Stream Continuity Assessment in the Taunton Watershed

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TAUNTON RIVER WATERSHED ALLIANCE, INC.
TRWA

Stream Continuity Assessment in the Taunton River Watershed

Table of Contents

List of Tables[1]

[1] There are a few instances throughout the Tables and Appendices that appear to show "duplicate" sites. Some sites may have been surveyed more than once and the surveys assigned separate Survey Identification numbers in the database.

List of Figures

Acknowledgments//

This report was prepared by Mass Audubon and the Taunton River Watershed Alliance, Inc. (TRWA). Priscilla Chapman, TRWA, compiled the data and tables and authored the report. E. Heidi Ricci, Mass Audubon, coordinated the project and edited the report. Christina Wiseman, Mass Audubon, performed final copyediting and layout. This is a project of Mass Audubon's Advocacy Department and its *Shaping the Future of Your Community* program, overseen by Jack Clarke, Director of Public Policy and Government Relations, and coordinated by Stefanie Covino.

Mass Audubon works to protect the nature of Massachusetts for people and wildlife through conservation, education, and advocacy. Mass Audubon's *Shaping* program informs, connects, and empowers people in the fastest developing parts of the state, including the Taunton watershed, to take action to create resilient communities through smart development and targeted natural resource protection. TRWA's mission is the protection and restoration of the water quality and aquatic ecosystems of the Taunton River and its tributaries and other habitats and ecosystems of the watershed.

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The assessment and prioritization of stream crossings for improvements across the Taunton watershed is a complex, ongoing endeavor. Numerous other volunteers and municipal, regional, state, and federal officials play important, ongoing roles. We thank everyone for their efforts to improve the connectivity of streams throughout the Taunton watershed.

Executive Summary

Streams are important natural systems that support a wide variety of native plant and animal species. Streams and adjacent riparian corridors also provide many benefits for people, including opportunities for recreation and enjoyment. Clean and intact streams support fisheries and water supplies, and natural vegetated streamside areas help absorb and filter water and prevent flooding.

Streams have been altered in many ways by human activity. In Massachusetts, tens of thousands of manmade structures (bridges, culverts, fords) enable roads and rail lines to cross rivers and streams. These structures often alter natural conditions and create barriers to movement of fish, other aquatic life, and many animals too – e.g. turtles and mammals. They can also cause conditions that impact human health, safety and welfare such as flooding, flow blockages, stagnation, elevated pollution levels, mosquito breeding habitat, and erosion of banks and riverfront areas.

"Stream continuity" refers to the uninterrupted connection of a river network where natural physical conditions and dynamic fluvial processes have not been significantly altered and in which water, organisms, organic material, and naturally mobilized sediments move freely. This free movement is essential to maintain healthy and diverse populations of aquatic life.

Southeastern Massachusetts, like many other coastal areas, is experiencing higher sea levels and tides and more frequent and intense storm events. These conditions are believed to be impacts of global climate change and are predicted to worsen in future years. Stream crossings that block the free flow of water exacerbate these conditions. Restoring stream continuity provides storage and passage for floodwaters, and helps to create resilient watersheds that will be better able to maintain ecosystem functions under future conditions.

The **Critical Linkages Project**[2] was designed to assess connectivity of ecological systems in Massachusetts and identify areas where natural stream connections are priorities for protection or restoration. Using spatial data of the Massachusetts landscape and a computer model that predicted the condition and passability of existing stream crossings, Critical Linkages calculated an "Impact" score for each crossing that estimated "ecological restoration potential," i.e., the amount of improvement in the ecological health of a water body if a crossing structure in that location were removed or replaced. Impact scores were divided into five tiers, ranging from Tier 1 that included sites with highest potential for ecological restoration to Tier 5 that included sites with lowest potential.

The Project identified 1,317 potential crossing sites in the Taunton River Watershed. Of these sites, 24 were ranked as Tier 1, with the highest ecological restoration potential; 108 sites were in Tier 2; 217 in Tier 3; 375 in Tier 4; and 593 in Tier 5. The rankings are periodically updated as additional information becomes available from field assessments and refinements to the model.

The **River and Stream Continuity Project**[3] was created by a partnership that includes the University of Massachusetts at Amherst, The Nature Conservancy, the Massachusetts Division

[2] www.umasscaps.org/applications/critical-linkages.html
[3] www.streamcontinuity.org

of Ecological Restoration (formerly Riverways Program) and American Rivers to develop a systematic approach to assessing and prioritizing stream crossings in order to improve aquatic continuity. The project has expanded throughout 13 states and is now known as the North Atlantic Aquatic Connectivity Collaborative (NAACC). It trains volunteers and technicians in the use of standardized protocols to inventory river and stream road crossings by recording specified measurements and observations into a database. Using 13 variables from the field assessments, the database generates an Aquatic Score that indicates the degree to which the crossing creates a barrier to aquatic passage and assigns each crossing to one of five categories: severe, significant, moderate, minor or insignificant barrier.

Under the direction of this Project, 516 crossing surveys were conducted in 27 of the municipalities in the Taunton River watershed between 2006 and 2014. Initial efforts focused on sites that were ranked in Tiers 1, 2 or 3 by the Critical Linkages Project, but some sites in the lower two tiers were also assessed as the project proceeded.

Section 6 of this report summarizes the results of these field assessments, i.e., the degree to which each crossing represents a barrier to aquatic passage. Of the 516 sites surveyed, the crossings were evaluated as follows:

Evaluation	# of sites
Severe barrier	1
Significant barrier	31
Moderate barrier	108
Minor barrier	245
Insignificant barrier	112

19 additional sites identified in the Critical Linkages Database were visited but recorded as "No Data" because no stream crossing was found.

Of the 516 sites, 375 matched a Critical Linkage site and 141 did not. The single site identified as a severe barrier to aquatic passage did not match and therefore had no Impact_In score. The 139 crossings evaluated as significant or moderate barriers to passage were further broken down as follows:

Critical Linkage site match	98
Tier 1 or Tier 2 site for ecological restoration	41 (10 of which were significant barrier crossings, 31 of which were moderate barrier crossings)

These sites are described in Section 7.

Note that some of the field surveys were completed several years ago. Crossing upgrades or replacements may have been completed subsequently in particular locations, or conditions may have degraded due to ongoing erosion or storms.

This report also provides information regarding the condition, alignment and degree of constriction of the surveyed crossings as recorded by the observers. This information may be useful to cities and towns in prioritizing crossing sites that need remediation. Complete lists of surveyed sites sorted by town and by sub-watershed of the Taunton River system are provided in Appendices A and B.

To restore stream continuity and healthy aquatic ecosystems for the future, crossings that create the barriers to passage must be replaced with structures that are designed and constructed to maintain natural streamflow and other natural conditions to the greatest extent possible. Cities and towns in the Taunton River watershed have critical roles in initiating and advancing replacement projects that will benefit ecological systems as well as human health, safety and welfare. This report is intended as a guide for residents and municipal officials to prioritize opportunities to improve streamflow through replacement of existing culverts and other crossing structures. It also identifies sources of information and assistance to municipalities that pursue such projects.

Residents of the Taunton River Watershed can get involved in many ways:

- Review the field data sheets for crossings located in your area at http://www.streamcontinuity.org/cdb2;
- Make field trips to observe the conditions of streams and crossings;
- Get trained in the field assessment methodology and/or encourage your local officials to be trained;
- Express your interest and concern to your local officials (e.g. Mayor or Selectmen, Conservation Commission, Planning Board and Department of Public Works) for upgrade or replacement of substandard crossings;
- Support efforts of local boards and officials who attempt to advance these projects;
- Support the inclusion of stream crossing assessment and upgrades in other local initiatives such as transportation improvement projects or the municipal Master Plan, Open Space and Recreation Plan, and Hazard Mitigation Plan;
- Connect with others – talk with your friends and neighbors, and get involved with organizations that support stream restoration.

We'd like to hear about and support your efforts and your success stories. See the contact lists and resources at the end of this report to learn more and connect with groups that can help.

Section 1. The Importance of Stream Continuity[4]

Under natural conditions in a stream or river, water, organisms, sediment, and organic material move freely. The movement is affected by seasonal cycles of flooding and low flow. The combination of free movement and seasonal variations supports a healthy and vibrant natural stream. These dynamic natural processes maintain conditions that provide habitat for native fish and other aquatic life.

"Stream continuity" refers to the uninterrupted connection of a river network where the natural physical characteristics of the stream have not been significantly altered and few or no barriers exist that would hinder or block movement up and downstream through the system.

Manmade stream crossings (bridges, culverts, fords) often alter the natural conditions and create barriers to movement.

Clogs from debris like this can also inhibit passage of fish and other wildlife

Impacts on Fish and Wildlife: Stream crossing barriers interfere with the processes that support animal and plant life. For example, crossings that are too small or have internal blockages restrict or prohibit passage of fish and other organisms. Crossings that are perched above the level of the stream may have streamflow that is too shallow to allow fish passage, or create an obstacle to passage that some fish and other organisms cannot overcome. Drops in elevation at the inlet or outlet of a crossing require animals to leap or climb, and some species lack this ability. The velocity of constricted water and the smoothness of pipes can further impede navigation through culverts. Some species require dry banks or rough sediments to navigate along streams. Animals that encounter a culvert they cannot traverse, or that they do not feel safe entering, will be prevented from crossing. Reptiles, amphibians, and mammals may climb into the roadway where they are at risk of being run over.

Infrastructure and Safety Impacts: Inadequate crossings can also create conditions that impact human health, safety and welfare. Undersized crossings reduce capacity to accommodate water surges during large storms, causing water backup, flooding of roads and property, erosion of banks and riverfront and elevated turbidity and sedimentation levels. In some instances, the constriction of water can erode the roadbed and threaten integrity of a road or railroad.

Water Quality and Human Health Impacts: Water that backs up behind undersized crossings can become stagnant, impairing water quality and habitat for fish that need clean, flowing water. Stagnant water can also provide breeding areas for potentially disease-bearing mosquitoes, and this is further exacerbated if fish that consume mosquito larvae are blocked from accessing a section of a stream.

[4] This discussion of stream continuity is derived from information on NAACC's website at www.streamcontinuity.org.

Climate Change: Precipitation patterns have been changing in recent decades. High intensity storms are increasing, interspersed with prolonged dry periods and droughts. Southeastern Massachusetts, like many other coastal areas, is experiencing higher sea levels and tides. These conditions are believed to be impacts of global climate change and are predicted to worsen in future years[5]. The Taunton watershed is particularly vulnerable to flooding, because it has a low gradient, dropping only 26 feet over the course of 40 miles. Tidal flows influence the river as much as 22 miles inland.[6] In this landscape setting, a heavy storm event combined with coastal storm surge could lead to serious flooding. The ability of water to drain from the landscape across roads and railroads is important to protect communities from flooding.

In order to protect "ecosystem services," such as flood protection and provision of food and water supplies, and to enhance the capacity of natural systems to adjust to new stresses and disturbances, our region like many others has recognized the need to create a "resilient" watershed. Restoring stream continuity provides storage and passage for floodwaters. It enables fish and other animals to move across the landscape and find refugia during extreme weather events. It is an important and effective tool to develop resilient communities and a resilient watershed that will be better able to handle future conditions.

Why is Aquatic Movement Important?

Aquatic ecosystems are in constant change. Animals need to move around. On a daily basis they travel to forage for food or to find cover and shelter from predators. Sometimes they need to move to avoid extreme weather, heat, icing, pollution, drought, flooding, or other natural or manmade disturbances. On a seasonal basis, animals may move upstream or downstream to find mates and to move between breeding and feeding areas. Fish require access to spawning areas such as gravel banks, scour holes, or floodplains, as well as nursery habitat for juvenile fish and then adult habitat for maturing fish. Anadromous species such as herring spend the winter in the ocean, but travel upriver in the spring to spawning grounds. Catadromous species such as eels reverse the travel pattern and spawn in the ocean. Maintaining stream continuity keeps the pathways for migration open.

On a longer time frame mobility of individual organisms is necessary to allow interaction with other populations of the same species. These interactions contribute to the ability of populations to remain genetically viable and persist over time.

Under natural conditions, aquatic habitats are constantly shifting and changing, and free movement of woody debris, organic material, and sediments around the system is essential. As the array of stream habitats including banks, wetlands, gravel or cobbled substrate, pools, rocks, and rapids shift, the animals that rely on them need to relocate as well. If a food source moves, animals must follow. Headwaters and other upstream areas are highly productive, and stream continuity ensures the continued transport of food to animal populations downstream.

Conditions in the stream itself also undergo constant change. The depth, velocity, turbulence, temperature, turbidity, and chemistry (such as dissolved oxygen levels) of the water fluctuate and aquatic organisms need to move in response to these changes. Some species need deep, fast-moving water for travel while others require slow-moving, shallow conditions. Coldwater

[5] https://necsc.umass.edu/northeast-climate
[6] http://pubs.usgs.gov/sir/2012/5277/pdf/sir2012-5277_report_508.pdf

fish need to swim upstream in search of cooler waters when temperatures downstream warm in spring and summer. Climate change makes it all the more important for animals to be able to move around the landscape in response to drought, floods, and temperature extremes.

Small streams, often located in headwaters, are critical to the health of a river system. They account for most of the stream miles within any watershed, provide more diverse habitat than large rivers including areas for spawning and juvenile nurseries, and support many animals that do not inhabit larger streams, such as salamanders and crayfish. Thanks to their proximity to adjacent upland habitats, small streams are also highly productive systems. Organisms that originate in upstream areas and travel or are carried downstream provide food for fish that mainly inhabit areas of the lower river system[7].

For all these reasons, the impact of a crossing that alters natural conditions of the stream and its banks is likely to be the decline of habitat or population.

Barriers to Movement in Streams

Most of the streams in the Taunton River watershed and in watersheds across the Commonwealth are crossed by transportation corridors. The crossings have varying interactions with rivers and streams. All of these crossings should allow the natural stream to flow without obstruction, but many do not. Some examples of barriers associated with crossings include:

- Partially or fully collapsed culverts or culverts that are blocked with debris, which reduce flow and impede animal passage;
- Weirs or baffles installed within a culvert to decrease velocity that can block passage for species that crawl on the streambed;
- Drops in elevation at the inlet or outlet, creating barriers to passage for fish and other organisms;
- Flow constrictions that increase velocity. Some species cannot swim against the faster flow, and fast-moving water can also create scour areas below the culvert which some organisms cannot navigate;

An example of a drop in elevation at Fall Brook, North Walker Street, Taunton

- If the crossing structure eliminates the natural streambank or replaces the natural streambed with a concrete or metal bottom, organisms that rely on the natural conditions of the bank or streambed to assist their movement will be immobilized.

[7] https://www.streamcontinuity.org/aquatic_connectivity/ecological_concerns/import_sm_streams.htm

Cost of Upgrade vs. Replacement In-Kind

The immediate costs of upgrading a culvert may be relatively high in comparison to simple replacement, but when the long-term integrity of the road is taken into account, along with the increased hazards associated with more intense storms, the investment is often worthwhile over the useful life of the structure.

