Chemistry Research Division

Revision 2.0
August 1993

ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

METHOD 180.1

DETERMINATION OF TURBIDITY BY NEPHELOMETRY

1.0 SCOPE AND APPLICATION

1.1 This method covers the determination of turbidity in drinking, ground, surface, and saline waters, domestic and industrial wastes.

1.2 The applicable range is 0-40 nephelometric turbidity units (NTU). Higher values may be obtained with dilution of the sample.

2.0 SUMMARY OF METHOD

2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. Readings, in NTU's, are made in a nephelometer designed according to specifications given in Sections 6.1 and 6.2. A primary standard suspension is used to calibrate the instrument. A secondary standard suspension is used as a daily calibration check and is monitored periodically for deterioration using one of the primary standards.

2.1.1 Formazin polymer is used as a primary turbidity suspension for water because it is more reproducible than other types of standards previously used for turbidity analysis.

2.1.2 A commercially available polymer primary standard is also approved for use for the National Interim Primary Drinking Water Regulations. This standard is identified as AMCO-AEPA-1, available from Advanced Polymer Systems.

3.0 DEFINITIONS

3.1 **Calibration Blank (CB)** -- A volume of reagent water fortified with the same matrix as the calibration standards, but without the analytes, internal standards, or surrogates analytes.

3.2 **Instrument Performance Check Solution (IPC)** -- A solution of one or more method analytes, surrogates, internal standards, or other test substances used to evaluate the performance of the instrument system with respect to a defined set of criteria.

3.3 **Laboratory Reagent Blank (LRB)** -- An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples. The LRB is used to determine if method

analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

3.4 **Linear Calibration Range (LCR)** -- The concentration range over which the instrument response is linear.

3.5 **Material Safety Data Sheet (MSDS)** -- Written information provided by vendors concerning a chemical's toxicity, health hazards, physical properties, fire, and reactivity data including storage, spill, and handling precautions.

3.6 **Primary Calibration Standard (PCAL)** -- A suspension prepared from the primary dilution stock standard suspension. The PCAL suspensions are used to calibrate the instrument response with respect to analyte concentration.

3.7 **Quality Control Sample (QCS)** -- A solution of the method analyte of known concentrations that is used to fortify an aliquot of LRB matrix. The QCS is obtained from a source external to the laboratory, and is used to check laboratory performance.

3.8 **Secondary Calibration Standards (SCAL)** -- Commercially prepared, stabilized sealed liquid or gel turbidity standards calibrated against properly prepared and diluted formazin or styrene divinylbenzene polymers.

3.9 **Stock Standard Suspension (SSS)** -- A concentrated suspension containing the analyte prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source. Stock standard suspension is used to prepare calibration suspensions and other needed suspensions.

4.0 INTERFERENCES

4.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles can cause high readings.

4.2 The presence of true color, that is the color of water which is due to dissolved substances that absorb light, will cause turbidities to be low, although this effect is generally not significant with drinking waters.

4.3 Light absorbing materials such as activated carbon in significant concentrations can cause low readings.

5.0 SAFETY

5.1 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable.

5.2 Each laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in

this method. A reference file of Material Safety Data Sheets (MSDS) should be made available to all personnel involved in the chemical analysis. The preparation of a formal safety plan is also advisable.

5.3 Hydrazine Sulfate (Section 7.2.1) is a carcinogen. It is highly toxic and may be fatal if inhaled, swallowed, or absorbed through the skin. Formazin can contain residual hydrazine sulfate. Proper protection should be employed.

6.0 EQUIPMENT AND SUPPLIES

6.1 The turbidimeter shall consist of a nephelometer, with light source for illuminating the sample, and one or more photo-electric detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. The turbidimeter should be designed so that little stray light reaches the detector in the absence of turbidity and should be free from significant drift after a short warm-up period.

6.2 Differences in physical design of turbidimeters will cause differences in measured values for turbidity, even though the same suspension is used for calibration. To minimize such differences, the following design criteria should be observed:

6.2.1 Light source: Tungsten lamp operated at a color temperature between 2200-3000°K.

6.2.2 Distance traversed by incident light and scattered light within the sample tube: Total not to exceed 10 cm.

6.2.3 Detector: Centered at 90° to the incident light path and not to exceed ±30° from 90°. The detector, and filter system if used, shall have a spectral peak response between 400 nm and 600 nm.

6.3 The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 NTU or less in waters having turbidities less than 1 unit. The instrument should measure from 0-40 units turbidity. Several ranges may be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.

6.4 The sample tubes to be used with the available instrument must be of clear, colorless glass or plastic. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. A light coating of silicon oil may be used to mask minor imperfections in glass tubes. They must not be handled at all where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be handled. Tubes should be checked, indexed and read at the orientation that produces the lowest background blank value.

6.5 Balance -- Analytical, capable of accurately weighing to the nearest 0.0001 g.

6.6 Glassware -- Class A volumetric flasks and pipets as required.

7.0 REAGENTS AND STANDARDS

7.1 Reagent water, turbidity-free: Pass deionized distilled water through a 0.45µ pore size membrane filter, if such filtered water shows a lower turbidity than unfiltered distilled water.

7.2 Stock standard suspension (Formazin):

7.2.1 Dissolve 1.00 g hydrazine sulfate, $(NH_2)_2.H_2SO_4$ (CASRN 10034-93-2) in reagent water and dilute to 100 mL in a volumetric flask. **CAUTION**-- carcinogen.

7.2.2 Dissolve 10.00 g hexamethylenetetramine (CASRN 100-97-0) in reagent water and dilute to 100 mL in a volumetric flask. In a 100 mL volumetric flask, mix 5.0 mL of each solution (Sections 7.2.1 and 7.2.2). Allow to stand 24 hours at 25 ±3°C, then dilute to the mark with reagent water.

7.3 Primary calibration standards: Mix and dilute 10.00 mL of stock standard suspension (Section 7.2) to 100 mL with reagent water. The turbidity of this suspension is defined as 40 NTU. For other values, mix and dilute portions of this suspension as required.

7.3.1 A new stock standard suspension (Section 7.2) should be prepared each month. Primary calibration standards (Section 7.3) should be prepared daily by dilution of the stock standard suspension.

7.4 Formazin in commercially prepared primary concentrated stock standard suspension (SSS) may be diluted and used as required. Dilute turbidity standards should be prepared daily.

7.5 AMCO-AEPA-1 Styrene Divinylbenzene polymer primary standards are available for specific instruments and require no preparation or dilution prior to use.

7.6 Secondary standards may be acceptable as a daily calibration check, but must be monitored on a routine basis for deterioration and replaced as required.

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 Samples should be collected in plastic or glass bottles. All bottles must be thoroughly cleaned and rinsed with turbidity free water. Volume collected should be sufficient to insure a representative sample, allow for replicate analysis (if required), and minimize waste disposal.

8.2 No chemical preservation is required. Cool sample to 4°C.

8.3 Samples should be analyzed as soon as possible after collection. If storage is required, samples maintained at 4°C may be held for up to 48 hours.

9.0 QUALITY CONTROL

9.1 Each laboratory using this method is required to operate a formal quality control (QC) program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and analysis of laboratory reagent blanks and other solutions as a continuing check on performance. The laboratory is required to maintain performance records that define the quality of data generated.

9.2 INITIAL DEMONSTRATION OF PERFORMANCE.

9.2.1 The initial demonstration of performance is used to characterize instrument performance (determination of LCRs and analysis of QCS).

9.2.2 Linear Calibration Range (LCR) -- The LCR must be determined initially and verified every six months or whenever a significant change in instrument response is observed or expected. The initial demonstration of linearity must use sufficient standards to insure that the resulting curve is linear. The verification of linearity must use a minimum of a blank and three standards. If any verification data exceeds the initial values by ±10%, linearity must be reestablished. If any portion of the range is shown to be nonlinear, sufficient standards must be used to clearly define the nonlinear portion.

9.2.3 Quality Control Sample (QCS) -- When beginning the use of this method, on a quarterly basis or as required to meet data-quality needs, verify the calibration standards and acceptable instrument performance with the preparation and analysis of a QCS. If the determined concentrations are not within ±10% of the stated values, performance of the determinative step of the method is unacceptable. The source of the problem must be identified and corrected before continuing with on-going analyses.

9.3 ASSESSING LABORATORY PERFORMANCE

9.3.1 Laboratory Reagent Blank (LRB) -- The laboratory must analyze at least one LRB with each batch of samples. Data produced are used to assess contamination from the laboratory environment.

9.3.2 Instrument Performance Check Solution (IPC) -- For all determinations, the laboratory must analyze the IPC (a mid-range check standard) and a calibration blank immediately following daily calibration, after every tenth sample (or more frequently, if required) and at the end of the sample run. Analysis of the IPC solution and calibration blank immediately following calibration must verify that the instrument is

within ±10% of calibration. Subsequent analyses of the IPC solution must verify the calibration is still within ±10%. If the calibration cannot be verified within the specified limits, reanalyze the IPC solution. If the second analysis of the IPC solution confirms calibration to be outside the limits, sample analysis must be discontinued, the cause determined and/or in the case of drift the instrument recalibrated. All samples following the last acceptable IPC solution must be reanalyzed. The analysis data of the calibration blank and IPC solution must be kept on file with the sample analyses data. NOTE: Secondary calibration standards (SS) may also be used as the IPC.

9.3.3 Where additional reference materials such as Performance Evaluation samples are available, they should be analyzed to provide additional performance data. The analysis of reference samples is a valuable tool for demonstrating the ability to perform the method acceptably.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Turbidimeter calibration: The manufacturer's operating instructions should be followed. Measure standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales. At least one standard should be run in each instrument range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities. Solid standards, such as those made of lucite blocks, should never be used due to potential calibration changes caused by surface scratches. If a pre-calibrated scale is not supplied, calibration curves should be prepared for each range of the instrument.