For example, a March 2015 report by Industrial Economics (IE) for the Massachusetts Division of Ecological Restoration (DER), "Economic and Community Benefits from Stream Barrier Removal Projects in Massachusetts," compared the costs of alternatives facing the owners of undersized culverts and failing dams. The costs for replacing three specific culverts and maintaining them for over thirty years were compared with the cost of upgrading the crossings to comply with the Commonwealth's Stream Crossing Standards. On average, upgrade of the three culverts was 38% less expensive than in-kind replacement and maintenance over 30 years. *(Section 8 describes a stream crossing replacement "success story" in the Taunton River watershed.)*

An example of a site stressed both by the culvert and stormwater (the two smaller pipes shown here are for stormwater discharge; note the large mound of sedimentation below the one on the left).

Section 2. The Taunton River, its Tributaries and Watershed

The retreat of a glacier from southeastern Massachusetts thousands of years ago left a glacial lake, which in turn drained into a river system with a watershed covering an area of 562 square miles[8]. As a result of glacial deposition, the landscape of the watershed included flat outwash plains, abundant wetlands, and kettle ponds. Today we know this area as the Taunton River watershed, the second largest in Massachusetts. It includes all or portions of forty-three municipalities. The Taunton River itself flows forty miles from the confluence of the Town and Matfield Rivers in Bridgewater to Mount Hope Bay. It is characterized by a gentle gradient because it drops only twenty feet in elevation over its entire course. The network of large and small tributaries to the Taunton River represents hundreds of stream miles.

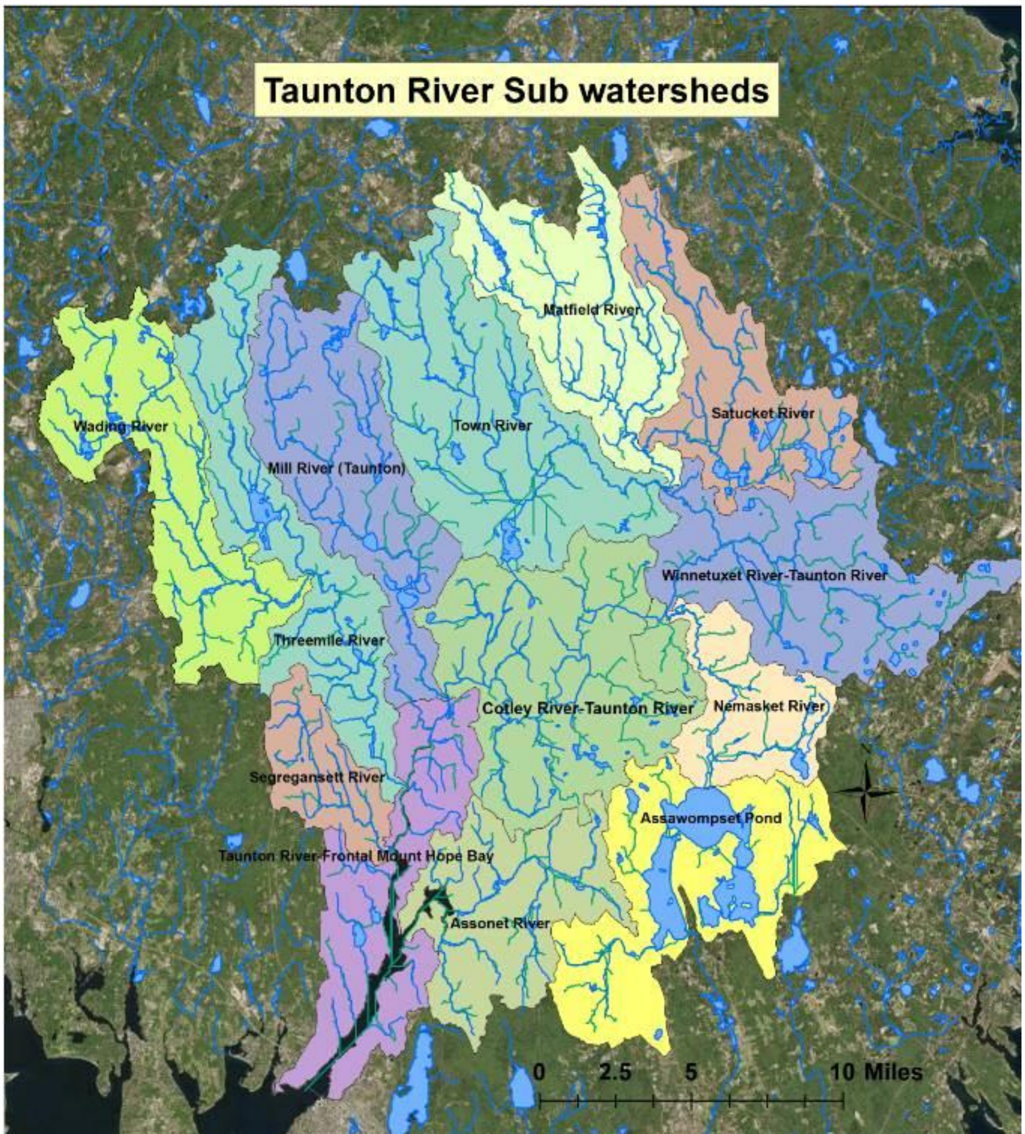

Figure 1: Map of the Taunton River Watershed[9]

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[8] http://savethetaunton.org/the-taunton-river-and-its-watershed/. This information is a summary of the Taunton River Stewardship Plan.

[9] Higher resolution versions of maps are available on request.

The river and its tributaries collectively represent a remarkably intact ecosystem of habitats that support 45 species of fish, 154 species birds, 360 species of plants and many other organisms. The watershed includes 31 distinctive wildlife habitats, including globally-rare freshwater and brackish tidal marshes, Atlantic White Cedar swamps, Acidic Graminoid Fens and hundreds of vernal pools. Coldwater streams in the watershed support the globally-rare bridle shiner and rainbow smelt. Overall, 58 species listed by the Massachusetts Natural Heritage and Endangered Species Program as "endangered", "threatened" or "of special concern" inhabit the watershed; these species include seven rare reptiles and amphibians, twelve birds and three freshwater mussels. The watershed contains three state-designated Areas of Critical Environmental Concern (ACECs).

The forty miles of the Taunton River flow unimpeded, representing the longest undammed coastal river in New England. In recognition of its free-flowing water, ecological diversity and other values, the Taunton River was granted designation as a "National Wild and Scenic River" by Congress in 2009. The ecological richness of the estuary and upstream portions of the river are in part attributable to the free-flowing water, the low gradient and the brackish tidal influence that extends twenty miles upriver from the Bay. At the same time, the river's biodiversity and productivity would be significantly diminished without the intricate network of feeder streams and headwaters that allow free movement of creatures, material and water and support critical ecological and physical processes that keep the Taunton River healthy.

Major Tributaries of the Taunton River

The Taunton River Stewardship Plan[10], completed in June of 2005 to support the addition of the river to the federal Wild and Scenic Rivers System, identified eight major tributaries to the river: the **Segregansett, Three Mile, Forge, Town, Matfield, Winnetuxet, Nemasket and Assonet.**

The Taunton River Watershed Stream Continuity Project included field surveys of crossings in each of these sub-watersheds and on smaller tributaries to the Taunton River. In this report, we also consider the **Mill River** as a major tributary, based on the size of its watershed. The **Forge River** is considered one of a group of smaller tributaries to the **Taunton River**. The watersheds of the smaller tributaries are divided into two areas: the **"Cotley River Sub-watershed"** in the area of Raynham, Taunton and Berkley, and the **"Lower Taunton River Coastal Sub-watershed"** in the area of Dighton, Somerset, Freetown and Fall River.

The sections below provide brief descriptions of each sub-watershed and a map or maps of the area. The Taunton River Watershed Stream Continuity Project included field surveys of crossings in each of the major sub-watersheds as well as in smaller tributaries to the Taunton River.

The **Segregansett River** originates in east Taunton north of Route 140 and flows about 8.2 miles to its confluence with the

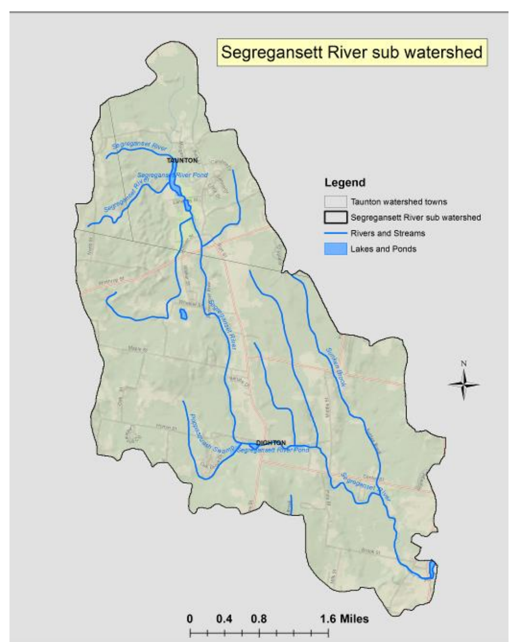


Figure 2

[10] http://www.tauntonriver.org/stewarshipplan.htm

Taunton River in Dighton about a mile south of the Berkley Bridge. The watershed lies entirely within Dighton and Taunton. Part of the river's headwaters in Taunton are designated Priority Habitat for rare species.

The **Wading River** drainage area (shown on the adjacent map) constitutes a major sub-watershed of the Three Mile River drainage area. Tributaries to the Wading River include Chartley Brook which originates in Attleboro, Meadow Brook in Wrentham, Cocasset River and Henkes Brook in Foxboro and Hodges Brook in Mansfield. The area also includes Lake Mirimichi and Turnpike Lake in Plainville. The Wading River is 13.9 miles long.

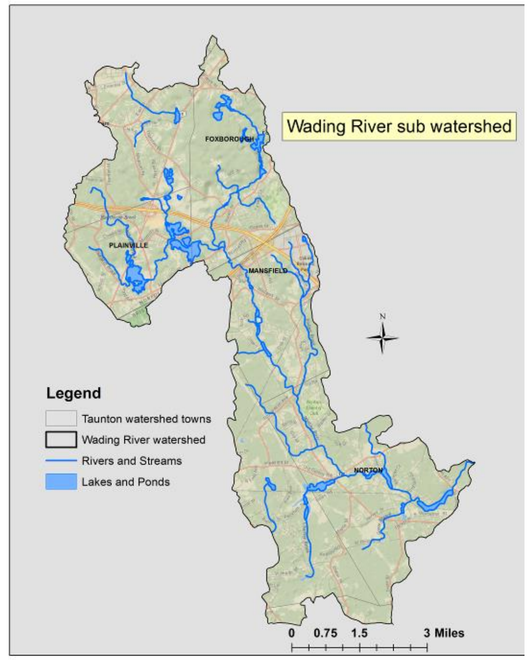


Figure 3

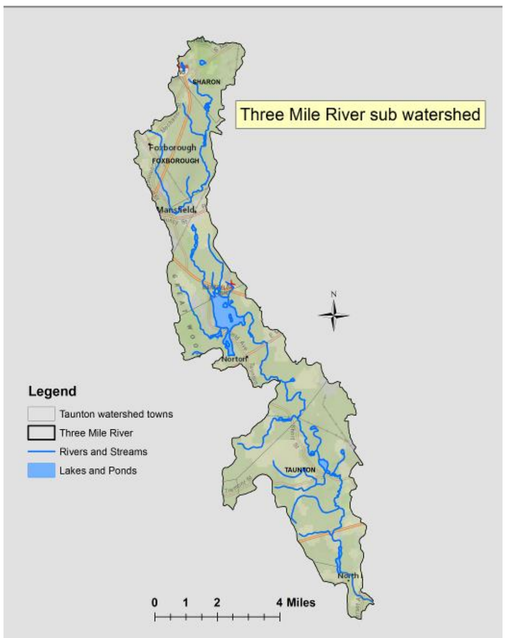


Figure 4

The **Three Mile River** is formed by the confluence of the Wading and Rumford Rivers in Norton. It flows southeast for about 3 miles through a silver maple floodplain forest in Taunton. This forest is considered to be the most intact example of this declining natural community in Massachusetts. The Three Mile joins the Taunton River at the Taunton/Dighton boundary. An area of 14,276 acres of the river's corridor in Dighton, Taunton and Norton was designated an ACEC in 2008.

The entire area that drains to the Three Mile River includes parts of Attleboro, Wrentham, Plainville, Foxboro, Mansfield, Norton, Taunton and Dighton. The adjacent map shows the drainage area of the Rumford River and the drainage area of the mainstem of the Three Mile River. The Rumford River is 12.5 miles long.

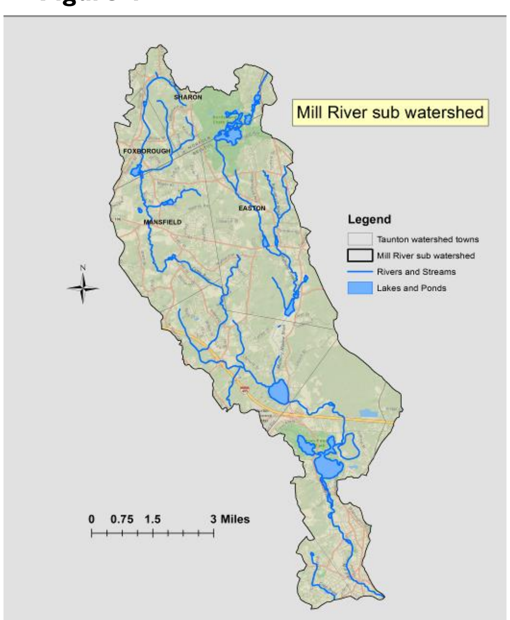


Figure 5

The **Mill River** runs out of Lake Sabbatia in Taunton and flows for 3.4 miles to join the Taunton River at High Street. It is fed by a large upstream drainage area that includes the watersheds of the Canoe River and the Mulberry, Meadow and Poquanticut Brooks. The Canoe River flows for 14.3 miles from Sharon, through Foxboro and Mansfield to Winnecunnet Pond in Norton. Mulberry Brook and its tributaries originate in Easton and also flow to Winnecunnet Pond. The Snake River connects Winnecunnet Pond to Lake Sabbatia. The Canoe River and associated resources encompassing 17,200 acres were designated an ACEC in 1991.

Two dams on the Mill River (the Whittenton and Hopewell Mills dams) were recently removed and a fish ladder was installed at Morey's Bridge at the outlet of Lake Sabbatia. Efforts to remove a third dam are underway. This removal will eventually open up an additional thirty miles of upstream fish passage.

The **Town River** originates in the 6,000-acre Hockomock Swamp near the West Bridgewater/Bridgewater town line at the conjunction of the Hockomock River and a feeder stream from Lake Nippenicket. It flows about ten miles, crossing into Bridgewater and joining the Matfield River to form the Taunton River. Besides the Hockomock River watershed, the drainage area of the Town River also includes the Coweeset Brook watershed that spans portions of West Bridgewater, Easton, Stoughton and Brockton.

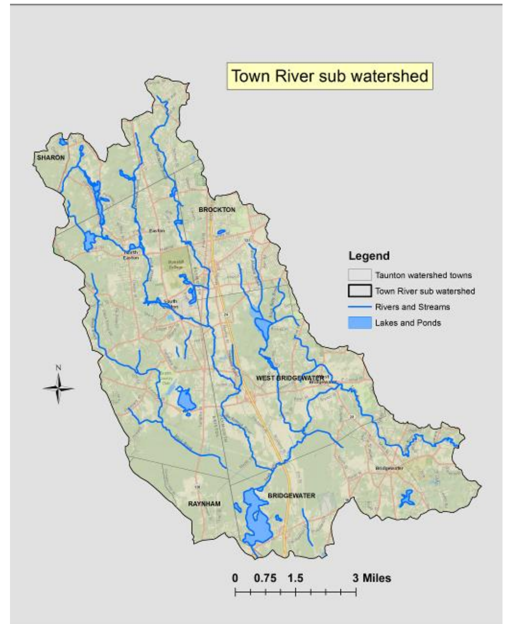
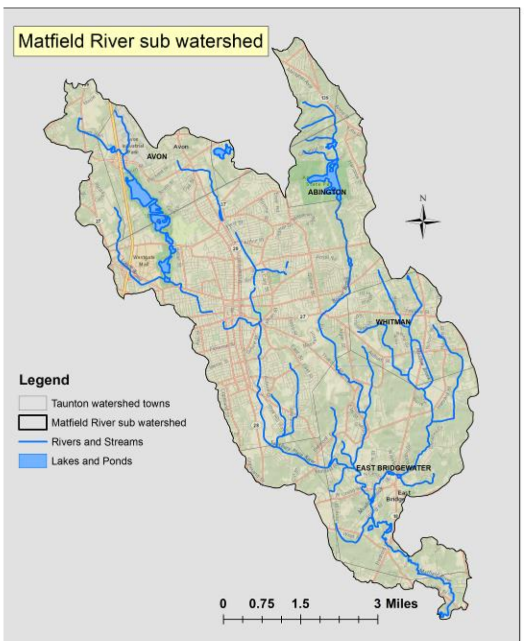


Figure 6

The Hockomock Swamp is a former glacial lake and the Commonwealth's largest freshwater wetland. Spanning portions of Easton, Raynham, Taunton, and West Bridgewater, it includes extensive areas of Atlantic White Cedar Swamp as well as Acidic Graminoid Fens, both identified by the Massachusetts Natural Heritage and Endangered Species Program as Priority Natural Communities. It supports bird species that require deep interior forest habitat and at least thirteen state-listed species including blue-spotted salamanders and the "threatened" Blanding's turtle. Nearly 17,000 acres in and around Hockomock Swamp have also been designated an ACEC. The majority of the Hockomock Swamp is protected by the Commonwealth as a Wildlife Management Area.



The **Matfield River** originates in East Bridgewater at the confluence of Beaver Brook and a smaller stream and flows 6.6 miles generally south into Bridgewater where it joins the Town River to form the Taunton River. Its drainage area includes the watershed of the Salisbury Plain River in Brockton.

The **Satucket River** is a major tributary of the Matfield. Its drainage area includes portions of Whitman and Abington where the Shumatuscacant River originates. It extends east to Hanson and also includes the Burrage Pond Wildlife Management Area, Mass Audubon's Stump Brook Wildlife Sanctuary and the Monponsett Ponds in Halifax. Plans are underway to remove a dam in West Bridgewater on the Satucket, which will open up an additional 4.4 miles of stream and provide anadromous fish with access to over 100 additional acres of spawning habitat.

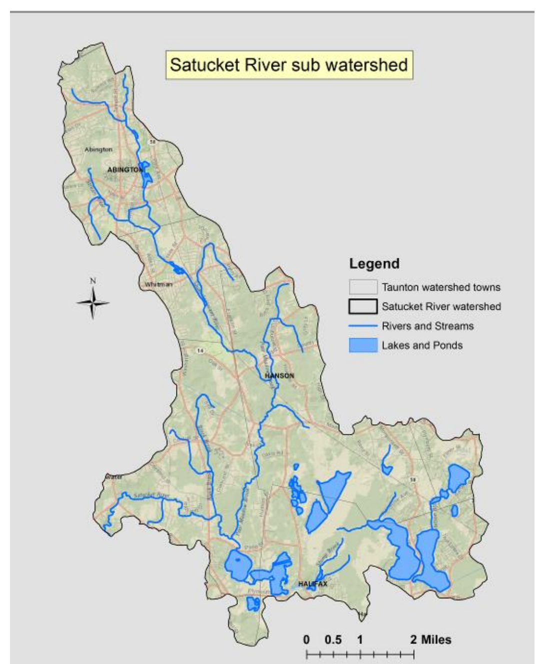


Figure 8

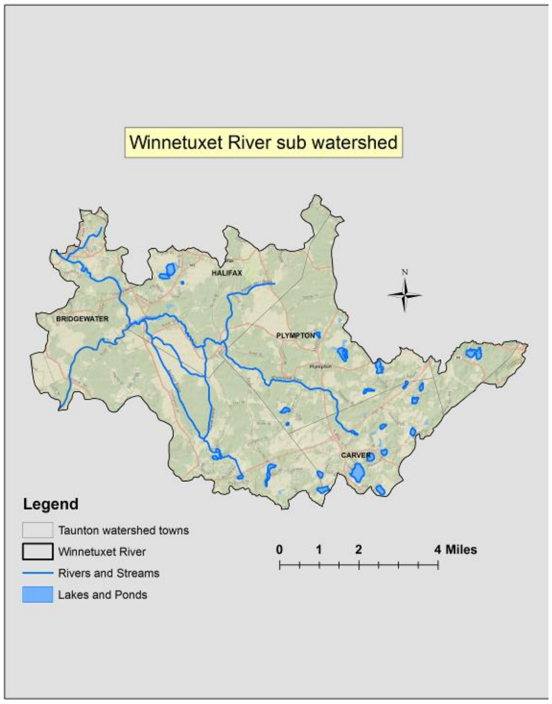


Figure 9

The **Winnetuxet River** originates in Carver at the confluence of Doten Brook and Muddy Pond Brook and flows 11.8 miles through Plympton and south Halifax to join the Taunton River at the boundary of Halifax and Bridgewater. Muddy Pond, a headwater area in Carver is designated as Priority Habitat, and the Winnetuxet flow through several Priority Habitat areas in Plympton. Its drainage area also includes the watersheds of Raven and Bartlett Brooks in Middleborough.

The **Nemasket River** flows out of the Assawompset Pond in Lakeville and travels 5.3 miles north and west through Middleborough to join the Taunton River. The historic Oliver Mills Dam and fish ladder is a favorite viewing place for the spring alewife run.

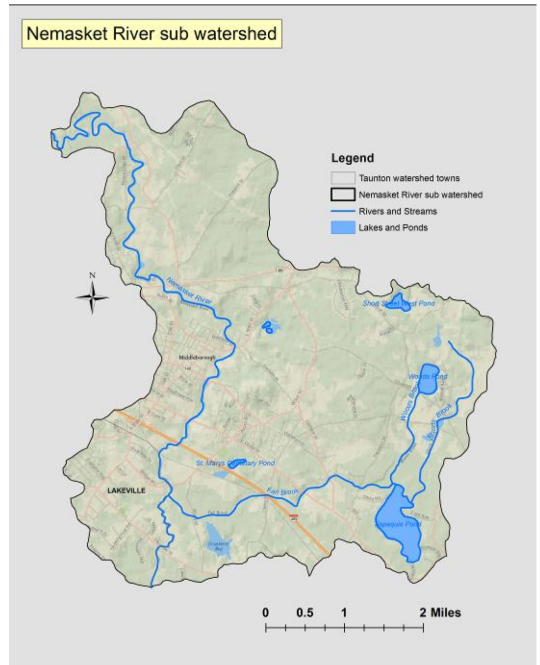
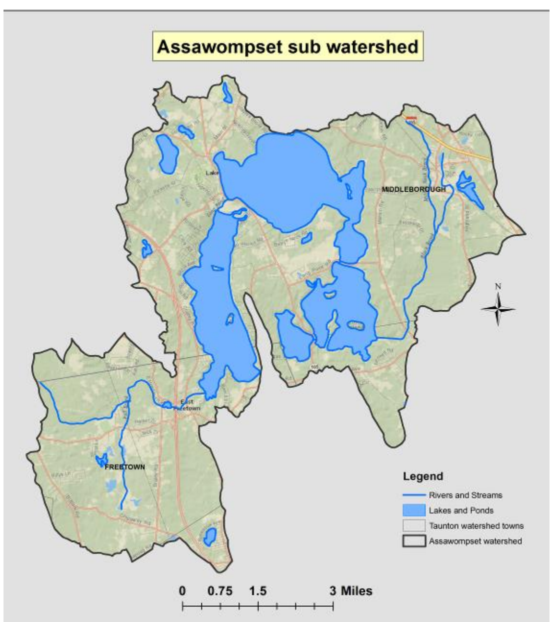


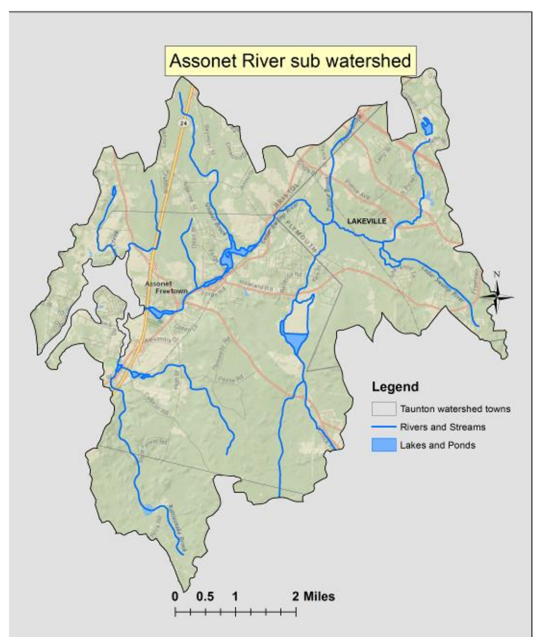
Figure 10

The **Taunton River** and the **Nemasket River** with its headwaters at Assawompset Pond provide the largest alewife run in Massachusetts.



The **Assawompset Pond** is one of five ponds in the Assawompset Pond Complex which represents the largest freshwater lake system in the Commonwealth. The watershed of the five ponds is shown in the adjacent map.

The **Assonet River** originates in the Assonet Cedar Swamp, the headwaters of the Cedar Swamp River in Lakeville. Over 1,000 acres of the swamp and its buffering upland are designated as BioMap2 Core Habitat and protected as a Mass Audubon Wildlife Sanctuary.



The Cedar Swamp River flows west to the Berkley and Freetown border, then turns south and becomes the Assonet River, which in turn flows through Assonet Bay in Freetown into the estuarine portion of the Taunton River. The combined length of the Cedar Swamp and Assonet Rivers is about 6.7 miles.

Smaller Tributaries to the Taunton River

In this report, smaller tributaries to the Taunton River are divided into two sub-watersheds: the **Cotley River sub-watershed** that includes tributaries to the Taunton River in the area of Raynham, Taunton and Berkley; and the **Lower Taunton River Coastal sub-watershed** that includes areas in Dighton, Freetown, Somerset and Fall River.

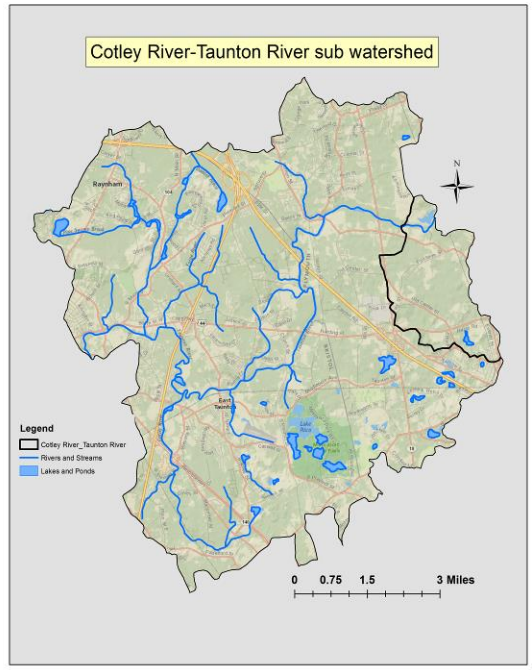


Figure 13

Cotley River Sub-watershed

The **Forge River** originates in King's Pond in Raynham and joins the Taunton River at the Taunton/Raynham boundary. One of its tributaries is the Pine Swamp River that originates in Taunton and flows east through the 275-acre Pine Swamp that straddles Taunton and Raynham and is designated Priority Habitat for rare species.

Other tributaries in this sub-watershed include: Cotley River, Dam Lot Brook (Raynham), Sawmill and Snows Brooks (Bridgewater), Poquoy and Purchade Brooks (Middleborough).

Lower Taunton River Coastal Sub-watershed

This sub-watershed includes tributaries in Berkley, Dighton, Somerset, and Fall River.

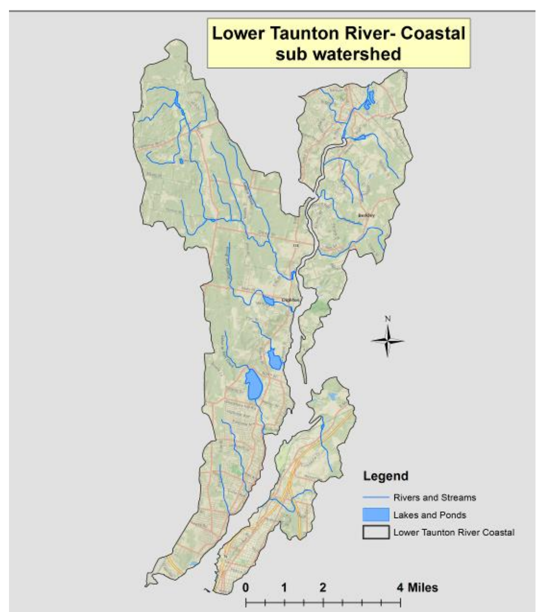


Figure 14

Coldwater Fisheries

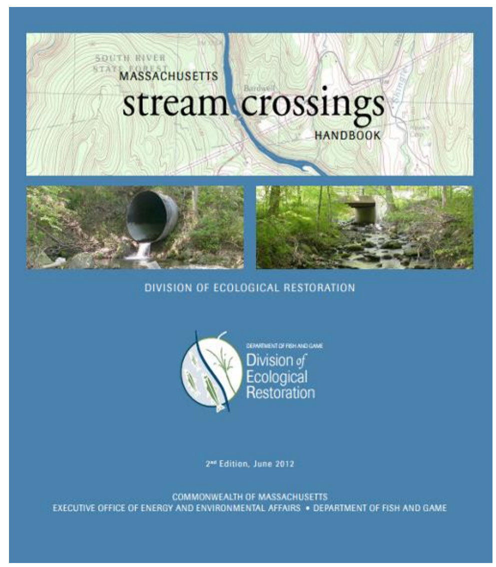
The watershed is home to a number of coldwater streams that support native brook trout, rainbow smelt and other species that require coldwater habitat. Coldwater streams in the watershed include: Henkes Brook, Leonard Washburn Brook, Poquoy Brook, Otis Pratt Brook, Puddingshear Brook and others. The Winnetuxet, Nemasket, and Town rivers support the globally-rare bridle shiner. Coldwater streams are considered "Outstanding Resource Waters" by the Massachusetts Department of Environmental Protection and afforded extra protection. An online map of the Commonwealth's Coldwater Fisheries Resources is available on the website of the Massachusetts Division of Fisheries and Wildlife.