11.0 PROCEDURE

11.1 Turbidities less than 40 units: If possible, allow samples to come to room temperature before analysis. Mix the sample to thoroughly disperse the solids. Wait until air bubbles disappear then pour the sample into the turbidimeter tube. Read the turbidity directly from the instrument scale or from the appropriate calibration curve.

11.2 Turbidities exceeding 40 units: Dilute the sample with one or more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and the diluted sample showed a turbidity of 30 units, then the turbidity of the original sample was 180 units.

11.2.1 Some turbidimeters are equipped with several separate scales. The higher scales are to be used only as indicators of required dilution volumes to reduce readings to less than 40 NTU.

Note: Comparative work performed in the Environmental Monitoring Systems Laboratory - Cincinnati (EMSL-Cincinnati) indicates a progressive error on sample turbidities in excess of 40 units.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Multiply sample readings by appropriate dilution to obtain final reading.

12.2 Report results as follows:

NTU	Record to Nearest:
0.0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 - 1000	50
>1000	100

13.0 METHOD PERFORMANCE

13.1 In a single laboratory (EMSL-Cincinnati), using surface water samples at levels of 26, 41, 75, and 180 NTU, the standard deviations were ±0.60, ±0.94, ±1.2, and ±4.7 units, respectively.

13.2 The interlaboratory precision and accuracy data in Table 1 were developed using a reagent water matrix. Values are in NTU.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 The quantity of chemicals purchased should be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

14.3 For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction," available from the American

Chemical Society's Department of Government Regulations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

15.0 WASTE MANAGEMENT

15.1 The U.S. Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect the air, water and land by minimizing and controlling all releases from hoods, and bench operations, complying with the letter and spirit of any waste discharge permit and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult the "Waste Management Manual for Laboratory Personnel," available from the American Chemical Society at the address listed in Section 14.3.

16.0 REFERENCES

1. Annual Book of ASTM Standards, Volume 11.01 Water (1), Standard D1889-88A, p. 359, (1993).

2. Standard Methods for the Examination of Water and Wastewater, 18th Edition, pp. 2-9, Method 2130B, (1992).

17.0 TABLES, DIAGRAMS, FLOWCHARTS AND VALIDATION DATA

TABLE 1. INTERLABORATORY PRECISION AND ACCURACY DATA

Number of Values Reported	True Value (T)	Mean (X)	Residual for X	Standard Deviation (S)	Residual for S
373	0.450	0.4864	0.0027	0.1071	-0.0078
374	0.600	0.6026	-0.0244	0.1048	-0.0211
289	0.65	0.6931	0.0183	0.1301	0.0005
482	0.910	0.9244	0.0013	0.2512	0.1024
484	0.910	0.9919	0.0688	0.1486	-0.0002
489	1.00	0.9405	-0.0686	0.1318	-0.0236
640	1.36	1.3456	-0.0074	0.1894	0.0075
487	3.40	3.2616	-0.0401	0.3219	-0.0103
288	4.8	4.5684	-0.0706	0.3776	-0.0577
714	5.60	5.6984	0.2952	0.4411	-0.0531
641	5.95	5.6026	-0.1350	0.4122	-0.1078

REGRESSIONS: $X = 0.955T + 0.54$, $S = 0.074T + 0.082$

APPENDIX E

TURBIDITY MONITORING FORMS

Sediment Management Plan

Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, MA 02129

May 2021

TURBIDITY MONITORING FORM
DAILY GRAB SAMPLES

Project Name: Quinapoxet Dam Removal
Contractor Name:
Contractor Representative:
Week of:
Daily Work Activities:

Has equipment been calibrated according to the Manufacturer (Y/N)? _____

Date	Time of Sample	Sample ID	Grab Sample Turbidity Reading (NTU)	Increase Above Background Turbidity (NTU)	Compliant (Y/N)?	Continuous Sample Turbidity Reading at Same Time (NTU)	Within 10% of Grab Sample (Y/N)?
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					
		WQ-B-1		NA	NA		
		WQ-C-1					
		WQ-C-2					

*Non-compliance refers to the thresholds in Table 5 of the Sediment Management Plan

Contractor Representative Signature: _____ Date:_____

SLR QAQC Manager Signature (As applicable): _____ Date:_____

TURBIDITY MONITORING FORM
INCREASED FREQUENCY FORM

Project Name: Quinapoxet Dam Removal
Contractor Name:
Contractor Representative:
Date:
Daily Work Activities:

Reason for Increased Frequency Monitoring:

Has equipment been calibrated according to the Manufacturer (Y/N)? _____
Have the results been immediately communicated to SLR and MWRA (Y/N): _____
Background Turbidity Reading (NTU): _____

Time of Sample	Sample ID	Description of Sample Location	Turbidity Reading (NTU)	Increase Above Background Turbidity (NTU)	Compliant (Y/N)?

*Non-compliance refers to the thresholds in Table 5 of the Sediment Management Plan

Contractor Representative Signature: _____ Date:_____

SLR QAQC Manager Signature: _____ Date:_____

APPENDIX F

CORRECTIVE ACTION PLAN

Sediment Management Plan

Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, MA 02129

May 2021

CORRECTIVE ACTION PLAN (CAP)
FOR THE SEDIMENT MANGEMENT PLAN (SMP)

Project Name: Quinapoxet Dam Removal
SLR QAQC Manager:
Contractor Name:
Contractor Representative:
Date of Non-Compliance Occurrence:
Date Submitted:

Reason for Required Correction Action:

Plan for Corrective Action:

Correction Actions Implemented:

Review Comments:

Contractor Representative Signature: _____ Date:_____

SLR QAQC Manager Signature: _____ Date:_____

MWRA Representative Signature: _____ Date:_____

APPENDIX I

2007 GZA DAM INSPECTION REPORT

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

dcr *department of* Conservation and Recreation

SHAFT NO. 1 INTAKE DAM

PHASE 1 INSPECTION / EVALUATION REPORT

Dam Name:	**Shaft No. 1 Intake Dam**
State Dam ID#:	**3-14-321-1**
NID ID#:	**MA02523**
Owner:	**Department of Conservation & Recreation**
Owner Type:	**State**
Town:	**West Boylston**
Consultant:	**GZA GeoEnvironmental, Inc.**
Date of Inspection:	**June 26, 2007**

GZA
GeoEnvironmental, Inc.

Engineers and Scientists

July 31, 2007
GZA File No. 18802.80

Mr. William Salomaa
DCR
Office of Dam Safety
251 Causeway Street, Suite 600
Boston MA 02114-2119

One Edgewater Drive
Norwood
Massachusetts
02062
781-278-3700
FAX 781-278-5701
www.gza.com

Re: Inspection/Evaluation Report
Shaft No. 1 Intake Dam, West Boylston
NID # MA02523
Worcester County

Dear Mr. Salomaa:

In accordance with our agreement dated August 14, 2006, GZA GeoEnvironmental, Inc. (GZA) has completed our inspection of the Shaft No. 1 Intake Dam in West Boylston, Massachusetts. The site visit was conducted on June 26, 2007. This work was done as part of a recent Department of Conservation and Recreation (DCR) request to provide an updated dam safety inspection. The purpose of our effort was to provide the DCR with an updated, formal phase one inspection for the dam in order to maintain compliance with 302 CMR 10.00 Dam Safety Regulations, pertaining to inspection frequency.

Based on our inspection, the dam is currently in **FAIR** Condition, in our opinion. A further discussion of our evaluation and recommended actions items are presented in the Inspection / Evaluation Report. An electronic version and two hard copies of the report have been provided. In accordance with your instructions, the report also includes a: (a) Dam Evaluation Summary Detail Sheet (b) completed checklist; (c) field sketch; and (d) selected photographs with captions. Our services and report are subject to the Limitations found in Appendix A.

We are happy to have been able to assist you with these inspections and appreciate the opportunity to continue to provide the DCR with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Inspection/Evaluation Report.

Sincerely,

GZA GeoEnvironmental, Inc.

David M. Leone, P.E.
Project Manager

Chad W. Cox, P.E.
Consultant / Reviewer

Anders B. Bjarngard, P.E.
Associate Principal

An Equal Opportunity Employer M/F/V/H

Dam Evaluation Summary Detail Sheet

1. NID ID: MA02523	**2. Dam Name:** Shaft No. 1 Intake Dam	**3. Dam Location:** W. Boylston, MA
4. Inspection Date: 06/26/2007	**5. Last Insp. Date:** Unknown	**6. Next Inspection:** 06/26/2012
7. Inspector: Anders Bjarngard, P.E.	**8. Consultant:** GZA GeoEnvironmental, Inc.	
9. Hazard Code: Significant	**10. Insp. Frequency:** 5 years	**11. Insp. Condition:** FAIR

E1. Design Methodology:	3	**E7. Low-Level Discharge Capacity:**	1
E2. Level of Maintenance:	3	**E8. Low-Level Outlet Physical Condition:**	1
E3. Emergency Action Plan:	3	**E9. Spillway Design Flood Capacity:**	Unknown
E4. Embankment Seepage:	5	**E10. Overall Physical Condition of the Dam:**	3
E5. Embankment Condition:	4	**E11. Estimated Repair Cost (in thousand $):**	200-400
E6. Concrete/Masonry Condition:	3		

Evaluation Description

E1: DESIGN METHODOLOGY
1. Unknown Design – no design records available
3. Some standard design features
5. State of the art design – design records available

E2: LEVEL OF MAINTENANCE
1. No evidence of maintenance, no O&M manual
2. Very little maintenance, no O&M manual
3. Some level of maintenance and standard procedures
4. Adequate level of maintenance and standard procedures
5. Detailed maintenance plan that is executed

E3: EMERGENCY ACTION PLAN
1. No plan or idea of what to do in the event of an emergency
2. Some idea but no written plan
3. No formal plan but well thought out
4. Available written plan that needs updating
5. Detailed, updated written plan available and filed with MADCR