Section 3. Regulatory Standards to Protect Streams

The Massachusetts Stream Crossing Handbook and Standards

To address the problem of substandard stream crossings, the Stream Continuity project (now NAACC) developed recommended standards for permanent crossings on fish-bearing streams and rivers in Massachusetts (and for other Northeast states). These standards were intended to achieve three goals:

- Facilitate movement for fish and other aquatic organisms such as aquatic amphibians and reptiles, crayfish, and mussels;
- Maintain continuity of the aquatic and benthic elements of riverine ecosystems by maintaining appropriate substrates and hydraulics, such as water depth, turbulence, velocity, and flow patterns;
- Facilitate movement of wildlife species including those primarily associated with river and stream ecosystems and others that may utilize riparian areas as movement corridors.[11]



In 2005 the Massachusetts Riverways Program (now the Division of Ecological Restoration) developed a **Stream Crossings Handbook**[12], along with an updated 2012 version. This publication was intended to inform local decision makers and advocates about the importance and benefit of properly designed and maintained culverts and bridges to fish and wildlife passage. It presented guidelines for designing culverts and bridges that would achieve those goals.

In 2014 the Massachusetts Department of Environmental Protection adopted the **Massachusetts Stream Crossing Standards** into regulation under the Massachusetts Wetlands Protection Act. New crossings must comply with the standards. Replacement of existing bridges or culverts must comply to the maximum extent practicable.

The Standards promote crossing designs that span the streambanks to allow for normal streamflow and retain appropriate channel conditions such as dimension, banks and streambeds to preserve the diversity and complexity of the stream through the crossing. The Standards are not intended to substitute for proper engineering and design that address drainage, capacity to handle flood flows and stability of the structure.

[11] https://www.streamcontinuity.org/aquatic_connectivity/crossing_design/ma_crossing_standards.htm
[12] http://www.mass.gov/eea/docs/dfg/der/pdf/stream-crossings-handbook.pdf

Section 4. Programs to Identify Critical Areas and Priorities for Crossing Upgrade/Replacement

The prioritization of stream crossing sites for potential upgrades flows from several projects that have compiled and analyzed data on the intersections between transportation infrastructure, streams, and areas of high ecological value.

A. Geographic Roadway Runoff Inventory Program[13]

The **Geographic Roadway Runoff Inventory Program (GRRIP)** was created in 1998 by the Southeastern Regional Planning and Economic Development District (SRPEDD) as a joint effort between the agency's Transportation and Environmental Planning Programs. GRIPP focuses on the intersection of transportation infrastructure with sensitive environmental receptors through analysis of specific roadway drainage facilities located in environmentally-sensitive areas. SRPEDD describes GRRIP as "a computer-based mapping product which includes 22 separate categories of environmental information and data with other base map layers to create an overview of a town's environmental and road network information."

The GRRIP Program was prompted by the recognition that rapid development in southeastern Massachusetts since the 1980's has resulted in removal of large areas of forest and soil compaction along with construction of impervious surfaces and disruption of natural hydrology. This increased stormwater loads. Many stormwater management systems became functionally obsolete, in some cases causing harm to environmentally-sensitive areas and risk to transportation safety because of polluted discharges, flooding, and erosion.

SRPEDD worked with federal, state, local, and non-profit partners to compile a database of sites, then conducted field inventory and photography of roadway crossings, drainage facilities, and culverts in environmentally-sensitive areas such as rare species habitat and water supply areas. The sites were mapped and an analysis of drainage facilities was completed that included type, condition, location, and function as well as surrounding conditions and environmental features. Approximately 200 sites in southeastern Massachusetts have been inventoried. Remedial action or mitigation including culvert replacement, dam removal, bank or buffer area restoration, or improvement of the drainage facility has occurred at over two dozen of the sites. The largest ongoing restoration project in the region is the Mill River Dam Removal and Ecological Restoration Project in Taunton. The Hopewell Mills and Whittenton dams were removed and a fish ladder was installed at Morey's Bridge; a third dam removal is planned.

SRPEDD has also been working with its partners to promote greater public awareness of significant coldwater streams and fisheries in southeastern Massachusetts.

B. BioMap2

The Massachusetts Natural Heritage and Endangered Species Program and The Nature Conservancy's Massachusetts Program developed **BioMap2**[14], a comprehensive plan to protect the Commonwealth's biodiversity, achieve effective conservation and build ecological resilience

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[13] http://www.srpedd.org/index.php?id=66

[14] http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/biomap2/

to counter projected effects of climate change. It applies extensive data on rare species and natural communities, using GIS analysis to identify large well-connected and intact ecosystems and landscapes across Massachusetts. It is designed to focus land protection and stewardship on areas that are most critical for insuring the long-term persistence of rare and other native species and their habitats, exemplary natural communities and ecosystem diversity.

BioMap2 identified 1,242,000 acres, 24% of the Commonwealth designated "Core Habitat" that are critical for the long-term persistence of rare species as well as a wide diversity of natural communities and intact ecosystems. Core Habitat includes habitats for rare, vulnerable or uncommon species or mammal, birds, reptiles, amphibians, fish, invertebrates and plants. It also includes Priority Natural Communities, high-quality wetlands, vernal pools, aquatic and coastal habitats and intact forest ecosystems.

BioMap2 also identified 1,783,000 acres as Critical Natural Landscape. These areas overlap with Core Habitat in some cases and include large landscape blocks that provide habitat for wide-ranging native species, support intact ecological processes, maintain connectivity among habitats and enhance ecological resilience. They also include adjacent uplands that buffer wetlands, aquatic and coastal habitats.

C. Conservation Assessment and Prioritization System (CAPS)

CAPS[15] was developed by the Department of Environmental Conservation at the University of Massachusetts Amherst. CAPS is a computer program and approach for conducting landscape-based assessments of ecological integrity for various natural communities, such as forest, shrub swamp, and headwater stream. Ecological integrity is defined by the structure and function of an area in relation to its ability to support native plants and animals and the natural processes necessary to sustain them over the long term.

The CAPS system identifies the developed and undeveloped elements of the landscape on a computer-based map and evaluates each point in the landscape for a number of variables, including: edge effects like microclimate alterations; intensity of road traffic in the vicinity; nutrient loading to aquatic ecosystems; and the effects of development on the ecological connectivity of the landscape. The results are used by the program to calculate an Index of Ecological Integrity (IEI) for each point in the landscape in relation to other surrounding points. The CAPS model presumes that by preserving intact areas of high ecological integrity we can conserve most (but not necessarily all) species and ecological processes.

D. The Critical Linkages Project

UMass further applied the CAPS modeling in the **Critical Linkages Project[16]** to assess connectivity of ecological systems in Massachusetts and identify areas where natural stream connections may be prioritized for protection or restoration to support intact, functioning ecosystems. Using spatial data (electronic maps) of the Massachusetts landscape, the assessment initially relied on a computer model to predict the condition and passability of unsurveyed crossings. The model continues to be refined as field survey information is added and utilized in running the model. The Aquatic Score predicts the degree to which a stream crossing creates a

[15] http://www.umasscaps.org/
[16] http://www.umasscaps.org/applications/critical-linkages.html

barrier to passage for aquatic organisms; it ranges from 0 to 1.0, where "0" indicates that the crossing provides no passage for organisms and "1.0" indicates full passage.

An "Impact" score for each identified crossing location was calculated from the Aquatic Scores and IEI scores from CAPS. Specifically, a "delta aquatic connectedness" score (the change in aquatic connectivity resulting from some action) was multiplied by IEI scores for individual cells on the landscape grid, then summed for all cells that would be affected by a replacement of the crossing structure. The resulting raw Impact Score estimates the ecological restoration potential, i.e., the amount of improvement in the ecological health of a water body if a crossing structure in that location were removed or replaced. Higher Impact Scores indicate the greater potential for improvement at that site. To adjust for the highly skewed nature of the Critical Linkages results, "Impact_ln" scores (a log-transformed version of the results) were created to make it easier to display and interpret the results.

Crossing locations were assigned to one of five tiers based on their Impact Scores:

Tier 1 (highest potential):	0.4013 to 0.9715
Tier 2:	0.2076 to 0.4012
Tier 3:	0.1095 to 0.2075
Tier 4:	0.0441 to 0.1094
Tier 5: (lowest potential):	0.0000 to 0.0440

Because Impact Scores incorporated IEI to evaluate potential for improvement of ecological health, crossings in densely developed/urban areas are likely to receive lower scores even though the crossing might create flooding or other problems that would be mitigated by replacement.

Results of the first phase of the Critical Linkages analysis indicated that a relatively small proportion of culvert replacements or dam removals would result in substantial improvement in aquatic connectivity. Of the 1300+ sites in the database, 24 were ranked as "Tier 1" sites (greatest potential for ecological restoration) and 108 were ranked as "Tier 2." The Taunton River and Stream Continuity Project focused on crossings that were ranked as Tiers 1, 2 or 3.

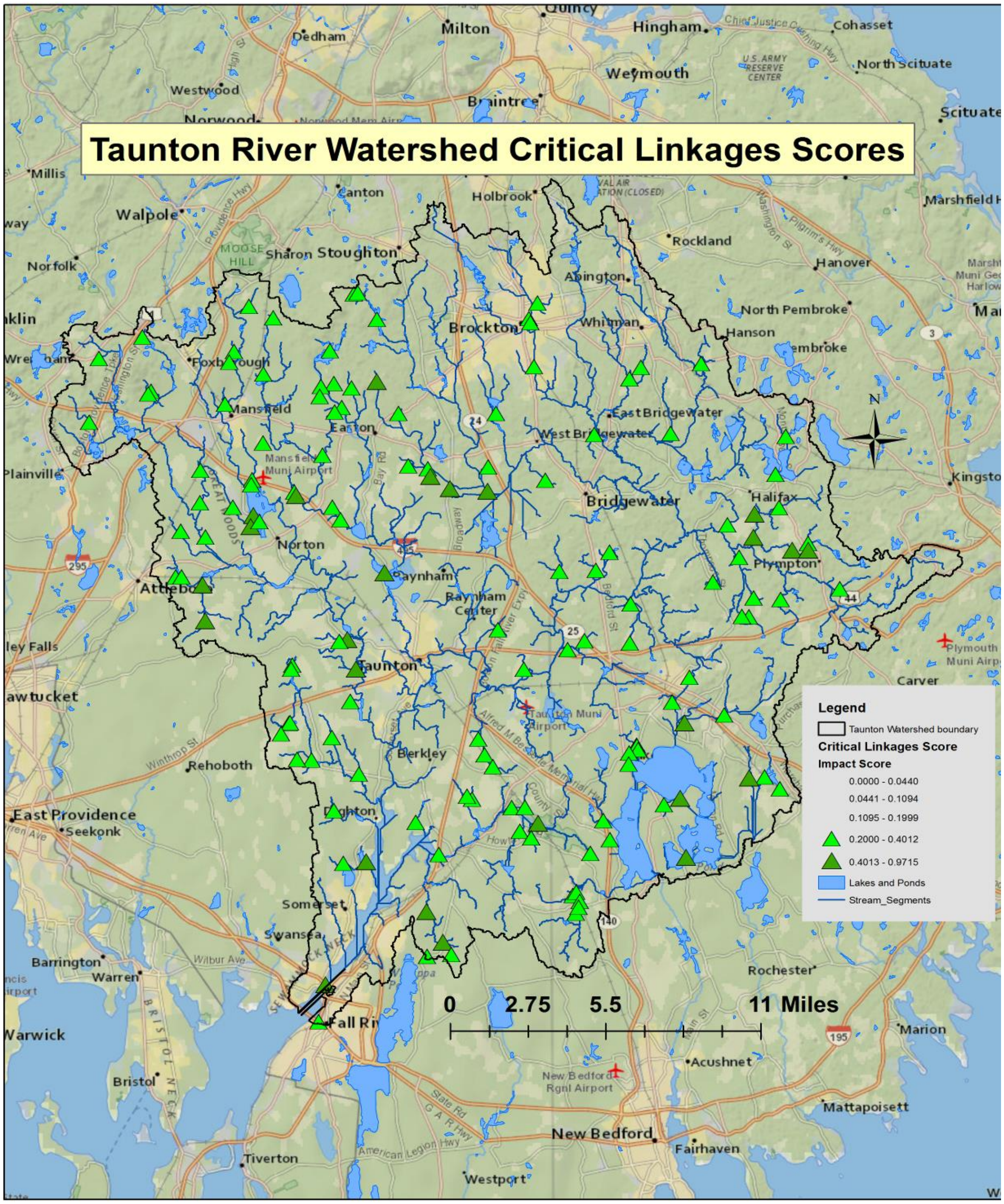


Figure 15: Map of Stream Crossings in the Taunton River Watershed Ranked as Tier 1 or Tier 2 Based on Critical Linkage Impact_In Scores

E. River and Stream Continuity Project/NAACC

NAACC (formerly Stream Continuity Project)[17] trains volunteers and technicians to conduct on-the-ground field surveys of river and stream road crossings. Impact_In scores generated by the Critical Linkages Project can be used to identify crossings with the highest estimated potential for ecological restoration, and surveys may then be focused on locations with scores in Tiers 1, 2 and 3. Evaluators record observations and measurements at specific bridges and culverts to determine if the crossing creates a barrier to free passage. The evaluators also photograph the crossings, and enter the data and the photos in the NAACC Database[18].

Using 13 variables from the field assessments, the Database generates an Aquatic Score. This score is similar to the Aquatic Score on the Critical Linkages Analysis; however the Critical Linkages score *estimates* barriers to passage whereas this score is computed from actual field measurements and observations. This score also ranges from 0 to 1.0, where "0" indicates that the crossing provides no passage for organisms and "1.0" indicates full passage, i.e., that the crossing meets "desired conditions" for the 13 factors considered.

Based on the Aquatic Scores, crossings were determined to create **severe** (score between 0 and 0.3), **significant** (between 0.31 and 0.5), **moderate** (between 0.51 and 0.67), **minor** or **insignificant** barriers to passage.

Aquatic scores from these field assessments replaced the modeled scores for Critical Linkages analyses (modeled scores were used only for crossings that had not been assessed in the field).

Massachusetts Division of Ecological Restoration (DER)

DER[19] works with many partners across a variety of aquatic systems – from freshwater to saltwater – to restore the ecological integrity of degraded habitats for the benefit of people and the environment. Many streams, especially in eastern Massachusetts, are subject to excessive water withdrawals and other manipulations of the natural hydrologic regime. DER's projects include culvert replacement and dam removal to restore fish passage and aquatic connectivity, as well as restoration of natural hydrology in historically altered freshwater wetlands and tidal flow in salt marshes. Working in partnership with public, private, and non-governmental organizations, DER has completed over 100 restoration projects, restoring over 1,000 acres of tidal wetlands and miles of rivers and freshwater habitats.[20]

DER's Stream Continuity Specialist Tim Chorey conducted a statewide survey to identify the obstacles local Departments of Public Works face when installing or replace existing crossings that allow for natural stream flow. Data from the survey is being used to develop DER's Stream Continuity Program, with the goal of increasing the statewide capacity to install new or replace existing culverts with more resilient and climate ready structures that allow for natural stream flow and aquatic organism passage.

See the end of this report for additional sources of information and assistance.

[17] www.streamcontinuity.org
[18] http://www.streamcontinuity.org/cdb2
[19] http://www.mass.gov/eea/agencies/dfg/der/
[20] http://www.mass.gov/eea/agencies/dfg/der/aquatic-habitat-restoration

Section 5. Stream Crossing Assessment Procedure

As noted above, NAACC trains volunteers and technicians to conduct on-the-ground field surveys of river and stream road crossings. For the Taunton watershed assessments, crossings identified in the Critical Linkages Project were assigned to one of five Tiers, indicating potential for ecological improvement and priority for further assessment. Evaluators record information on Field Data Forms, including the date of observation, location and stream name, flow condition and landmarks to confirm location (such as street sign, number on utility pole, description of nearby building). They determine the latitude and longitude of the site with Geophysical Positioning System units (GPS) and photograph the inlet and outlet of the crossing. Information about the characteristics of the roadway, stream, crossing, and specific crossing structure is recorded, including various measurements. The assessments included: evaluation of the condition of the crossing; the crossing span (potential constriction of flow); the presence of scour pools at the outlet; depth of drops at the inlet and outlet of the crossing, if any; the alignment of the crossing (degree to which the crossing skewed the direction of streamflow); and observations of blockage within the crossing structure or other unusual or harmful conditions at the site.

The data and photos collected were entered in the Stream Continuity Database. As noted in the previous section, an Aquatic Score is generated from the field assessments, and based on that score, crossings were categorized as posing **severe, significant, moderate, minor or insignificant** barriers to passage.

Measuring a crossing.

AQUATIC CONNECTIVITY
Stream Crossing Survey
DATA FORM

DATABASE ENTRY BY ____ ENTRY DATE ____

DATA ENTRY REVIEWED BY ____ REVIEW DATE ____

CROSSING DATA

Crossing Code____ Local ID (Optional)____

Date Observed (00/00/0000)____ Lead Observer____

Town/County____ Stream____

Road____ Type ☐ MULTILANE ☐ PAVED ☐ UNPAVED ☐ DRIVEWAY ☐ TRAIL ☐ RAILROAD

GPS Coordinates (Decimal degrees) ☐☐.☐☐☐☐☐ °N Latitude — ☐☐.☐☐☐☐☐ °W Longitude

Location Description

Crossing Type ☐ BRIDGE ☐ CULVERT ☐ MULTIPLE CULVERT ☐ FORD ☐ NO CROSSING ☐ REMOVED CROSSING ☐ BURIED STREAM ☐ INACCESSIBLE ☐ PARTIALLY INACCESSIBLE ☐ NO UPSTREAM CHANNEL ☐ BRIDGE ADEQUATE

Number of Culverts/ Bridge Cells ____

Photo IDs INLET____ OUTLET____ UPSTREAM____ DOWNSTREAM____ OTHER____

Flow Condition ☐ NO FLOW ☐ TYPICAL-LOW ☐ MODERATE ☐ HIGH

Crossing Condition ☐ OK ☐ POOR ☐ NEW ☐ UNKNOWN

Tidal Site ☐ YES ☐ NO ☐ UNKNOWN

Alignment ☐ FLOW-ALIGNED ☐ SKEWED (>45°)

Road Fill Height (Top of culvert to road surface; bridge = 0)____

Bankfull Width (Optional)____ Confidence ☐ HIGH ☐ LOW/ESTIMATED

Constriction ☐ SEVERE ☐ MODERATE ☐ SPANS ONLY BANKFULL/ ACTIVE CHANNEL ☐ SPANS FULL CHANNEL & BANKS

Tailwater Scour Pool ☐ NONE ☐ SMALL ☐ LARGE

Crossing Comments

STRUCTURE 1

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Outlet Armoring ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width____.__ B. Height____.__ C. Substrate/Water Width____.__ D. Water Depth____.__

Outlet Drop to Water Surface____.__ Outlet Drop to Stream Bottom____.__ E. Abutment Height (Type 7 bridges only)____.__

L. Structure Length (Overall length from inlet to outlet)____.__

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions A. Width____.__ B. Height____.__ C. Substrate/Water Width____.__ D. Water Depth____.__

ADDITIONAL CONDITIONS

Slope % (Optional)____ Slope Confidence ☐ HIGH ☐ LOW

Internal Structures ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER____

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN Height above Dry Passage____

Comments

5/26/16

Figure 16: Field Data Form: Road-Stream Crossing Inventory

Note: This is the updated NAACC data form. The assessments performed through 2014 for this report used an earlier version.

Only data contributed by certified surveyors can be included in the NAACC database

Structure Shape & Dimensions

1) Select the Structure Shape number from the diagrams below and record it on the form for Inlet and Outlet Shape.

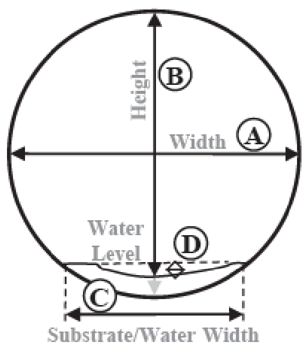
2) Record on the form in the approriate blanks dimensions **A**, **B**, **C** and **D** as shown in the diagrams;
C captures the width of water or substrate, whichever is wider; for dry culverts without substrate, C = 0.
D is the depth of water -- be sure to measure inside the structure; for dry culverts, D = 0.

3) Record Structure Length (**L**). (Record abutment height (**E**) only for Type 7 Structures.)

4) For multiple culverts, also record the Inlet and Outlet shape and dimensions for each additional culvert.

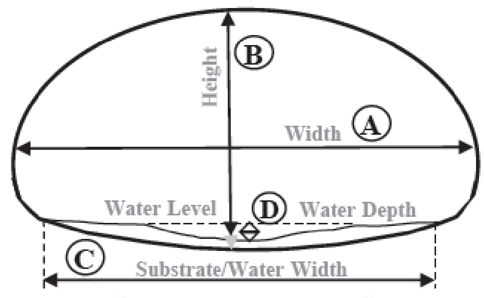
NOTE: Culverts 1, 2 & 4 may or may not have substrate in them, so height measurements (B) are taken from the level of the "stream bed", whether that bed is composed of substrate or just the inside bottom surface of a culvert (grey arrows below show measuring to bottom, black arrows show measuring to substrate).

1



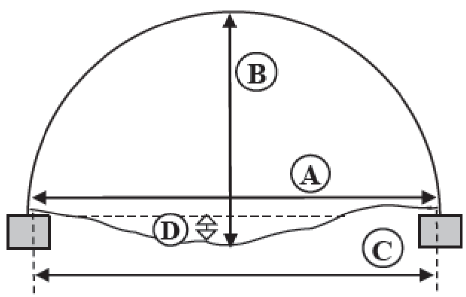
Round Culvert

2



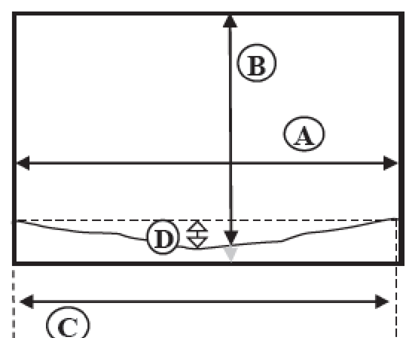
Pipe Arch/Elliptical Culvert

3



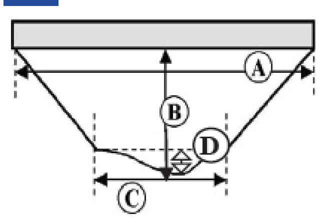
Open Bottom Arch Bridge/Culvert

4



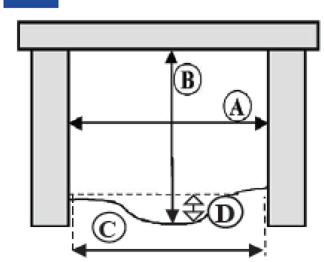
Box Culvert

5



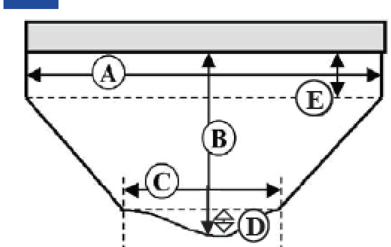
Bridge with Side Slopes

6



Box/Bridge with Abutments

7



Bridge with Abutments and Side Slopes

Note: This is the updated NAACC data form. The assessments performed through 2014 for this report used an earlier version.

Only data contributed by certified surveyors can be included in the NAACC database

Section 6. Overview of Findings of the Taunton River Watershed Stream Crossing Surveys

The Critical Linkages Project identified 1317 potential crossings in the Taunton River Watershed. The locations were ranked as follows, with Tier 1 as the highest potential for ecological restoration and "no data" probably indicating that no crossing existed in that location:

Tier	# of sites
1	24
2	108
3	217
4	375
5	593
No data	14

In the period from 2006 to 2014, field assessments were conducted at 516 sites in 27 municipalities. A focus was placed on sites that were ranked as Tier 1, 2 or 3, although some surveyed crossings were ranked as Tiers 4 or 5 or did not match a Critical Linkages site.

Taunton Watershed Survey Results

Surveyed crossings included:

- 45 bridges
- 18 open-bottom arches
- 2 fords
- 237 single culverts
- and 199 multiple culverts

A "ford" is defined as a log, stone or Gabian baskets, or a gravel crossing of a stream.

Overall the TRW results reflected the statewide predictions of the Critical Linkages Project, i.e., that a relatively small portion of culvert replacements or dam removals would result in substantial improvement in aquatic connectivity.

Crossings of tributaries to the Taunton River. All of the crossings evaluated as **severe**, **significant**, or **moderate** barriers were located on tributaries.

One crossing in the watershed was evaluated as a **severe barrier** to passage: a culvert on Cocasset Brook at Lakeview Road in Foxboro with an Aquatic Score of 0.24.

Thirty-one crossings in 17 towns were determined to create a **significant barrier** to passage. Two of these were located on a tributary to the Wading River and one on the Forge River. The remaining significant barrier crossings were located on smaller tributaries.

One hundred and eight crossings represent a **moderate barrier** to passage, while 245 crossings represent a **minor barrier** to passage and 112 represent an **insignificant barrier** to passage. Records for 19 other sites were entered in the database but were evaluated as "no data."

Crossings of the Taunton River. Like many large rivers, the crossings on the Taunton River are spanned by bridges. Of four crossings surveyed on the Taunton River, three were evaluated as **insignificant** barriers (Summer Street in Middleborough, Cape Highway in Raynham and County Street in Taunton). One crossing on Gordon Owen Way in Taunton was evaluated as a **minor** barrier.

Table 1 lists the number of sites surveyed in each city of town broken down by category of severity of barrier to passage.

Table 1: Number of Sites Surveyed by Municipality with Barrier Evaluation

City or town	Severe	Significant	Moderate	Minor	Insignificant	No Data	Total
Attleboro		4	3	6			13
Berkley			2	8	1		11
Bridgewater		1	5	4	1		11
Brockton			2	14	4		20
Carver				1			1
Dighton			6	2	4		12
East Bridgewater		1	4	5	1	1	12
Easton		1	11	34	11		57
Fall River		1		1			2
Foxboro	1	2	17	18	6	2	46
Freetown		1	4	8	12		25
Halifax		1	1	7	3		12
Hanson				1	1		2
Lakeville			6	12	3	1	22
Mansfield		1	15	20	14	3	53
Middleborough		2	7	26	13	4	52
Norton		3	5	20	1		29
Plainville		1	3	4	2		10
Plympton		1	1	3			5
Raynham		2	1	12	8		23
Rochester				1			1
Sharon		2	9	10	2	4	27
Somerset					1		1
Stoughton				3		1	4
Taunton		6	6	11	13	3	39
West Bridgewater				5	9		14
Wrentham		1		9	2		12
Totals	**1**	**31**	**108**	**245**	**112**	**19**[21]	**516**

[21] 19 sites identified in the Critical Linkages Database were visited but recorded as "No Data" because no stream crossing was found.

Table 2 lists the severe or significant barrier crossings with their Impact_In Score (if the crossing matched a Critical Linkage site) and Aquatic Scores.

Table 2: Crossings Identified as Severe or Significant Barriers to Aquatic Passage

Crossing Code	Town	Road	Stream	Imp_In Score	Aquatic Score
Severe Barrier					
xy4206952671269558	Foxboro	Lakeview Road	Cocasset Brook		0.24
Significant Barrier					
xy4193103571245070	Attleboro	Pike Avenue	Branch of Chartley Brook		0.49
xy4192231071237215	Attleboro	Wilmarth Street	Chartley Brook	0.6244	0.42
xy4194174471239039	Attleboro	Peckham Street	Chartley Brook	0.6820	0.46
xy4191538871233625	Attleboro	Smith Street	Branch to Chartley Brook		0.36
xy4196350170961152	Bridgewater	Conant Street	Branch of Sawmill Brook	0.0088	0.46
xy4200355770901795	East Bridgewater	near Plymouth St.	Stump Brook		0.45
xy4204427471157644	Easton	Mill Street	Branch of Poquanticut Brook	0.3444	0.50
xy4174673371075007	Fall River	Bell Rock Road	Mill Brook	0.5971	0.45
xy4207684671279659	Foxboro	Pierce Street	Carpenter Brook		0.48
xy4204592971275532	Foxboro	Mill Street	Trib. to Cocasset River		0.50
xy4179738971029296	Freetown	Howland Road	Trib. to Assonet River	0.0601	0.46
xy4197889570859046	Halifax	Franklin Street	Palmer Mill Brook	0.7831	0.49
xy4204856671186396	Mansfield	Maple Street	Trib. to Canoe River		0.40
xy4187700670879787	Middleborough	Wareham Street	Stony Brook	0.0288	0.48
xy4191600370857469	Middleborough	Katrina Road	Branch of Raven Brook	0.1001	0.40
xy4196783271236703	Norton	Off Walker Street	Trib. to Wading River	0.2771	0.43
xy4195021171227230	Norton	S. Worcester St.	Goose Brook	0.0789	0.50
xy4197071871231797	Norton	Walker Street	Trib. to Wading River		0.45
xy4201982871313791	Plainville	Shepard Street	Turnpike Lake Conn.	0.0989	0.39
xy4196405270817006	Plympton	Center Street	Trib. to Colchester Brook	0.0285	0.42
xy4191561971043687	Raynham	North Main St.	Damlot Brook	0.0270	0.42
xy4193260371053567	Raynham	Gardiner Street	Forge River		0.33
xy4206294571179613	Sharon	Mansfield Street	Trib. to Little Canoe River		0.46
xy4209953671136038	Sharon	Castle Drive	Branch of Queset Brook		0.50
xy4187825270986918	Taunton	Massasoit Park Rd.	Trib. to Furnace Brook		0.41
xy4185739270987111	Taunton	S. Precinct Street	Trib. to Furnace Brook	0.0921	0.46
xy4186289970977942	Taunton	Highstone Street	Thompson Brook	0.1008	0.40
xy4189570271133601	Taunton	N. Walker Street	Fall Brook	0.4938	0.48
xy4194811271113647	Taunton	Bay Street	Watson Pond/Lake Sabbatia	0.5053	0.47
xy4194811271113647	Taunton	Bay Street	Watson Pond/Lake Sabbatia	0.5053	0.43
xy4206533271309673	Wrentham	Thurston Street	Trib. to Meadow Brook	0.2309	0.49

Figure 17: Locations of Crossings ranked as Severe and Significant Barriers to Aquatic Passage

Surveys by Municipality

The 516 surveyed stream crossing sites were located in 27 of the 43 cities and towns in the Taunton River Watershed. The numbers of sites surveyed in each of these cities and towns varied, ranging from 1 to 54. Reasons for this range included: the difference in total land area; proportion of the municipality within the Taunton River watershed vs. other watersheds; varying terrain and topography; local relative density of stream and river miles; and density of development vs. municipalities with large areas of protected open space, which may have fewer road crossings per stream mile.