E4: EMBANKMENT SEEPAGE
1. Severe piping and/or seepage with no monitoring
2. Evidence of monitored piping and seepage
3. No piping but uncontrolled seepage
4. Controlled seepage
5. No seepage or piping

E5: EMBANKMENT CONDITION
1. Severe erosion and/or large trees
2. Significant erosion or significant woody vegetation
3. Brush and exposed embankment soils, or moderate erosion
4. Unmaintained grass, rodent activity and maintainable erosion
5. Well maintained healthy uniform grass cover

E6: CONCRETE CONDITION
1. Major cracks, misalignment, discontinuities causing leaks, seepage or stability concerns
2. Cracks with misalignment inclusive of transverse cracks with no misalignment
3. Significant longitudinal cracking and minor transverse cracking
4. Spalling and minor surface cracking
5. No apparent deficiencies

E7: LOW LEVEL OUTLET DISCHARGE CAPACITY
1. No low level outlet
2. Outlet with insufficient drawdown capacity
3. Inoperable gate with potentially sufficient drawdown capacity
4. Operable gate with sufficient drawdown capacity
5. Operable gate with capacity greater than necessary

E8: LOW LEVEL OUTLET PHYSICAL CONDITION
1. Outlet inoperative needs replacement, non-existent or inaccessible
2. Outlet inoperative needs repair
3. Outlet operable but needs repair
4. Outlet operable but needs maintenance
5. Outlet and operator operable and well maintained

E9: SPILLWAY DESIGN FLOOD CAPACITY
1. 0 - 20% of the SDF
2. 21- 40% of the SDF
3. 41- 60% of the SDF
4. 61- 80% of the SDF
5. 81- 100% of the SDF

E10: OVERALL PHYSICAL CONDITION OF THE DAM
1. *UNSAFE* – Major structural, operational, and maintenance deficiencies exist under normal operating conditions
2. *POOR* - Significant structural, operation and maintenance deficiencies are clearly recognized under normal loading conditions
3. *FAIR* - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to. critical parameters
4. *SATISFACTORY* - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result In deficiencies.
5. *GOOD* - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF

E11: ESTIMATED REPAIR COST
Estimation of the total cost to address all identified structural, operational, maintenance deficiencies. Cost shall be developed utilizing standard estimating guides and procedures

Changes/Deviations to Database Information since last inspection

Structural Height = 18 feet (Not 9)
Drainage Area = 57 square miles (Not 0)

EXECUTIVE SUMMARY

This report summarizes the results of the visual dam inspection conducted by GZA GeoEnvironmental, Inc. (GZA) on June 26, 2007 for the Shaft No. 1 Intake Dam in West Boylston, Massachusetts. GZA found the dam to be in **FAIR** condition.

Current deficiencies at the dam include the following:

- Stone masonry fish ladder in poor condition: stone masonry has voids, missing / displaced stones, scour damage, and leakage;
- Missing stone masonry at spillway training walls on right side near spillway weir;
- Deteriorated concrete at the downstream face and apron of the spillway weir;
- Scour at toe of spillway, particularly near left side near bedrock channel outcrop;
- Minor depression at lower portion downstream slope of right earth embankment near Shaft No. 1 building;
- Small depressions within right portion of earth embankment behind stone masonry training walls;
- Brush and saplings growing in joints of stone masonry training wall at several locations;
- Brush and saplings growing in joints and immediately upstream of spillway weir at center and left side; impoundment vegetation creating minor impediment to flow.
- Impoundment virtually full of coarse gravel, cobbles, and small boulders.
- Isolated large trees on dike;
- No apparent low level outlet.

GZA recommends the following actions to be performed by a qualified, registered professional engineer experienced in dam safety:

Studies and Investigations:

- Operations & Maintenance Plan;
- Hydraulic/Hydrologic Analyses;
- Perform a dam breach versus repair and fish passage feasibility study. At this juncture, it is not possible to recommend a specific course of action regarding breach versus repair. Additional information should be gathered to evaluate the functionality of the dam, further understanding of its structural condition, and weigh the advantages and disadvantages of breach and repair (see also Section 3.6). One factor to be considered is that the dam's intended purpose, to provide sedimentation / water quality benefits, may no longer be served as the impoundment is filled with coarse alluvial deposits. Therefore, while it may be equally as or less expensive to repair the dam and reconstruct the fish ladder as it may be to breach the dam, it may not be sensible to do so unless the impounded sediment is removed, thus restoring the dam's functionality, adding significant cost to the repair option. In GZA's opinion, the fate (and disposal) of the impounded alluvial deposits and the constructability of the potential breach or repair (i.e., water control and water quality impacts to the Wachusett Reservoir) are the most significant issues to address in the repair vs. breach feasibility study.

- Monitor depressions in embankment.

Repairs and Remedial Measures:

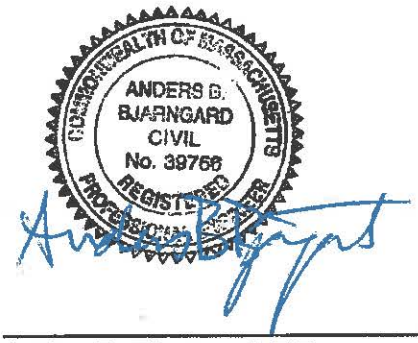
- Cut/remove brush, saplings, and weeds from stone masonry throughout dam;
- Remove debris, sediment, and vegetation from upstream and downstream of the spillway channel;
- Repoint stone masonry and replace locally missing stones at right training wall;
- Monitor low areas / depressions at the right embankment for changes in size and depth;
- Depending on the results of the feasibility study described in Section 3.20, breach the dam or repair the dam and reconstruct the fish ladder at the left side of the spillway.

PREFACE

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.



Anders B. Bjarngard, P.E.

Massachusetts License No.: 39766
Associate Principal
GZA GeoEnvironmental, Inc.

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FIGURES

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APPENDICES

Appendix A: Limitations
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1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The Department of Conservation and Recreation (DCR) has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual inspection and develop a report of conditions for the Shaft No. 1 Intake Dam along the Quinapoxet River in West Boylston, Massachusetts. This inspection and report were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws as amended by Chapter 330 of the Acts of 2002. This report is subject to the Limitations in **Appendix A**.

1.1.2 Purpose of Work

The purpose of this investigation is to inspect and evaluate the present condition of the dam and appurtenant structures in accordance with 302 CMR10.07. The primary objective is to observe existing surficial conditions at the dam, and render an opinion concerning maintenance measures, repairs, improvements, monitoring and/or investigations judged necessary to address deficiencies identified during the inspection.

The investigation is divided into four parts: 1) obtain and review available reports, investigations, and data pertaining to the dam and appurtenant structures; 2) perform a visual inspection of the site; 3) evaluate the status of an emergency action plan for the site and; 4) prepare and submit a final report presenting the evaluation of the structure, including recommendations and remedial actions, and opinion of probable costs.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix E**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; and 5) miscellaneous.

1.2 Description of Project

1.2.1 Location

Shaft No. 1 Intake Dam is located in the Oakdale section of the Town of West Boylston, Massachusetts, immediately upstream of the Shaft No. 1 building where the Quabbin Aqueduct discharges to the Wachusett Reservoir. The dam impounds water along the Quinapoxet River and is located adjacent to the Wachusett Reservoir's Thomas Basin. The dam is located near the northwestern limits of the Wachusett Reservoir; refer to Figure 1 – Locus Plan. The coordinates of the dam are approximately 42.3870° N and 71.8029° W. The dam is accessible via a gated access road controlled by the DCR Division of Water Supply and Protection (DWSP).

1.2.2 Owner/Operator

Shaft No. 1 Intake Dam is owned by the Commonwealth of Massachusetts. The dam is operated and maintained by the DCR DWSP.

	Dam Owner	Dam Caretaker
Name	DCR DWSP c/o Pat Austin	Same as Owner
Mailing Address	180 Beaman Street	
Town	West Boylston, MA 01583	
Daytime Phone	508-792-7423	
Emergency Phone	Unknown	
Email Address	pat.austin@state.ma.us	

1.2.3 Purpose of the Dam

Shaft No. 1 Intake Pond is used as a sedimentation basin for the Quinapoxet River as it reaches its confluence with the Wachusett Reservoir. However, the impoundment is nearly full of coarse alluvial deposits (gravel, cobbles, and small boulders), and its continued functionality as a sediment basin at the time of our visit was questionable.

1.2.4 Description of the Dam and Appurtenances

Shaft No. 1 Intake Dam is an approximately 250-foot-long, 18-foot-high earthen embankment and stone masonry dam that was constructed in circa 1890. The dam is located immediately upstream of the Wachusett Reservoir and the outlet of the Quabbin Aqueduct (Shaft No. 1). The earthen embankment portion of the dam appears to be limited to the right side, upstream of the Shaft No. 1 Building. The upstream side of the dam consists of a vertical, large-block mortared stone masonry wall. The embankment extends upstream of the dam to form a low earthen embankment dike.

The major feature of the dam is an approximately 135-foot-long, 9-foot-high stone masonry and concrete arched-shape spillway weir. The weir appears to be founded on bedrock, as outcrops are visible along the left side of the dam. The spillway is concrete with granite block stone masonry facing that was installed in circa 1902, according to available design drawings. The spillway channel downstream of the weir has a gravel, boulder, and natural bedrock channel floor. There is also a stone masonry fish ladder present at the left spillway abutment. The fish ladder has apparently has slots for baffles, which did not appear to be in place. The fish ladder discharges to the Quinapoxet River a short distance downstream of the spillway.

The Shaft No. 1 Intake Building is located immediately downstream of the dam. Discharge from the Quabbin Aqueduct enters the Quinapoxet River / Wachusett Reservoir at this location. However, the building does not appear to be related to the dam.