Densely developed municipalities are likely to have more stream crossings; however a stream segment flowing through developed areas, especially streams with segments that are channelized or piped, would be likely to receive a lower Critical Linkages score, indicating lower potential for ecological restoration. It is likely that numerous urban crossings were omitted from the field assessments on the basis of low Critical Linkages scores. Streams flowing through cranberry bogs are often channelized or otherwise altered with berms and diversions; crossings in these areas were generally not included. Finally, some sites with high Critical Linkage scores were not surveyed because they were located on rail lines where public access is restricted or on highways or other areas where difficult terrain or safety concerns limited accessibility.

"Low-impact" vs. "Higher-impact" Municipalities. All crossings that were surveyed in Carver, Hanson, Rochester, Sharon, Stoughton, and West Bridgewater were evaluated as minor or insignificant crossings. All of the surveyed sites in Berkley, Brockton, Dighton, and Lakeville were evaluated as moderate, minor or insignificant crossings. A list of all surveyed crossings for each city and town is found in Appendix A.

Sub-watershed Survey Results

Of the 516 crossings surveyed, the highest number was completed in the Three Mile River sub-watershed, a total of 158, with many also surveyed in the Mill River, Town River, and Nemasket River sub-watersheds. Smaller numbers of sites were surveyed in the other sub-watersheds as shown in Table 3.

Table 3: Number of Crossings Surveyed and Barrier Evaluation by Sub-watershed

Sub-watershed	Severe	Significant	Moderate	Minor	Insignificant	No data	Total sites surveyed
Segregansett			6	2	3		11
Three Mile	1	12	36	71	35	3	158
Mill		5	20	37	12	9	83
Forge		1		2	2		5
Town		1	17	45	18	1	82
Matfield		1	5	10	2	1	19
Winnetuxet		2	1	7	3		13
Nemasket		2	10	31	17	5	65
Assonet		2	4	15	7		28
Smaller tribs. to Taunton River		5	9	25	13		52

The Segregansett was the only sub-watershed with no significant barrier crossing, but six of its crossings were evaluated as moderate barriers. While priority should be given to sites receiving the highest Critical Linkage scores, efforts should be directed to replacing all crossings that present significant barriers to aquatic passage. For crossings assessed as moderate barriers, the Critical Linkage score should be checked as an indication of degree of potential for ecological restoration. Site-specific information on local field conditions and maps and other information about adjoining resources should also be consulted.

A complete list of all sites surveyed in each sub-watershed is provided in Appendix B.

Correlation of Surveyed sites with Critical Linkage sites.

As noted above, to a large extent the Critical Linkage ranking was used to determine which crossings in the watershed should be surveyed in the field. Of the 516 crossings that were surveyed:

- 375 matched with locations that had been assigned a Critical Linkage Impact Score
- 143 surveyed sites did not match a Critical Linkages site

One possible reason that these sites did not match is that stream networks in the Critical Linkage dataset were "trimmed" to drop all streams with a watershed area less than 30 hectares, i.e., very small streams with small drainage areas. The value of improvement of crossings in such areas may be low compared to larger areas, although headwater habitats are important and each site should be considered in local context. The single site evaluated as a severe barrier (Lakeview Road crossing of Cocasset Brook in Foxboro) did not have a CL site match – possibly because of its location in the headwaters of the Wading River and small watershed size.

Sixty-three of the sites that were scored as "Tier 1" or "Tier 2" Critical Linkage sites were not assessed in the field. These include some crossings located on rail lines or major highways, but 43 of those unassessed crossings were located on roads or trails that appear to be accessible. A list of these unassessed sites is included in Table 13 in Appendix C. We recommend that efforts be made to complete field surveys of as many of these as possible. Approximately 230 locations that were not surveyed ranked as Tier 1, 2 or 3 in the Critical Linkages Project. Additional surveys can continue to be made by qualified volunteers – see contact information at the end of the report to learn more and get involved.

Other Survey Results

As noted above, Critical Linkage scores evaluated the potential for ecological restoration if a crossing were replaced or upgraded. 306 of the assessed crossings received Impact_In scores that placed them in the lower three tiers of restoration potential and 143 assessed sites did not match a Critical Linkage site.

This section of the Wading River crossing at Walker St. in Norton flooded the road in 2010. Photo credit: Jennifer Carlino.

While many of the crossings in the Taunton River Watershed evaluated in this project may not represent high potential for ecological restoration, **their condition may contribute to serious flooding problems or other problems related to drainage or pollution, and those crossings should be considered for upgrade.** One example is a crossing of the Wading

River on Walker Street in Norton that has experienced severe flooding problems but was evaluated as a minor barrier to passage in this project. Among the parameters evaluated in the field surveys, a number of them may help identify crossings that are causing localized problems. Summaries of the results for four critical parameters: crossing condition, crossing span, crossing alignment and presence of inlet or outlet drops are provided below.

Condition of the crossing. Evaluators recorded the condition of each crossing in one of six categories including: new, excellent, good, fair, poor, broken, collapsing, eroding, or rusted through. Evaluators described 212 crossings as fair, 139 as good, 38 as excellent and 7 as new.

Problems were observed in another 98 crossings as follows:

Condition	# of sites
Poor	52
Broken	5
Collapsing	12
Eroding	19
Rusted through	10

A town-by-town list of crossing sites where poor conditions or other problems were noted is provided in Table 9 in Appendix C.

Crossing Span. This parameter described the width of the crossing relative to natural conditions of the stream. Evaluators were asked to describe the crossing span as: creating a severe restriction to flow, creating a mild constriction, spanning the stream from bank to bank, and spanning the channel and the banks of the stream (best case). Of the crossings surveyed, evaluators identified:

Crossing Span	# of sites
Severe constriction	89
Mild constriction	194
Spans bank to bank	169
Spans channel and banks	33

A town-by town list of crossings with severe constrictions is provided in Table 10 in Appendix C.

Crossing Alignment. The field survey included assessment of the extent to which the alignment of the crossing matches the alignment of the stream. As a reference, evaluators used a line connecting the center of the channel where it enters the crossing structure and the center of the channel as it exits. If the channel deviates from this line by more than a 45 degree angle, the alignment is considered "skewed." A skewed alignment could potentially restrict flow during major storms. From the surveys that furnished data on this parameter, 142 crossings were determined to be "flow aligned." The alignment at 62 crossings was determined to be "skewed."

Table 11 in Appendix C provides a town-by-town list of crossings where skewed stream alignment was observed.

Inlet and Outlet Drops. As described in Section 1, drops in elevation at the inlet or outlet of a crossing can constitute serious disruption to passage for aquatic organisms. A list of crossings in each town where inlet or outlet drops were observed is provided in Table 12 in Appendix C.

The field data sheets also include observations of blockage within the crossing structure or other unusual or harmful conditions at the site. The sample Field Data Sheet provided above in Section 5 shows all of the parameters evaluated in the field assessments.

Table 4: Example of Information from Database

Survey ID	Crossing Code	Date Observed	Last Updated	Town	Stream	Road	Evaluation	Culvert
3005	xy4195354971280015	2008/01/08	2008/01/24	Attleboro MA	Bungay River	Holden Street	Insignificant barrier	1
3057	xy4193741971290251	2008/02/15	2008/02/21	Attleboro MA	Bungay River	Olive Street	Insignificant barrier	1
3059	xy4195064071284387	2008/02/15	2008/02/21	Attleboro MA	Bungay River	Bank Street	Insignificant barrier	1
6364	xy4193103571245070	2012/10/24	2013/02/19	Attleboro MA	Unknown	Pike Avenue	Significant barrier	1
6365	xy4192231071237215	2012/05/30	2013/02/19	Attleboro MA	Chartley Brook	Wilmarth Street	Significant barrier	1
6373	xy4195394171257873	2012/10/11	2013/02/19	Attleboro MA	Unknown	Pleasant Street	Minor barrier	1
6382	xy4193708771255283	2012/10/24	2013/02/19	Attleboro MA	Unk	Bishop Street	Moderate barrier	1
6383	xy4192275871244807	2012/10/24	2013/02/19	Attleboro MA	Unknown	Thayer Farm Road	Minor barrier	1
6384	xy4194169971250161	2012/10/24	2013/02/19	Attleboro MA	Unknown	Pike Avenue	Minor barrier	2
6385	xy4194271671266266	2012/10/24	2013/02/19	Attleboro MA	Unknown	Garfield Avenue	Moderate barrier	3
7384	xy4195209971262592	2013/07/09	2013/10/23	Attleboro MA	unknown	East Access Road	Moderate barrier	1
7590	xy4194174471239039	2012/10/24	2013/11/11	Attleboro MA	Chartly Brook	Peckham Street	Significant barrier	1

Section 7. Taunton River Watershed Sites with Significant Potential for Ecological Restoration

This section focuses on specific crossings that were evaluated as severe, significant or moderate barriers to aquatic passage and as sites with significant potential for ecological restoration. It identifies highest priority sites and discusses others with likely restoration potential. Information about areas of high ecological value in proximity to specific crossings is included along with some of the specific observations recorded by the field surveyors.

Correlation of the Crossing Survey Results with the Critical Linkages Predictions

Of the 375 surveyed crossings that matched a Critical Linkage site, 69 crossings received an Impact_In score of 0.2 or greater, indicating **significant potential for ecological restoration** if the crossing were replaced, based on computer analysis of aerial photographs. We compared this list of crossings with the list of crossings determined by the field surveys to be severe, significant or moderate barriers to aquatic passage, in order to identify the crossings which have the highest potential for ecological restoration.

Highest Priority Sites

The following sites were identified as the highest priorities for restoration.

- Severe barrier (1 site): Cocasset Brook in Foxboro. This site does not have a CL Impact_In score, probably because it is in a headwater area that was not captured by the CL analysis.
- 10 out of 31 significant barriers with Impact_In scores greater than 0.2;
- 31 of the 108 moderate barriers with Impact_In scores greater than 0.2;
- 11 significant barrier sites that do not have a CL score.

The remaining 28 sites with CL scores of 0.2 or greater were evaluated as minor or insignificant barriers to aquatic passage. Although not high ecological restoration priorities, local conditions (e.g. flooding or degraded conditions of a crossing) may warrant upgrades at these sites.

Table 5: Highest Priority Sites for Ecological Restoration: Significant Barriers with CL Impact_In score greater than 0.2

Priority Ranking	Crossing Code	Town	Road	Stream	Imp_In Score
1	xy4197889570859046	Halifax	Franklin Street	Palmer Mill Brook	0.7831
2	xy4194174471239039	Attleboro	Peckham Street	Branch of Chartley Br.	0.6820
3	xy4192231071237215	Attleboro	Wilmarth Street	Branch of Chartley Br.	0.6244
4	xy4174673371075007	Fall River	Bell Rock Road	Mill Brook	0.5971
5	xy4194811271113647	Taunton	Bay Street	Watson Pd./Lake Sabbatia	0.5053
6	xy4194811271113647	Taunton	Bay Street	Watson Pd./Lake Sabbatia	0.5053
7	xy4189570271133601	Taunton	North Walker St.	Fall Brook	0.4938
8	xy4204427471157644	Easton	Mill Street	Poquanticut Brook	0.3444
9	xy4196783271236703	Norton	off Walker St.	Trib. to Wading River	0.2771
10	xy4206533271309673	Wrentham	Thurston Street	Trib. to Meadow Br.	0.2309

Table 6: Moderate Barriers with Impact_In score Greater Than 0.2					
Crossing Code	**Town**	**Road**	**Stream**	**Barrier**	**Imp_In Score**
xy4195905070833376	Plympton	Cross Street	Colchester Brook	Moderate	0.6057
xy4205219871118523	Easton	Randall Street	Black Brook	Moderate	0.4548
xy4191166071139545	Taunton	Tremont Street	Trib. to Fall Brook	Moderate	0.4542
xy4176337971086240	Freetown	Rd. in State Forest	Rattlesnake Brook	Moderate	0.4505
xy4183519070864101	Middleborough	Miller Road	Miller's Neck Brook	Moderate	0.4404
xy4199029571174407	Norton	Newcomb Street	Trib. to Canoe River	Moderate	0.4129
xy4179477170973353	Lakeville	Freetown Street	Cedar Swamp River	Moderate	0.3781
xy4199804371002719	Bridgewater	North Street	One Mile Brook	Moderate	0.3600
xy4190907870945331	Middleborough	Old Centre Street	Trib. to Purchade Brook	Moderate	0.3576
xy4186622171179761	Dighton	Wheeler Street	Trib. to Segregansett River	Moderate	0.3454
xy4184669471174290	Dighton	Horton Street	Poppasquash Swamp	Moderate	0.3243
xy4200629571096898	Easton	Howard Street	Trib. to Black Brook	Moderate	0.3116
xy4203472971103581	Easton	Depot Street	Black Brook	Moderate	0.2976
xy4186663271179006	Dighton	Wheeler Street	Trib. to Segregansett River	Moderate	0.2973
xy4205129271148045	Easton	Rockland Street	Poquanticut Brook	Moderate	0.2730
xy4203045771316473	Plainville	Cowell Street	Hawthorne Brook	Moderate	0.2717
xy4205659271196393	Foxboro	East Street	Canoe River	Moderate	0.2704
xy4206895271216690	Foxboro	Oak Street	Trib. to Rumford River	Moderate	0.2633
xy4204725371273895	Foxboro	Mill Street	Trib. to Cocasset River	Moderate	0.2554
xy4180328571013862	Lakeville	Howland Road	Trib. to Cedar Swamp Riv.	Moderate	0.2528
xy4182092570922625	Lakeville	Betty's Neck Road	Tamett Brook	Moderate	0.2500
xy4208713071189573	Sharon	East Foxboro St.	Trib. to Canoe River	Moderate	0.2478
xy4208713071189573	Sharon	East Foxboro St.	Trib. to Canoe River	Moderate	0.2478
xy4208606771117931	Sharon	West Street	Trib. to Ames Long Pond	Moderate	0.2383
xy4206316171219913	Foxboro	Cocasset Street	Runfore River	Moderate	0.2343
xy4210069571131315	Sharon	Bay Road	Trib. to Queset Brook	Moderate	0.2259
xy4186054471185385	Dighton	Maple Street	Trib. to Segregansett River	Moderate	0.2224
xy4185347570941249	Lakeville	Main St. (Rte. 105)	Bates Brook	Moderate	0.2155
xy4198646071240339	Mansfield	Oak Street	Hodges Brook	Moderate	0.2153
xy4187814971137517	Taunton	South Walker St.	Trib. to Three Mile River	Moderate	0.2119
xy4210014671133793	Sharon	Penny Brook Lane	Penny Brook	Moderate	0.2045

Table 7: Severe and Significant Crossings That Did Not Match a Critical Linkage Site			
Severe Barrier	**Town**	**Road**	**Stream**
xy4206952671269558	Foxboro	Lakeview Road	Cocasset Brook
Significant Barrier			
xy4191538871233625	Attleboro	Smith Street	Br. of Chartley Brook
xy4193103571245070	Attleboro	Pike Avenue	Br. of Chartley Brook
xy4200355770901795	E. Bridgewater	N. of Plymouth St.	Stump Brook
xy4207684671279659	Foxboro	Pierce Street	Carpenter Brook
xy4204592971275532	Foxboro	Mill Street	Trib. to Cocasset River
xy4197889570859046	Halifax	Franklin Street	Palmer Mill Brook
xy4204856671186396	Mansfield	Maple Street	Trib. to Canoe River
xy4197071871231797	Norton	Walker Street	Trib. to Wading River
xy4193260371053567	Raynham	Gardiner Street	Forge River
xy4206294571179613	Sharon	Mansfield Street	Trib. to Little Canoe River
xy4187825270986918	Taunton	Massasoit Park Rd.	Trib. to Furnace Brook

Surveyed crossings that were evaluated as significant barriers but received Impact_In scores below 0.2 probably do not represent significant ecological restoration potential. However, the evaluation as a significant barrier indicates conditions observed in the field that resulted in low Aquatic Scores: conditions such as flow constriction, collapsed or damaged culverts, blockage, or skewed alignment of streamflow. These crossings (listed in Table 8 below) should be evaluated further to determine whether replacement or upgrade would reduce existing problems such as flooding, erosion, stagnation and/or pollution.

Table 8: Significant Barrier Crossing with Impact_In Score Less Than 0.2				
Crossing Code	**Town**	**Road**	**Stream**	**Imp_In Score**
xy4186289970977942	Taunton	Highstone Street	Thompson Brook	0.1008
xy4191600370857469	Middleborough	Katrina Road	Trib. to Raven Brook	0.1001
xy4201982871313791	Plainville	Shepard Street	Turnpike Lake Conn.	0.0989
xy4185739270987111	Taunton	S. Precinct St.	Trib. to Furnace Brook	0.0921
xy4195021171227230	Norton	S. Worcester St.	Goose Brook	0.0789
xy4179738971029296	Freetown	Howland Road	Trib. to Assonet River	0.0601
xy4187700670879787	Middleborough	Wareham Street	Fall Brook	0.0288
xy4196405270817006	Plympton	Center Street	Trib. to Colchester Brook	0.0285
xy4191561971043687	Raynham	North Main St.	Dam Lot Brook	0.0270
xy4196350170961152	Bridgewater	Conant Street	Branch of Sawmill Brook	0.0088

The following section provides more information on selected priority sites.

Top Ten Priorities for Restoration

A brief description of the ten sites, assessed as significant barriers with Impact_In scores higher than 0.2, is provided below.

1. The crossing of **Palmer Mill Brook on Franklin Street in Halifax** received the highest Imp_In score of all the significant barrier sites. It consists of three round culverts, each with an outlet drop. This brook originates north of Plymouth Street in Halifax (Route 106). This area is just south of the Burrage Pond Wildlife Management Area and a significant area of BioMap 2 Core Habitat. The brook flows into the Winnetuxet River.

This crossing has a severe constriction to water flow with a large scour pool downstream of the culvert and skewed alignment. There was an outlet drop at each of the three culverts.

2. The crossing of **Chartley Brook at Peckham Street in Attleboro** is located west of the Attleboro landfill. It consists of a bridge with abutments. The outlet is clogged, collapsed or submerged. Large cement barriers block both sides of the crossing, creating a barrier to passage of fish and wildlife. The crossing is in poor condition with a severe restriction and large scour pool. Chartley Brook flows along the western edge of the Chartley Brook Conservation Area into Chartley Pond. The entire area is part of a BioMap2 Core Habitat Area. This sub-watershed is one of the headwater areas of the Wading River.

3. The crossing of **Chartley Brook at Wilmarth Street in Attleboro** consists of a single culvert that creates severe constriction of stream flow and has a large scour pool at the outlet. The crossing is a severe restriction with a large scour pool. This crossing is also part of the Wading River headwaters and BioMap2 Core Habitat Area referred to in the item above.

4. The crossing of **Mill Brook on Bell Rock Road in Fall River** consists of four culverts in poor condition. All four inlets and two of the outlets are clogged, collapsed, or submerged, as are two outlets. The crossing creates severe constriction and skewed alignment of the streamflow. Mill Brook and its downstream stretch known as Rattlesnake Brook form a coldwater stream that flows into the Taunton River. The crossing lies within a large block of BioMap 2 Core Habitat Area in the Fall River/Freetown State Forest and the Southeastern Massachusetts Bioreserve. A planned dam removal on the lower portion of Rattlesnake Brook will open fish passage from the Assonet River. Improvement of this crossing would extend passage upstream.

5 and 6. These two stream segments **run under Bay Street in Taunton** and represent a key connection between the Canoe River and Watson Pond with Lake Sabbatia. Both of them have large inlet drops of 31" with flashboards and gauges at both inlets.

7. The crossing of **Fall Brook at North Walker Street in Taunton** is a single narrow culvert with a large inlet drop of 36." The crossing consists of a single culvert that acts as a dam, creating a severe restriction and large scour pool. The dam is at the upstream end of the crossing. This brook originates and flows through a BioMap2 Core Habitat Area and discharges into the Three Mile River.

Measuring the culvert at North Walker Street in Taunton

8. The crossing of **Poquanticut Brook at Mill Street in Easton** is a single culvert in collapsing condition. The culvert is blocked with big rocks and tree limbs. This brook flows out of Leach Pond in the Borderland State Park, most of which is designated BioMap2 Core Habitat. The brook flows to New Pond and continues south as Mulberry Brook to Winnecunnet Pond, then emerges as the Snake River.

9. The crossing of a **tributary to the Wading River off Walker Street in Norton** is a box culvert with an outlet drop of 6 to 12 inches. The river experiences seasonal low-flow conditions in this segment and sometimes dries up. There was no streamflow at the time of observation (1-10-08). This crossing lies within or just north of a BioMap2 Core Habitat Area that encompasses a small portion of the river corridor south of the Norton/Mansfield boundary.

10. The crossing of a **tributary to Meadow Brook at Thurston Street in Wrentham** consists of two round culverts with outlet drops. This tributary originates in a BioMap2 Core Habitat Area in the eastern portion of the Wrentham State Forest

Moderate barrier crossings with CL Scores greater than 0.2

Thirty-one crossings rated as moderate barriers to aquatic passage received Impact_In scores above 0.2 and merit further review. Where two or more crossings are located in proximity to each other on a river or on tributaries to the same river, the overall ecological benefits from replacement or upgrade may be enhanced. Examples of such crossings are described below.

Crossings of four tributaries to the Segregansett River in Dighton on Wheeler, Horton and Maple Streets. These crossings are located within three miles of each other in an area that includes the Poppasquash Swamp, and all of them received Imp_In scores above 0.2. Two crossings on Wheeler Street received scores of 0.3454 and 0.2973. A crossing of the Poppaquash Swamp River on Horton Street received a score of 0.3243, and a crossing of another tributary to the Segregansett on Maple Street received a score of 0.2224. Especially considering the high Impact_In scores, potential cumulative benefits of restoring all four crossings should be evaluated.

This undersized culvert at the Maple St. crossing of the Segregansett River restricts water flow and fish passage. Photo credit: Rachel Calabro

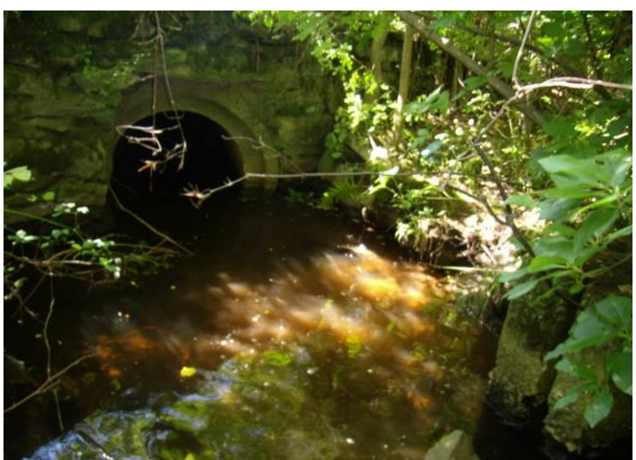
Black Brook in Easton. Two crossings of Black Brook north of the Hockomock Swamp Wildlife Management Area received high Imp_In scores. One of them, located on Randall Street, received the second highest score among moderate barrier sites (0.4548), while a second crossing on Depot Street was scored at 0.2976. South of Depot Street, Black Brook flows into the Hockomock Swamp. A crossing of a tributary to Black Brook on Howard Street which flows into the Swamp and Brook in the area south of Foundry Street received a score of 0.3116. After this point, the Brook flows generally southwest through the Swamp and joins the Hockomock River in West Bridgewater. Potential benefits of restoring all three crossings should be evaluated.

Crossings of the Cedar Swamp River on Freetown Street and a tributary to Cedar Swamp River on Howland Road in Lakeville. The Freetown Street crossing is located in the headwaters of the river just before it enters the Cedar Swamp, while the tributary flows into the Cedar Swamp from the south. The Swamp is designated as BioMap2 Core Habitat and includes an exceptional stand of Atlantic White Cedar as well as Priority Habitat for several rare species. Over 1,000 acres of the Swamp and its buffer zone are protected as Mass Audubon's Cedar Swamp Sanctuary.

Crossing of Rattlesnake Brook in Freetown. This crossing is located downstream of the significant barrier crossing of Mill Brook in Fall River within the Fall River/Freetown State Forest and the Southeastern Massachusetts Bioreserve. As noted previously, a planned dam removal on this brook will open fish passage from the Assonet River, and replacement of this crossing would enhance the restoration efforts.

Crossing of Colchester Brook on Cross Street in Plympton. This crossing received an Imp_In score of 0.6057, the highest of scores for moderate barrier crossings. It is located roughly one mile downstream of a significant barrier crossing of the same brook on Center Street which received a lower score of 0.0285. The reason for the difference in scores is not obvious, but the potential benefits of restoring both crossings should be further evaluated. Just north of the Plympton/Halifax town line, the brook joins Palmer Mill Brook, then flows into the Winnetuxet River.

Crossings of a tributary to Fall Brook on Tremont Street and a tributary to the Three Mile River on South Walker Street in Taunton. An area of over 14,000 acres of the Three Mile River's corridor was designated an Area of Critical Environmental Concern in 2008. These two crossings fall within that corridor, and within BioMap2 Core Habitat. The Three Mile River and Fall Brook (a tributary) both experience periods of low streamflow or no flow during summer months. Crossing replacement or upgrade might mitigate these stressed periods.



Miller Road in Middleborough

Crossings of Tamett Brook on Betty's Neck Road and Bates Brook on Main Street in Lakeville and Miller's Neck Brook on Miller Road in Middleborough. These streams are all tributaries to the Assawompset Pond Complex. Tamett and Bates Brooks flow into Long Pond. Long Pond is a source of drinking water for the City of New Bedford. Miller's Neck Brook is a tributary to Black Brook which flows into Great Quitticas Pond.

The streams associated with some of the other crossings in this group represent connections from or between ecologically significant areas. Following are several examples:

Crossing of a tributary to the Canoe River at Newcomb Street in Norton. This stream flows through BioMap2 Core Habitat and joins a stretch of the Canoe River that is also designated as Core Habitat.

Crossing of One Mile Brook at North Street in Bridgewater. The One Mile Brook flows from Bridgewater through a portion of the Hockomock Swamp Wildlife Management Area in West Bridgewater and joins the Town River.

Crossing of Hawthorne Brook on Cowell Street in Plainville. This crossing is downstream of the portion of Hawthorne Brook that flows out of the Wrentham State Forest.

Crossing of the Canoe River on East Street, Foxboro. This crossing is downstream of the portion of the river that forms the boundary of the Canoe River Wilderness Area.

Crossing of a tributary to the Rumford River at Oak Street in Foxboro. Areas upstream of this crossing include Vandy's Pond in Foxboro and Gavin's and Wolomopoag Ponds in Sharon.

Crossing of a tributary to the Cocasset River on Mill Street in Foxboro. Lakeview Pond, Cocasset Lake and Foundry Pond are upstream of this crossing and the upper portion of the river forms part of the boundary of the Harold B. Clark Town Forest.

Crossing of Hodges Brook on Oak Street in Mansfield. Less than a mile upstream of this crossing, Hodges Brook flows through Mansfield's Great Woods Conservation Area.

Crossing of Poquanticut Brook on Rockland Street in Easton. Slightly north of this crossing, this brook flows out of an area designated as BioMap2 Core Habitat in Borderland State Park.

Severe or Significant Barrier Crossings that did not match a Critical Linkage Site

Twelve crossings evaluated as severe or significant barriers to passage did not match a Critical Linkages site. This report recommends that these sites be further evaluated for their potential for ecological restoration based on conditions noted in the field surveys and/or proximity to valuable ecological areas.

Severe barrier site:

The connection of Lakeview Pond and Cocasset Brook on Lakeview Road in Foxboro was the only site in the Taunton River watershed evaluated as a "severe" barrier to aquatic passage. It is located in an upper headwater area of the Wading River watershed, and may have been eliminated from the Critical Linkage Database because of its small drainage area. Lakeview Pond is adjacent to a significant area of BioMap2 Core Habitat, most of which comprises the Gilbert Hills State Forest and the Harold B. Clark Town Forest.

The crossing includes a dam and large rocks, with an outlet drop of three feet, creating a severe impediment to aquatic passage.

Significant barrier sites:

1. Crossing of a **tributary to Furnace Brook on Massasoit Park Road in Taunton.** The single culvert has an inlet drop of 6 to 12" to water surface; also a 10" drop at the tailwater concrete armoring. This crossing is located within the Massasoit State Park.

2. A crossing of a **tributary to Chartley Brook at Smith Street in Attleboro.** The single culvert is in poor condition with severe constriction, a large scour pool and skewed alignment.