1.2.5 Operations and Maintenance

The dam is maintained by the DCR DWSP. It is GZA's understanding that no formal operation procedure is in place.

1.2.6 DCR Size Classification

Shaft No. 1 Intake Dam has a maximum structural height of approximately 18 feet and a reported maximum storage capacity of approximately 75 acre-feet. Therefore, in accordance with Department of Conservation and Recreation Office of Dam Safety classification, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00 as amended by Chapter 330 of the Acts of 2002, Shaft No. 1 Intake Dam is considered to be an

Intermediate size structure based on the height of between 15 and 40 feet and storage between 50 and 1000 acre-feet.

1.2.7 DCR Hazard Classification

Shaft No. 1 Intake Dam is located upstream of bridge crossings and the Shaft No. 1 Intake building. It appears that a failure of the dam at maximum pool may cause serious damage to important utilities, a roadway, other properties, and possibly the Shaft No. 1 Intake structure. Therefore, in accordance with Department of Conservation and Recreation classification procedures, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.06, Shaft No. 1 Intake Dam is classified as having a **Significant** (Class 2) hazard potential.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

The drainage area for Shaft No. 1 Intake Pond is approximately 57 square miles. The drainage area is generally wooded with moderate to steep slopes.

1.3.2 Reservoir

The following information was obtained from USGS topographic quadrangle maps and the DCR dam database.

	Length (feet)	Width (feet)	Surface Area (acres)	Storage Volume (acre-feet)
Normal Pool	800	150	3	1*
Maximum Pool	1,500	160	6	75
SDF Pool	Unknown	Unknown	Unknown	Unknown

** - Due to sedimentation of impoundment*

1.3.3 Discharges at the Dam Site

No records are kept of discharges at the dam.

1.3.4 General Elevations

The following elevations (in feet) are provided in the 1902 design drawings, which do not specify the datum used, but datum is close to mean sea level.

A.	Top of Dam	411
B.	Spillway Design Flood Pool	Unknown
C.	Normal Pool	402
D.	Spillway Crest	402
E.	Upstream Water at Time of Inspection	402.1±
F.	Streambed at Toe of the Dam	393.5±

1.3.5 Main Spillway

1.	Type	Uncontrolled broad crested weir
2.	Length	Approx. 135 feet

3. Invert Elevation 402 feet
4. Upstream Channel About 401 feet
5. Downstream Water About 393.5 feet

1.3.6 Design and Construction Records

DCR DWSP supplied drawings from 1902 and 1921 which show the (at the time) existing conditions at the dam and the proposed details for providing granite block facing for the spillway. Additional drawings related to the stone masonry fish ladder, dated 1935, are also available.

1.3.7 Operating Records

The dam is operated and maintained by the DCR DWSP. No formal operating records are kept for the dam. Records of discharge from Shaft No. 1 are maintained by DCR DWSP.

2.0 INSPECTION

2.1 Visual Inspection

GZA engineers Anders B. Bjarngard, P.E. and David M. Leone, P.E., accompanied by Ms. Patricia Austin, P.E., Supervisor, Environmental Quality, Wachusett/Sudbury Watershed, Office of Watershed Management of DCR, inspected Shaft No. 1 Intake Dam on June 26, 2007. At the time of the inspection, the weather was hazy with temperatures around 85° Fahrenheit. Photographs to document the current conditions of the dam were taken during the inspection and are included in **Appendix B**. At the time of inspection, the impoundment was about one inch above the spillway crest, at an elevation of approximately 402.1 feet. Underwater areas were not inspected. A copy of the inspection checklist is included in **Appendix C**.

2.1.1 General Findings

In general, Shaft No. 1 Intake Dam was found to be in **FAIR** condition. Specific observations are described in the sections below:

2.1.2 Dam

The top and downstream slope of the earthen embankment on the right side of the dam is primarily covered with well-established grass. There are minor depressions in the embankment locally, particularly along the spillway channel training wall. There is also a minor depression near the downstream toe of the right embankment in the vicinity of the Shaft No. 1 Intake building. Portions of the embankment near the crest and upstream dike were covered in saplings and brush.

The upstream side is a vertical stone masonry wall which appeared to be in good to fair condition. The wall extends from the upstream face to the spillway / spillway channel training walls (see below). Minor vegetation is growing within the stone masonry joints in several localized areas, including at the top of the dam adjacent to the right spillway abutment. The wall was missing mortar locally. Embankment-abutment contact appears to be stable, but some leakage was observed downstream of the right retaining walls.

2.1.3 Appurtenant Structures

The uncontrolled, broad-crested spillway was found to be in fair condition. Spillway overflows hindered GZA's observations, particularly for leakage at the spillway weir. The granite

facing stone appeared to be intact. There was some scour damage observed at the downstream toe of the spillway weir, particularly at the left side of the spillway. Vegetation was growing from the joints in the downstream side facing, particularly at the center and left portion of the spillway. Vegetation was also growing from impounded sediment at the left side, which is obstructing flow and resulting in the majority of flow occurring at the right side of the spillway.

There is a concrete spillway apron and groin which extends from the base of the spillway to about 75-feet downstream of the weir. The apron is in fair condition and exhibits some spalling and scour damage.

The Shaft No.1 Intake building is located just downstream of the dam and was not inspected, as it does not appear to be related to the dam's operations.

2.1.4 Downstream Area

The discharge area consists of a wide open channel with bedrock outcrops along the center and left side. Vegetation is growing in a sand and gravel island present in the channel near the outcrops on the left side. Discharge from Shaft No. 1 enters the channel a short distance downstream of the spillway. Many trout and other fish were observed to be present at the Aqueduct outlet.

2.1.5 Reservoir Area

The Shaft No. 1 Intake Pond slopes are generally moderate and wooded and appear stable.

2.2 Caretaker Interview

An informal interview was conducted during the inspection with Patricia Austin of the DCR DWSP. The operations and maintenance of the dam was discussed during the informal interview, the results of which were used in the preparation of this report.

2.3 Operation and Maintenance Procedures

2.3.1 Operational Procedures

The dam is owned by the DCR DWSP. There is no formal written operations procedure for the dam. The dam does not require operations to function. The fish ladder is reportedly ineffective.

2.3.2 Maintenance of Dam and Operating Facilities

There are no formal maintenance procedures in place for the dam. Maintenance mowing of grassed portions of the embankment is performed by DCR.

2.4 Emergency Warning System

There is no Emergency Warning System or written Emergency Action Plan (EAP) for the dam.

2.5 Hydrologic/Hydraulic Data

There were no hydrologic / hydraulic analyses for the dam available to GZA at the time of our visual inspection. A detailed hydrologic / hydraulic analysis should be undertaken to assess the

adequacy of the spillway under conditions of the Spillway Design Flood (SDF) as a part of the alternative analysis.

A. Spillway Design Flood (SDF) Return Period:	100-year
B. SDF Peak Outflow:	Unknown
C. Primary Spillway Capacity:	Unknown

2.6 Structural Stability/Overtopping Potential

2.6.1 Structural Stability

Although no stability analyses of the dam could be located, observation of the existing conditions indicates that the dam and dike slopes appear stable at the present time. However, depressions near training walls could indicate loss of soil material from within the embankment. It should be noted, however, that embankment stability depends on constantly changing internal and external conditions. It should therefore not be assumed that the present condition of the dam will continue to exist in the future.

2.6.2 Overtopping Potential

A detailed hydraulic and hydrologic analysis should be performed using up-to-date methodology to estimate the overtopping potential at the dam.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, the overall condition of the Shaft No. 1 Intake Dam is **FAIR**. The following is a summary of deficiencies identified during the inspection:

- Stone masonry fish ladder in poor condition: stone masonry has voids, missing / displaced stones, scour damage, and leakage;
- Missing stone masonry at spillway training walls on right side near spillway weir;
- Deteriorated concrete at the downstream face and apron of the spillway weir;
- Scour at toe of spillway, particularly near left side near bedrock channel outcrop;
- Minor depression at lower portion downstream slope of right earth embankment near Shaft No. 1 building;
- Small depressions within right portion of earth embankment behind the stone masonry training walls;
- Brush and saplings growing in joints of stone masonry training wall at several locations;
- Brush and saplings growing in joints and immediately upstream of spillway weir at center and left side; impoundment vegetation creating minor impediment to flow.
- Impoundment virtually full of coarse gravel, cobbles, and small boulders.
- Isolated large trees on dike.
- No apparent low level outlet.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the dam. Prior to undertaking recommended maintenance, repairs and remedial measure, the applicability of environmental permits needs to be determined prior to undertaking activities that may occur within resource areas under the jurisdiction of local conservation commissions, MADEP, or other regulatory agencies.

3.2 Studies and Analyses

GZA recommends the following investigations to be performed/documents prepared by a qualified, registered professional engineer experienced in dam safety:

1. An Operations & Maintenance Manual, as defined under 302 CMR 10.03, should be developed to provide guidance to caretaker personnel under routine and storm conditions, if dam is maintained.

2. A detailed Hydraulic and Hydrologic analysis using up-to-date methodology should be conducted as part of the alternatives analysis to evaluate the adequacy of the spillway.

3. A dam breach versus repair feasibility study should be undertaken. At this juncture, it is not possible to recommend a specific course of action regarding breach versus repair. Additional information should be gathered, through the conducting studies below, to evaluate the functionality of the dam, further understanding of its structural condition, and weigh the advantages and disadvantages of breach and repair (see also Section 3.6). One factor to be considered is that the dam's intended purpose, to provide sedimentation / water quality benefits, may no longer be served as the impoundment is filled with coarse alluvial deposits. Therefore, while it may be equally as or less expensive to repair the dam and reconstruct the fish ladder as it may be to breach the dam, it may not be sensible to do so unless the impounded sediment is removed, thus restoring the dam's functionality, adding significant cost to the repair option. In GZA's opinion, the fate (and disposal) of the impounded alluvial deposits and the constructability of the potential breach or repair (i.e., water control and water quality impacts to the Wachusett Reservoir) are the most significant issues to address in the repair vs. breach feasibility study.

   The study should include the following:

- <u>Topographic/Bathymetric survey, sediment sampling, and wetland delineation</u>.
  These field studies will support the evaluations recommended below.

- <u>Hydrologic/hydraulic (H&H) analyses to evaluate existing and proposed post-breach conditions</u>.
  Typically, dam breach vs. repair studies evaluate the flood control impacts of the dam and possible ramifications to downstream areas in the event of dam decommissioning. In the case of the Shaft No. 1 Intake Dam, the impoundment has been virtually filled with sediment, and the Wachusett Reservoir, due to its large size, appears to be able to compensate for what little flood control benefits the dam may possess.

  However, the H&H analysis is recommended to evaluate sediment transport potential of the site if the dam were to be removed. The dam once functioned to impound sediment before it reached the Wachusett Reservoir—a function that it apparently fulfilled given that the impoundment is full of sediment. The H&H analysis would also be useful in developing engineering design to mitigate sediment transport through installation of riprap to the breach channel, selected dredging, and/or in sizing smaller "riffles," in-stream structures (passable by fish) which are designed to provide small pools / low-velocity zones for sedimentation and aquatic habitat.

- <u>Qualitatively assess wetlands, aquatic habitat, and fisheries information for existing and proposed post-breach conditions</u>.
  The current setting appears to be a cold-water fishery, thanks in part to the contribution of the Quabbin Aqueduct flow. There were many trout present in the downstream area during

GZA's visit. These observations should be expanded to establish the design criteria, including target species, for the breach channel or the reconstructed fish ladder.

- Evaluation of two conceptual alternatives: (1) repair of the dam and reconstruction / replacement of the fish ladder, and (2) permanently breaching the dam.
  Dam breaching typically can be a less expensive alternative to traditional dam repair. Dam removal also improves the fish passage conditions and removes the liability of DCR in the event of dam failure. In addition to conceptual cost estimates and the other evaluations discussed above, the following issues should also be considered:

  - The loss of the dam for sedimentation purposes and its affects on the water quality of the Wachusett Reservoir;
  - Fate, transport potential, and disposal options for the impounded sediment: The sediment may be removed and re-used if it is found to meet proper environmental quality criteria. The sediment should be removed from the impoundment to restore the dam's intended functionality or if the dam is breached (to mitigate the potential for downstream transport), in GZA's opinion;
  - Constructability of the repair vs. breach option, including water control during construction and erosion and sediment control / construction impacts on the water quality of Wachusett Reservoir;

- Concept-level plans, including sediment management, channel stabilization, and erosion control, for the recommended alternative.
  A conceptual dam breach design may involve a partial breach of the dam at its maximum section and removal of upstream sediment at the breach section. A breach channel design may incorporate a series of stone weirs, sized appropriately such that they are not destroyed during high-flow conditions, to preserve some sediment control benefits. The portion of the dam near the bedrock outcrops on the left side may remain in-place as a cost-consideration.

  A dam repair design may involve the local repointing of stone masonry at the right portion of the dam and removal of vegetation from the joints of stone masonry throughout the dam. The fish ladder at the left side of the dam is in poor condition and should be removed and reconstructed. Soil borings might be required before final design.

- An investigation of the historic/cultural significance of the Dam.
  The historical significance of the dam, according to the Massachusetts Historical Commission, should be determined. The dam's historical significance may influence design options and costs.

- Permitting Requirements.
  The applicability of various federal, state and local permits, including but not limited to those shown below, should be evaluated for the dam breach or repair alternative:

  - Wetlands Protection Act: Notice of Intent and Order of Conditions (Local Conservation Commission);
  - Environmental Notification Form and, if required, an Environmental Impact Report [required for breach] (Massachusetts Environmental Policy Act Office);
  - Water Quality Certification (Section 401, Massachusetts Department of Environmental Protection);

- Chapter 253 Dam Safety Permit (Massachusetts Department of Conservation and Recreation, Office of Dam Safety);
- Massachusetts Historic Commission Project Notification Form (MHC);
- Section 404 Permit: Fill of waters or wetlands (U.S. Army Corps of Engineers).

3.3 Yearly Recommendations

Until the dam is removed or repaired, GZA recommends the following recurrent maintenance level activities that can be undertaken by the dam owner/caretaker and do not require engineering design:

1. Removal of debris from spillway and approach area
2. Mowing of grass and removal of vegetation from embankment slopes and crest, as well as from joints in the stone masonry training walls and spillway facing
3. Perform annual self-inspection of dam and document findings
4. Monitor depression on embankment

Additional detail regarding annual maintenance activities should be listed in the O&M Manual.

3.4 Recommendations, Maintenance, and Minor Repairs

GZA recommends that the owner arrange for the following repair measures to be performed on the dam in the short-term:

1. Mowing of grass and removal of vegetation from embankment slopes and crest, as well as from joints in the stone masonry training walls and spillway facing.
2. Remove debris, sediment, and vegetation from upstream and downstream of the spillway channel to reduce obstruction of flow over spillway.
3. Locally repoint stone masonry training wall at the right side of the dam.
4. Establish monitoring points at low areas at the earthen embankment, right of the spillway.

3.5 Remedial Measures

1. Depending upon the results of the studies recommended in Section 3.2, design and construct a partial breach of the dam or design and repair dam and reconstruct the fish ladder at the left spillway abutment.
2. To restore the dam's functionality or to breach the dam, the impounded sediment should be removed entirely or in part. At the minimum, GZA recommends removing the impounded sediment upstream of the spillway, which is enabling the vegetation growth that appears to be hindering the spillway's hydraulic efficiency and capacity.

3.6 Alternatives

No Action: Due to the size and hazard of the structure, continued deterioration of the structure could result in a threat to the integrity of the dam. In the opinion of GZA, the "No Action" alternative is not recommended due to the potential public safety hazard and threat to important infrastructure.

Dam Breach: A dam breach alternative may be feasible at this site. Please see Section 3.20 for further discussion. Typically, undertaking a dam breach has the following advantages and disadvantages:

ADVANTAGES

- No repair costs associated with rehabilitating the dam potential (significant cost savings);
- No liability for potential dam failure;
- Greatly reduces long-term maintenance costs;
- Restoring river to "original" free-flowing condition is a positive environmental impact;
- Improved fish passage;
- Any remaining structure no longer regulated as a dam by MADCR;
- Lowered water surface elevations upstream of site during flood events.

DISADVANTAGES

- Cost of demolishing and partially removing dam, but typically less than repair option;
- Cost of erosion control and bank stabilization (armoring) of restored river channel;
- Short-term aesthetic and ecological impacts after impoundment is dewatered;
- More extensive permitting process;
- Water quality impacts during construction (also a consideration for repair construction);
- Loss of potential sedimentation basin (versus repaired dam with dredged impoundment).

3.7 Opinion of Probable Construction Costs

The conceptual cost estimate for the recommended studies and analyses above is approximately $60,000 to $120,000, while the estimated cost for repair / remedial items (including engineering) is approximately $250,000 to $500,000. It is assumed that annual maintenance-related items contained in Section 3.3 and monitoring items in Section 3.4 can be completed by DCR staff at no additional cost. The cost breakdown is as follows:

Study Item	Conceptual Cost
Operations & Maintenance Plan	$3,000 - $4,000
Hydraulic and Hydrologic Analyses	$5,000 - $10,000
Dam Breach / Repair Feasibility Study*	$40,000 - $80,000
25% Contingency	$12,000 - $26,000
Total	$60,000 - $120,000

* - Does not include soil boring.

Repair Item	Conceptual Cost
Locally Repoint Right Training Wall	$20,000 - $40,000
Remove Sediment Immediately Upstream of Spillway**	$20,000 - $40,000
25% Contingency	$10,000 - $20,000
Total	$50,000- $100,000

** - Does not include dredging of the entire impoundment.

Please note that the estimate above does not include construction cost estimates for a reconstruction of the fish ladder nor a partial dam breach, as the costs for such cannot be accurately estimated prior to the completion of the study recommended in Section 3.20. Typical dam breach construction costs, based on GZA's previous experience, range from about $200,000 to $400,000.

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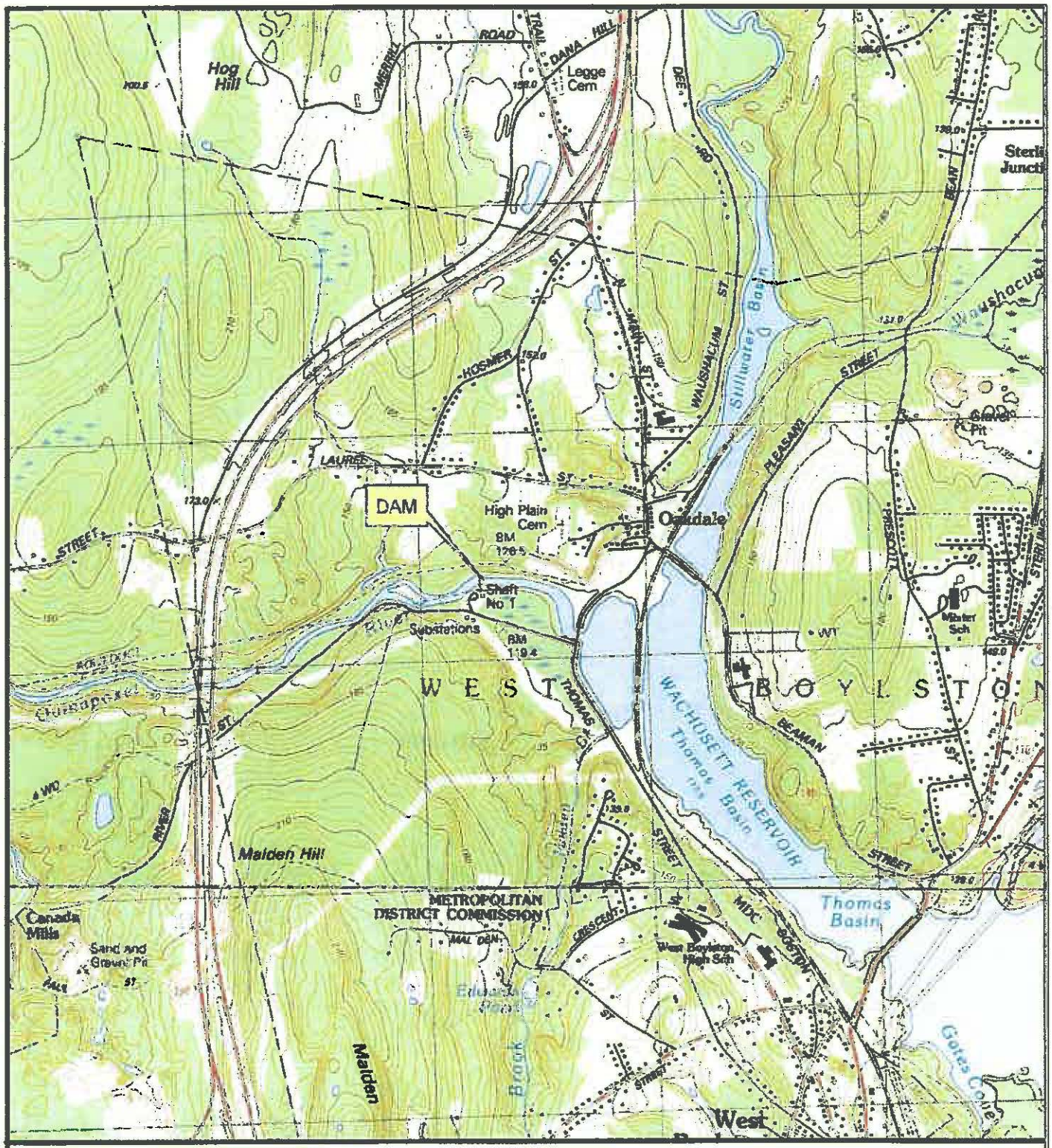
FIGURES



SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES SCANNED BY THE MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS, MASSGIS. DISTRIBUTED JUNE, 2001.

Data Supplied by : MASS GIS

0 1,000 2,000 4,000 6,000 Feet

N W E S

GZA

PROJ. MGR.: DML
DESIGNED BY: BBF
REVIEWED BY: ABB
OPERATOR: BBF

DATE: 08-01-2007

LOCUS MAP - SHAFT No.1 INTAKE DAM
WEST BOYLSTON, MASSACHUSETTS

DCR DIVISION OF WATER SUPPLY PROTECTION

JOB NO. 18802.70

FIGURE NO. 1

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GZA
GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, MA 02062
781-278-3700
Fax 781-278-5701
http://www.gza.com

Engineers and Scientists

JOB 18802.70
SHEET NO. 1 OF 1
CALCULATED BY DML DATE 6-27-07
CHECKED BY ABB DATE 6-28-07
SCALE NTS

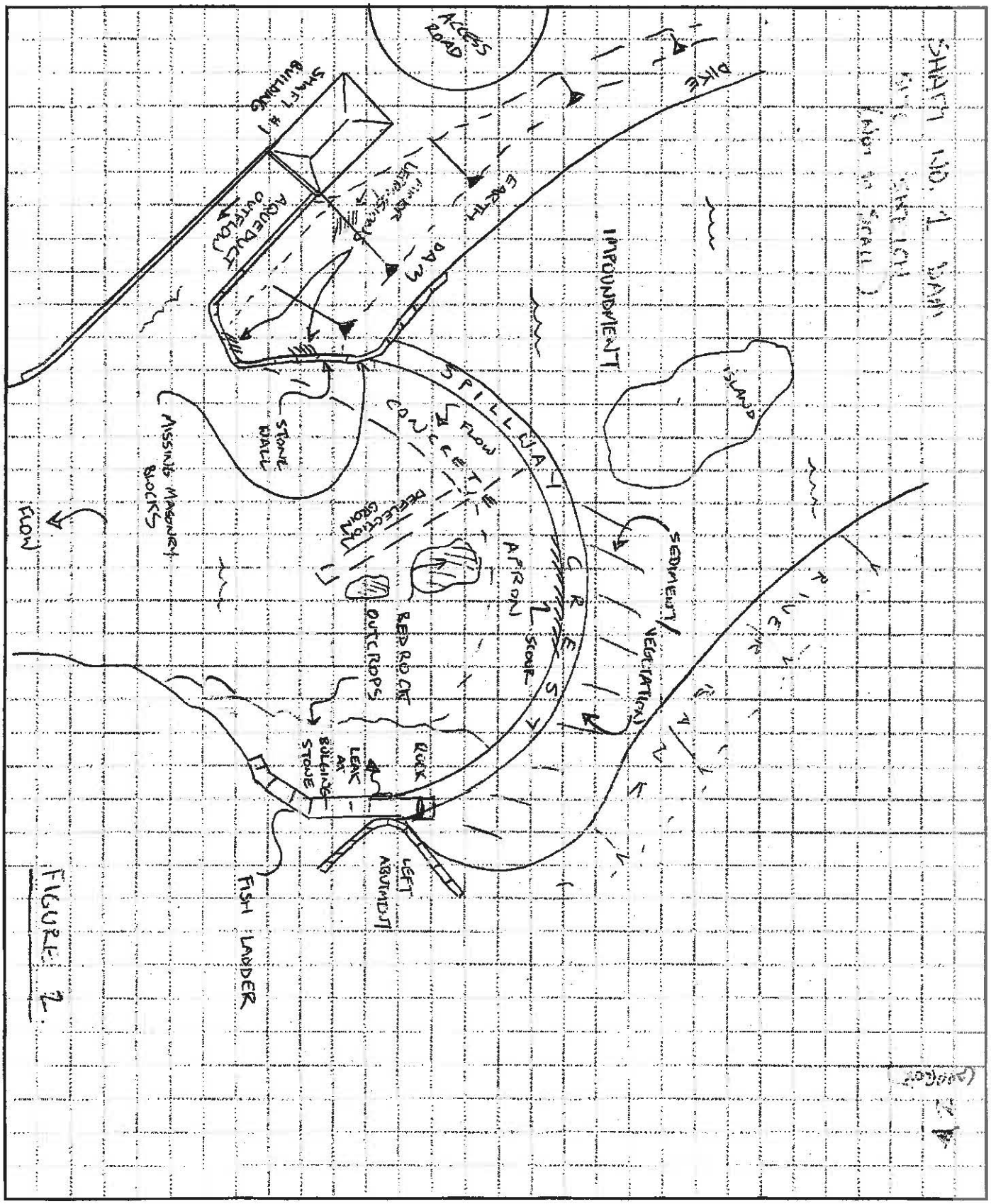

FIGURE 2.

APPENDIX A

LIMITATIONS

DAM ENGINEERING & VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the Department of Conservation and Recreation (DCR).

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by the DCR as well as Federal, state, and local officials and other parties referenced therein. GZA has also relied on certain information contained in the files of the DCR, the Office of Dam Safety as well as Federal, state, and local officials and other parties which were available to GZA at the time of the inspection. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the dam reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA based any hydraulic analysis on existing conditions based on the site plans made available to GZA as of the date of this report or upon field reconnaissance. In the event that any changes in the nature, design or location of the dam or its appurtenant structures are planned, the conclusions and recommendations contained in this Report shall not be considered valid unless the changes are reviewed and conclusions of this Report modified or verified by GZA.

7. Any GZA hydrologic analysis presented herein is for the rainfall volumes and distributions stated herein. For storm conditions other than those analyzed, the response of the sites drainage network has not been evaluated.

8 This report has been prepared for the exclusive use of the Massachusetts DCR for specific application to these existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

9. This dam inspection verification report has been prepared for this project by GZA. This report is for the DCR's broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

APPENDIX B

PHOTOGRAPHS

Photo 1. Aerial overview of dam (Microsoft Virtual Earth).

Photo 2. Overview of dam from downstream river bank.

Photo 3. Shaft No. 1 building and downstream slope of dam (between building and spillway).

Photo 4. Minor depression adjacent to right training wall at downstream slope.

Photo 5. Overview of spillway from right spillway abutment.

Photo 6. View of left side of spillway. Note bedrock outcrops, vegetation growth, and fish ladder in background.

Photo 7. View of right side of spillway. Note concrete apron and deflection weir/groin.

Photo 8. Missing stone blocks at right spillway training wall, near crest.

Photo 9. View of leakage through voids at fish ladder, left side of spillway. Note displaced stone block at leakage areas.

Photo 10. View of scour at base of spillway on left side.

Photo 11. View of fish ladder upstream entrance and coarse aggregate upstream of the spillway crest.

APPENDIX C

INSPECTION CHECKLIST

DAM SAFETY INSPECTION CHECKLIST

NAME OF DAM:	SHAFT NO. 1 INTAKE DAM	STATE ID #:	3-14-321-1
REGISTERED:	☐ YES ☐ NO	NID ID #:	MA02523
STATE SIZE CLASSIFICATION:	INTERMEDIATE	STATE HAZARD CLASSIFICATION:	SIGNIFICANT

LOCATION INFORMATION

CITY/TOWN:	WEST BOYLSTON	COUNTY:	WORCESTER
DAM LOCATION:	North of River Road near MWRA Shaft No 1	AKA NAME:	Quinapoxet River Circular Dam
USGS QUAD.:	Sterling	LAT.: 42.3870°N	LONG.: 71.8029°W
DRAINAGE BASIN:	Nashua	RIVER:	QUINAPOXET RIVER
IMPOUNDMENT NAME(S):	Shaft No. 1 Intake Pond		

GENERAL DAM INFORMATION

TYPE OF DAM:	Earth Embankment w/ Concrete & Stone Spillway	OVERALL LENGTH (FT):	About 250 ft
PURPOSE OF DAM:	Formerly sediment control	NORMAL POOL STORAGE (ACRE-FT):	1
YEAR BUILT:	1890	MAXIMUM POOL STORAGE (ACRE-FT):	75
STRUCTURAL HEIGHT (FT):	18	EL. NORMAL POOL (FT):	402 (1902 Drawings)
HYDRAULIC HEIGHT (FT):	9	EL. MAXIMUM POOL (FT):	411 (1902 Drawings)

FOR INTERNAL MADCR USE ONLY

FOLLOW-UP INSPECTION REQUIRED: ☐ YES ☐ NO CONDITIONAL LETTER: ☐ YES ☐ NO

NAME OF DAM: SHAFT NO. 1 INTAKE DAM

STATE ID #: 3-14-321-1

NID ID #: MA02523

INSPECTION SUMMARY

DATE OF INSPECTION: June 26, 2007

DATE OF PREVIOUS INSPECTION: Unknown

TEMPERATURE/WEATHER: Hazy, 85 F

ARMY CORP PHASE I: ☐ YES ☑ NO If YES, date

CONSULTANT: GZA GeoEnvironmental, Inc.

PREVIOUS DCR PHASE I: ☐ YES ☑ NO If YES, date

BENCHMARK/DATUM: Unknown - Design drawings from 1902 do not describe datum used. Assumed Mean Sea Level.

OVERALL CONDITION: FAIR

DATE OF LAST REHABILITATION: Unknown

EL. POOL DURING INSP.: ~1" over spillway

EL. TAILWATER DURING INSP.: ~9' below spillway

PERSONS PRESENT AT INSPECTION

NAME	TITLE/POSITION	REPRESENTING
Anders B. Bjarngard, PE	Assoc. Principal/Geotech	GZA GeoEnvironmental, Inc.
David M. Leone, PE	Project Mgr/Hydrologist	GZA GeoEnvironmental, Inc.
Patricia Austin	Supervisor, Env. Quality Wachusett/Sudbury Watershed	DCR Division of Water Supply & Protection

EVALUATION INFORMATION

E1) TYPE OF DESIGN	3	E8) LOW-LEVEL OUTLET COND.	1
E2) LEVEL OF MAINTENANCE	3	E9) SPILLWAY DESIGN FLOOD	Unknown
E3) EMERGENCY ACTION PLAN	3	E10) GENERAL CONDITIONS	3
E4) EMBANKMENT SEEPAGE	5	E11) ESTIMATED REPAIR COST ($000)	200-400
E5) EMBANKMENT CONDITION	4	ROADWAY OVER CREST	☐ YES ☑ NO
E6) CONCRETE/MASONRY CONDITI	3	BRIDGE NEAR DAM	☐ YES ☑ NO
E7) LOW-LEVEL OUTLET CAP	1		

SIGNATURE OF INSPECTING ENGINEER:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM

STATE ID #: 3-14-321-1

NID ID #: MA02523

OWNER:		CARETAKER:	
ORGANIZATION	DCR Div. Water Supply & Protection	ORGANIZATION	Same as Owner
NAME/TITLE	Supervisor, Env Quality	NAME/TITLE	
STREET	180 Beaman Street	STREET	
TOWN, STATE, ZIP	W. Boylston MA 01583	TOWN, STATE, ZIP	
PHONE	508-792-7423	PHONE	
FAX	508-792-7805	FAX	
EMAIL	pat.austin@state.ma.us	EMAIL	
OWNER TYPE	State		

PRIMARY SPILLWAY TYPE: Arch-shape broad crested

SPILLWAY LENGTH (FT): 135

SPILLWAY CAPACITY (CFS): Unknown

AUXILIARY SPILLWAY TYPE: None

AUX. SPILLWAY CAPACITY (CFS): N/A

NUMBER OF OUTLETS: None

OUTLET(S) CAPACITY (CFS): N/A

TYPE OF OUTLETS: None

TOTAL DISCHARGE CAPACITY (CFS): Unknown

DRAINAGE AREQ (SQ MI): 57

SPILLWAY DESIGN FLOOD (PERIOD/CFS): 100-yr / Unknown

HAS DAM BEEN BREACHED OR OVERTOPPED ☐ YES ☑ NO IF YES, PROVIDE DATE(S)

FISH LADDER (LIST TYPE IF PRESENT): Present at left abutment--unknown type / design

DOES CREST SUPPORT PUBLIC ROAD? ☐ YES ☑ NO IF YES, ROAD NAME:

PUBLIC BRIDGE WITHIN 50' OF DAM? ☐ YES ☑ NO IF YES, ROAD/BRIDGE NAME:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

EMBANKMENT

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	SURFACE TYPE	Grassed; Top of stone masonry wall at upstream face.			
	SURFACE CRACKING	None observed			
	SINKHOLES, ANIMAL BURROWS	None observed			
	VERTICAL ALIGNMENT (DEPRESSIONS)	None observed			
	HORIZONTAL ALIGNMENT	Curved along upstream side of river--OK (1)			
	RUTS AND/OR PUDDLES	None observed			
	VEGETATION (PRESENCE/CONDITION)	Well-maintained grass. Some brush near upstream face. (2)			X
	ABUTMENT CONTACT	OK			

ADDITIONAL COMMENTS: (1) Embankment extends upstream on right side of dam; could be considered a dike. Low embankment, about 4-ft high (maximum). Similar condition as crest and downstream slope, with the exception of increased brush cover, which should be cleared.
(2) Isolated large trees on dike.

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

EMBANKMENT

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S SLOPE	WET AREAS (NO FLOW)	None observed. Shaft No 1 building & aqueduct discharge near toe of dam (1)			
	SEEPAGE	None observed. Shaft No 1 building & aqueduct discharge near toe of dam (1)			
	SLIDE, SLOUGH, SCARP	Minor depression in downstream slope near toe in vicinity of Shaft 1 building. (2)		X	
	EMB.-ABUTMENT CONTACT	OK			
	SINKHOLE/ANIMAL BURROWS	None observed.			
	EROSION	None observed.			
	UNUSUAL MOVEMENT	None observed.			
	VEGETATION (PRESENCE/CONDITION)	Grassed, well-maintained.			

ADDITIONAL COMMENTS: (1) Quinapoxet River and Quabbin Aqueduct discharge submerge portions of downstream area, obscuring observation.
(2) Minor depressions along training wall at right side of spillway.

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

EMBANKMENT

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S SLOPE	SLIDE, SLOUGH, SCARP SLOPE PROTECTION TYPE AND COND. SINKHOLE/ANIMAL BURROWS EMB.-ABUTMENT CONTACT EROSION UNUSUAL MOVEMENT VEGETATION (PRESENCE/CONDITION)	N/A			

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

EMBANKMENT

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
INSTR.	PIEZOMETERS	None observed			
	OBSERVATION WELLS	None observed			
	STAFF GAGE AND RECORDER	Appears to be a flow gage at the Quabbin Aqueduct downstream, but none at dam			
	WEIRS	None observed			
	INCLINOMETERS	None observed			
	SURVEY MONUMENTS	None observed			
	DRAINS	None observed			
	FREQUENCY OF READINGS	None taken			
	LOCATION OF READINGS	None taken			

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

UPSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S WALLS	WALL TYPE	Mortared large block stone masonry			
	WALL ALIGNMENT	Curved along upstream side			
	WALL CONDITION	Fair. Some missing stones near spillway crest on right side. (1)			X
	HEIGHT: TOP OF WALL TO MUDLINE	min: max: avg: 9			
	SEEPAGE OR LEAKAGE	None observed			
	ABUTMENT CONTACT	OK			
	EROSION/SINKHOLES BEHIND WALL	Minor depressions at right side		X	
	ANIMAL BURROWS	None observed			
	UNUSUAL MOVEMENT	None observed			
	WET AREAS AT TOE OF WALL	None observed			

ADDITIONAL COMMENTS: (1) Some missing mortar locally. Saplings growing within joints locally, particulary at top of wall on right side, near spillway. Missing stones are located on right side, just downstream and below the spillway weir crest.

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

DOWNSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S WALLS	WALL TYPE	Mortared large block stone masonry: spillway training wall at right; stone masonry fish ladder at left.			
	WALL ALIGNMENT	Curved, good			
	WALL CONDITION	Fair. Some missing stones near spillway crest on right side. (1)			X
	HEIGHT: TOP OF WALL TO MUDLINE	min: 9 max: 18 avg:			
	SEEPAGE OR LEAKAGE	At left side, fish ladder in poor condition. Leakage through right fish ladder wall just d/s of spillway (1)			X
	ABUTMENT CONTACT	OK			
	EROSION/SINKHOLES BEHIND WALL	Minor depressions at right side		X	
	ANIMAL BURROWS	None observed			
	UNUSUAL MOVEMENT	Stone masonry fish ladder in poor condition w/ missing stone, voids, displaced blocks.			X
	WET AREAS AT TOE OF WALL	Submerged by Quinapoxet River and Quabbin Aqueduct discharge			

ADDITIONAL COMMENTS: (1) Leakage near spillway about 2 ft below crest elevation. About 20 gpm through joint/void in vicinity of displaced stone block.
Scour and missing stones at fish ladder (throughout) on left side of spillway.

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

DOWNSTREAM AREA

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S AREA	ABUTMENT LEAKAGE	None observed			
	FOUNDATION SEEPAGE	None observed			
	SLIDE,SLOUGH,SCARP	None observed			
	WEIRS	None observed			
	DRAINAGE SYSTEM	None observed			
	INSTRUMENTATION	Monitoring of Quabbin Aqueduct flows downstream			
	VEGETATION	Grassed/wooded on right & left sides, respectively			
	ACCESSIBILITY	Access controlled by locked fences and gates at access roads			
	DOWNSTREAM HAZARD DESCRIPTION	Reportedly Significant due to roadway x-ing downstream & Shaft No. 1 Intake Building at toe of dam			
	DATE OF LAST EAP UPDATE	None			

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

MISCELLANEOUS

AREA INSPECTED	CONDITION	OBSERVATIONS
MISC.	RESERVOIR DEPTH (AVG)	Impoundment virtually full of coarse sediment
	RESERVOIR SHORELINE	Wooded
	RESERVOIR SLOPES	Moderate (river banks)
	ACCESS ROADS	Access to right abutment via private, gated roadway; to left via bike path (nearby)
	SECURITY DEVICES	Fencing, gates
	VANDALISM OR TRESPASS	YES: ☐ NO: ☑ WHAT:
	AVAILABILITY OF PLANS	YES: ☑ NO: ☐ DATE: 12/16/1902
	AVAILABILITY OF DESIGN CALCS	YES: ☐ NO: ☑ DATE:
	AVAILABILITY OF EAP/LAST UPDATE	YES: ☐ NO: ☑ DATE:
	AVAILABILITY OF O&M MANUAL	YES: ☐ NO: ☑ DATE:
	CARETAKER/OWNER AVAILABLE	YES: ☑ NO: ☐ DATE: 6/26/2007
	CONFINED SPACE ENTRY REQUIRED	YES: ☐ NO: ☑ PURPOSE:

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

PRIMARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	Concrete weir with granite block facing and concrete toe apron			
	WEIR TYPE	Broad-crested with slightly rounded downstream face (1)			X
	SPILLWAY CONDITION	Fair. Partially obscured by spillway overflow (2)			X
	TRAINING WALLS	Stone masonry (mortared). See Page 8 and 8A.			X
	SPILLWAY CONTROLS AND CONDITION	Uncontrolled			
	UNUSUAL MOVEMENT	None observed			
	APPROACH AREA	Quinapoxet River-mostly full of coarse sediment. (3)			X
	DISCHARGE AREA	Quinapoxet River; Confluence with Quabbin Aqueduct just downstream.			
	DEBRIS	Vegetative debris (see note 3).			X
	WATER LEVEL AT TIME OF INSPECTION	About 1 inch over spillway			

ADDITIONAL COMMENTS: (1) Vegetation growing within joints, particularly at left side. Fish ladder at left side in poor condition--see page 8A.
(2) Concrete apron at higher elevation at right side. Deflection groin extends about 75-ft downstream. Apron is in fair condition, with some pitting and erosion. Toe of spillway weir exhibits scour damage, especially at left side near bedrock outcrops.
(3) Vegetation growing upstream of weir at left side, diverting flow to right side.

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

AUXILIARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	N/A			
	WEIR TYPE				
	SPILLWAY CONDITION				
	TRAINING WALLS				
	SPILLWAY CONTROLS AND CONDITION				
	UNUSUAL MOVEMENT				
	APPROACH AREA				
	DISCHARGE AREA				
	DEBRIS				
	WATER LEVEL AT TIME OF INSPECTION				

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM

STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007

NID ID #: MA02523

OUTLET WORKS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
OUTLET WORKS	TYPE	N/A			
	INTAKE STRUCTURE				
	TRASHRACK				
	PRIMARY CLOSURE				
	SECONDARY CLOSURE				
	CONDUIT				
	OUTLET STRUCTURE/HEADWALL				
	EROSION ALONG TOE OF DAM				
	SEEPAGE/LEAKAGE				
	DEBRIS/BLOCKAGE				
	UNUSUAL MOVEMENT				
	DOWNSTREAM AREA				
	MISCELLANEOUS				

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
GENERAL	TYPE	N/A			
	AVAILABILITY OF PLANS				
	AVAILABILITY OF DESIGN CALCS				
	PIEZOMETERS				
	OBSERVATION WELLS				
	INCLINOMETERS				
	SEEPAGE GALLERY				
	UNUSUAL MOVEMENT				

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM

STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007

NID ID #: MA02523

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S FACE	TYPE SURFACE CONDITIONS CONDITIONS OF JOINTS UNUSUAL MOVEMENT ABUTMENT CONTACTS	N/A			

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007 NID ID #: MA02523

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S FACE	TYPE SURFACE CONDITIONS CONDITIONS OF JOINTS UNUSUAL MOVEMENT ABUTMENT CONTACTS DRAINS LEAKAGE	N/A			

ADDITIONAL COMMENTS:

NAME OF DAM: SHAFT NO. 1 INTAKE DAM

STATE ID #: 3-14-321-1

INSPECTION DATE: June 26, 2007

NID ID #: MA02523

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS
CREST	TYPE SURFACE CONDITIONS CONDITIONS OF JOINTS UNUSUAL MOVEMENT HORIZONTAL ALIGNMENT VERTICAL ALIGNMENT	N/A

ADDITIONAL COMMENTS:

APPENDIX D

PREVIOUS REPORTS AND REFERENCES

REFERENCES

The following is a list of reports that were located during the file review, or were referenced in previous reports.

1. Drawing: "Wachusett Reservoir Sec.10, Circular Concrete Dam, Quinepoxet River," Metropolitan Water Works, December, 1902.
2. Drawing: "Proposed Granite Facing for Crest of Quinapoxet Dam," Metropolitan District Commission Water Division, July, 1921.
3. Drawing: "Plan of Fish Ladder Over Metropolitan District Commission Dam on the Quinapoxet River," K.M. Finlayson, September, 1935.
4. Drawing: "Masonry Fish Ladder at the Circular Dam on the Quinapoxet River," July, 1936.

The following references were utilized during the preparation of this report and the development of the recommendations presented herein.

1. Commonwealth of Massachusetts Regulations, 302 CMR 10.00 – Dam Safety, Effective 11/4/05

APPENDIX E

DEFINITIONS

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to 302 CMR10.00 Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA. Please note should discrepancies between definitions exits, those definitions included within 302 CMR 10.00 govern for dams located within the Commonwealth of Massachusetts.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Size Classification
(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

Large – structure with a height greater than 40 feet or a storage capacity greater than 1,000 acre-feet.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 50 to 1,000 acre-feet.

Small – structure with a height between 6 and 15 feet and a storage capacity of 15 to 50 acre-feet.

Non-Jurisdictional – structure less than 6 feet in height or having a storage capacity of less than 15 acre-feet.

Hazard Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. On million U.S. gallons = 3.068 acre feet
Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

Unsafe - Major structural, operational, and maintenance deficiencies exist under normal operating conditions.

Poor - Significant structural, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

Satisfactory - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.

APPENDIX J

PUBLIC NOTICE

Expanded Environmental Notification Form
Supplemental Information Report

The Massachusetts Water Resources Authority

Charlestown Navy Yard

100 First Avenue, Building 39

Boston, Massachusetts 02129

May 2021

PUBLIC NOTICE OF ENVIRONMENTAL REVIEW

PROJECT: Quinapoxet Dam Removal

LOCATION: River Road, West Boylston, Massachusetts

PROPONENT: Massachusetts Water Resources Authority

The undersigned is submitting an Environmental Notification Form ("ENF") to the Secretary of Energy & Environmental Affairs on or before
June 1, 2021

This will initiate review of the above project pursuant to the Massachusetts Environmental Policy Act ("MEPA", M.G.L. c. 30, s.s. 61-62I). Copies of the ENF may be obtained from:

Massachusetts Water Resources Authority https://www.mwra.com/01news/2021/030121-quinapoxet-dam-notice.html

Or

SLR International Corporation, attn: Aidan Barry, abarry@slrconsulting.com, (203) 271-1773

During the interim Covid-19 response period, electronic copies of the ENF are also being sent to the Conservation Commission and Planning Board of West Boylston.

The Secretary of Energy & Environmental Affairs will publish notice of the ENF in the Environmental Monitor, will receive public comments on the project for 20 days, and will then decide, within ten days, if an environmental Impact Report is needed. A site visit and consultation session on the project may also be scheduled. All persons wishing to comment on the project, or to be notified of a site visit or consultation session, should write to the Secretary of Energy & Environmental Affairs, 100 Cambridge St., Suite 900, Boston, Massachusetts 02114, Attention: MEPA Office, referencing the above project.

By: Massachusetts Water Resources Authority

TELEGRAM&GAZETTE
telegram.com

Order Confirmation

Ad Order Number	Customer	Payor Customer	PO Number
0000469590	SLR	SLR	
Sales Rep.	**Customer Account**	**Payor Account**	**Ordered By**
tgivins	1000019374	1000019374	
Order Taker	**Customer Address**	**Payor Address**	**Customer Fax**
tgivins	99 REALTY DRIVE CHESHIRE CT 06410 USA	99 REALTY DRIVE CHESHIRE CT 06410 USA	
Order Source			**Customer EMail**
Rep	**Customer Phone**	**Payor Phone**	
	475-244-2314	475-244-2314	**Special Pricing**
			None

Invoice Text	Ad Order Notes	Materials	Promo Type	Blind Box

Tear Sheets	Net Amount	Tax Amount	Total Amount	Payment Method	Payment Amount	Amount Due
0	$204.00	$0.00	$204.00	Credit Card - Visa:0322	$204.00	$0.00

Ad Number	Ad Type	Ad Size	Color	Production Method	Production Notes
0000469590-01	1Legal	: 1.0 X 4.0000"	<NONE>	AdBooker	

External Ad Number	Ad Attributes	Ad Released	Pick Up	Affidavits	Proofs
		No		0	0

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