The crossing has an outlet drop of 9" to water surface and 12" to streambed. This area is part of a BioMap2 Core Habitat Area in one of the headwater areas of the Wading River.

3. A crossing of a **tributary to Chartley Brook at Pike Avenue in Attleboro** consists of a single culvert in poor condition with severe constriction and large scour pool. It has a steep outlet drop of 10" to surface water and 20" to streambed that creates a barrier to aquatic passage. This crossing is located in the BioMap2 Core Habitat Area referred to in the item above.

4. A crossing of the **Forge River at Gardiner Street in Raynham** is a bridge with rusted abutments, severe constriction and a small scour pool. There is an inlet drop greater than 24" and an outlet drop greater than 24" to the water surface. The drop functions as a dam that is a barrier to aquatic passage. This crossing is downstream of Pine Swamp and Pine Swamp River, designated as BioMap2 Core Habitat.

Walker Street in Norton

5. A crossing of a **tributary to the Wading River at Walker Street in Norton** is a single round culvert embedded or with persistent water. The culvert is in poor condition with severe constriction, large scour pool and skewed alignment. There is an outlet drop of 2" to water surface and 6" to streambed. Improvement of aquatic passage at this crossing could result in significant benefit because of its location of this crossing on a major tributary with a large drainage area upstream in Mansfield and Foxboro.

6. A crossing of **Palmer Mill Brook at Franklin Street in Halifax** consists of three round culverts. The crossing represents a severe constriction with a large scour pool and skewed alignment. Culvert 1 has an estimated outlet drop of 18" to water surface; culvert 2 has an estimated outlet drop of 6" to water surface; and culvert 3 has an estimated 3" outlet drop to water surface. Three branches of the brook originate near Route 106 in Halifax roughly one to two miles upstream of this crossing.

7. A crossing of **Stump Brook near Plymouth Street in East Bridgewater** is a single box culvert that connects a cranberry bog reservoir to Robbins Pond. It forms a severe constriction and small scour pool. There is an estimated 31" outlet drop to water surface and a 37" drop to streambed. The outlet drop creates a barrier to passage. Upstream of this crossing, Stump Brook originates in West Monponsett Pond in Halifax. It runs through a Mass Audubon Sanctuary that includes stands of Atlantic White Cedar Swamp, then continues through portions of the Burrage Pond Wildlife Management Area. Both areas are designated as BioMap2 Core Habitat. Replacement of this crossing could contribute to restoring a historic herring run.

8. A crossing of a **tributary to the Canoe River at Maple Street in Mansfield** is a box culvert which is excellent condition but causes severe constriction of flow. There is also an inlet drop of 84" that creates a severe barrier to passage. This crossing is roughly two miles downstream of the Canoe River Wilderness Area in Foxboro that forms part of the river's headwaters.

Maple Street in Mansfield

9. A crossing of a **tributary to Little Canoe River at Mansfield Street in Sharon** is a single round culvert. The culvert is in eroding condition and causes mild constriction of streamflow. At the time of observation, the culvert was blocked with tree branches, rocks and muck, creating barriers to passage. The crossing is located in the upper headwaters of the Little Canoe River.

10. A crossing of **Carpenter Brook on Pierce Street in Foxboro** is a single culvert in broken condition with a small scour pool. There is culvert observable on the downstream side of the river and on the upstream side it is very small. It forms a barrier to passage. The brook is located in the upper headwaters of Cocasset Brook and Cocasset River.

11. A crossing of a **tributary to Cocasset River on Mill Street in Foxboro** consists of round culverts in excellent condition. There is a mild constriction with no inlet or outlet drops.

Significant barrier crossings with Critical Linkages Imp_In scores below 0.2.

Crossings that were evaluated as significant barriers to aquatic passage but received Imp_In scores below 0.2 are not considered to have significant potential for ecological restoration, possibly because the areas upstream of the crossing do not have high ecological value. However, the designation as a "significant" barrier indicates that these crossings received low Aquatic Scores based on measurements and observations recorded in the field surveys, indicating one or more problems such as flow constriction, collapsed or damaged culverts or skewed alignment of streamflow. These conditions may cause impoundment and stagnant water, degraded water quality, flooding of roads and nearby property and/or erosion and sedimentation. This report recommends that significant barrier crossings with CL scores below 0.2 be considered for replacement or upgrade, based on further evaluation to determine the value that improvement would provide.

1. A crossing of **Thompson Brook on Highstone Street in Taunton** is a single culvert that connects Big Bearhole Pond in Massasoit State Park with an upstream area. This crossing received an Aquatic Score of 0.4. The crossing creates a severe constriction. There is an inlet drop of 6 to 12" and an outlet drop greater than 24".

2. A crossing of a **tributary to Raven Brook on Katrina Road in Middleborough** received an Aquatic Score of 0.4. This crossing lies in a headwaters area near Rt. 44. The culvert is in poor condition with skewed alignment. There is an outlet drop of 10" to water surface and 12" to the streambed with a freefall cascade.

3. A crossing of a **connector to Turnpike Lake on Shepard Street in Plainville** received an Aquatic Score of 0.39. Turnpike Lake connects to Lake Mirimichi, headwaters of the Wading River. The crossing consists of two round culverts, both of which are eroded with outlet drops of 6 to 12". The culverts are blocked by weeds, muck and dirt.

4. A crossing of **a tributary to Furnace Brook on South Precinct Street in Taunton** received an Aquatic Score of 0.46. Holloway Brook originates in Bearhole Pond in the Massasoit State Park and flows into Cedar Swamp River in Lakeville. The crossing is a bridge with abutments. Permanent barriers to passage that were 6" thick were observed.

5. A crossing of **Goose Brook on South Worcester Street in Norton** received an Aquatic Score of 0.5. Goose Brook is a tributary to the Wading River. A relatively small BioMap2 Core Habitat area lies upstream of this crossing. The crossing is a bridge with abutments. There is a severe constriction with large scour pool and an estimated 48" inlet drop.

6. A crossing of a **tributary to the Assonet River on Howland Road in Freetown** received an Aquatic Score of 0.46. This crossing lies in an area that could provide a permanent connection between Mass Audubon's Cedar Swamp Sanctuary and the Fall River/Freetown State Forest and Southeastern Massachusetts Bioreserve. The crossing consists of two round culverts. There is a large scour pool. An outlet drop at Culvert 1 was measured as 10" to water surface and 23" to streambed, and at Culvert 2, 9" to water surface and 29" to streambed.

Howland Road in Freetown

7. A crossing of **Fall Brook on Wareham Street (Rt. 28) in Middleborough** received an Aquatic Score of 0.48. This section of Fall Brook connects the Fall Brook Washburn Conservation Area with Tispaquin Pond. This crossing is a bridge with abutments. It forms a severe constriction and large scour pool; also an inlet drop greater than 24" and an outlet drop to water surface, also greater than 24".

8. A crossing of **Colchester Brook at Center Street in Plympton** received an Aquatic Score of 0.42. This crossing is upstream of the area where the brook flows along the southwest boundary of a Conservation Area that straddles Plympton and Halifax. The crossing consists of two round culverts. The culverts are in poor condition with a large scour pool. Both culverts showed an inlet drop of 12". Weirs in both culverts create barriers to passage. It is a cranberry bog control structure with drop blocks to control water flow.

9. A crossing of **Dam Lot Brook on North Main Street in Raynham** received an Aquatic Score of 0.42. This tributary connects a significant upstream area; it flows out of Johnson Pond which connects with upstream areas of Hewitt Pond and Gushee Pond. The crossing is a bridge with abutments and an inlet drop greater than 24". There is a dam at the outlet with a 10 foot freefall, creating a permanent barrier to aquatic passage.

10. A crossing of **Sawmill Brook at Conant Street in Bridgewater** received an Aquatic Score of 0.46. The crossing is a bridge with abutments in poor condition with severe constriction, large scour pool and skewed alignment. There is an outlet drop of 6" to water surface and 10" to streambed. Fallen stones also present severe barriers to passage. Upgrading this crossing would provide aquatic passage to Ice Pond.

Section 8. Stream Crossing Success Story

One local example of a successful culvert replacement project is a crossing of an unnamed tributary to the Taunton River on Hill Street in Raynham[22]. The culvert was round, perched above the streambed and three feet wide. Extensive business and industrial development along Route 44 in recent decades significantly increased impervious surface upstream of the crossing, creating increased storm runoff discharging into the stream. Rainstorms often caused flooding events upstream, and large storms occasionally produced flooding up to Route 44. The stream was classified by the Division of Fisheries and Wildlife as a cold water fishery.

In 2007, a battery manufacturing company named Electrochem wished to build a new facility on a 20-acre site in the Raynham Industrial Park on land upstream of the crossing. Pressure from residential property owners in the vicinity, the company itself, and the Taunton River Watershed Alliance convinced the Town of Raynham to upgrade the culvert to meet Massachusetts Stream Crossing Standards. The cost adjusted to 2014 dollars was $450,000. The town received $340,000 in "Chapter 90" funding from the Commonwealth which is designated for local road repair and $27,000 from a Massachusetts Opportunity Relocation and Expansion Grant (MORE), reducing the cost to Raynham to $72,000.

The Division of Ecological Restoration's (DER) report on the project estimated that the cost to Raynham of an "in-kind" replacement of this culvert -- i.e., no upgrade -- would include $120,000 for a 25-year replacement plus annual maintenance cost of $9,000. Over thirty years, this cost would total $390,000. The savings to the town from the culvert upgrade was estimated between 75-82%.

The culvert at Hill St. in Raynham, before (L) and after (R). Photo credit: Bill Napolitano

[22] 2015. *Economic & Community Benefits from Stream Barrier Removal Projects in Massachusetts.* Massachusetts Department of Fish and Game, Division of Ecological Restoration (DER). http://www.mass.gov/eea/docs/dfg/der/pdf/phase-iii-benefits-from-stream-barrier-removal-projects.pdf

In addition, social and economic benefits that resulted from culvert replacement include avoided damages to infrastructure, property value benefits and increased recreational benefits. The upgrade reduced risk of flooding to nearby residential properties and improved fish passage with possible improvement in recreational opportunities.

The report concluded that 'the liability cost of the poor drainage at the Hill Street culvert decreased the value of the [Electrochem industrial park] site as an industrial development option and threatened to preclude opportunities for 300 new jobs and an estimated $700,000 annual tax revenue source for the region." Electrochem subsequently constructed an 82,000 square-foot facility on the Industrial Park site which currently supports 300 jobs and generates tax revenue.

The report does not attempt to evaluate or assign an economic value to the ecological restoration that is likely to have occurred at the Hill Street crossing site. As noted above, the unnamed tributary is classified as a cold water stream.

For more information on this topic, we recommend: *Flood Effects on Road-Stream Crossings Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs* written by the U.S. Department of Agriculture, American Rivers and The Nature Conservancy.

Section 9. What Cities and Towns Can Do

Most of the crossings identified as having the highest potential for improvement in this report are located on local roadways, as opposed to state or federal highways. Cities and towns are responsible for maintenance and improvement of local roadways within their boundaries. To restore stream continuity and healthy aquatic ecosystems for the future, city and town officials and boards must take the lead to replace substandard crossings with structures that are designed and constructed to restore the conditions of natural streamflow. Resources for advice, assistance, and grants are listed below.

In addition, city and town officials, municipal staff, and residents have invaluable knowledge of local natural resources including rivers and streams. Key municipal departments and boards include Public Works, Water Supply, Planning Board, Conservation Commission, and Open Space Committee. In addition, many neighborhood associations and local watershed groups address issues related to natural resource protection and restoration as well as issues of pollution, flooding and erosion. We would welcome feedback on this report from local entities and individuals, as well as information about streams and river segments that have significant ecological value and/or are experiencing problems with streamflow continuity, but were not included in these assessments.

We encourage municipalities to plan for upgrades or replacement of crossings that create barriers to aquatic passage as well as those that cause flooding, stagnation or pollution, and are potential mosquito breeding areas. Residents can play important roles supporting efforts of local boards and officials who attempt to advance these projects. We also recommend that all of this information be considered in conjunction with other programs related to restoration (such as DER's Dam Removal Program and GRRIP), in order to identify sites where crossing replacement will enhance the benefits of other restoration projects in the vicinity.

This section identifies critical roles that municipal boards, commissions and departments play in the effort to restore stream continuity throughout the Taunton River watershed, and to increase resiliency to impacts of climate change, sea level rise, increased intensity of storms and more widespread flooding.

Department of Public Works (DPW). DPWs plan and supervise repair and replacement of local streets and roads. Existing stream crossings should be identified in road replacement projects early in the planning stage with investigation into the need for and value of upgrading the crossing. Wetlands regulations require that replacement crossings meet the stream crossing standards to the maximum extent practicable. While the upgrade of a crossing may increase the immediate design and construction costs of a project, this increase should be compared with the cost of maintenance and future need for replacement of that crossing if it were replaced "in-kind," i.e., with the same structure. DPWs can also work with regional and state agencies (see below) to identify potential sources of financial assistance. If stream crossing upgrades are included in road repair projects that are submitted to and approved by the regional planning agency and MassDOT, "Chapter 90" funds are likely to be available to assist with the cost of the project.

Sometimes culverts and bridges are repaired or replaced under "emergency" circumstances following a severe storm that causes extensive damage to roads or other property. These situations may lead to installation of another culvert or bridge of the same dimensions and design as the damaged crossing, in order to expedite the repair and restore access. When a damaged crossing is replaced "in-kind," no improvement of earlier conditions results. Post-emergency retrofitting may be required to meet wetlands regulatory requirements. To avoid such situations, cities and towns should identify crossings that should be upgraded in advance and develop a plan to respond to emergencies with replacements that are appropriately designed to restore natural streamflow, banks and habitats.

Planning Boards review and approve plans for new roads and in some cases review repair/replacement of existing roads. They should verify that crossings on new road construction comply with the Massachusetts Stream Crossing Standards and should also work with DPW officials to review potential for upgrades of crossings in repair or replacement projects where appropriate. Planning Boards are also responsible for preparing municipal Master Plans, and these plans should include identification of undersized or non-functional crossings with recommendations for upgrade.

Conservation Commissions are required to review all projects that involve work in wetland resource areas or in specified buffer zones, and are responsible for ensuring compliance with the Stream Crossing Standards for all permitted crossings. For replacement crossings, Commissions can consult informally with DPW officials to identify plan necessary upgrades. Conservation Commissions are also involved in development of municipal Open Space and Recreation Plans. These plans should include assessment of degraded natural resources including conditions created by stream crossing structures and identify measures to restore healthy aquatic resources. Members of Conservation Commission participate in site inspections that often involve areas crossed by streams or rivers, so their knowledge of local conditions is likely to be extensive.

Planning Boards and Conservation Commissions both play an important role in educating the public regarding the benefits to public health and safety, environmental quality and financial savings from projects that remove barriers to natural streamflow. In addition, as discussed previously, a number of sites that were identified with high restoration potential in the Critical Linkages Project were not assessed in the field. Residents or municipal officials who have information regarding crossings that may represent barriers to passage but were not assessed should contact Mass Audubon, TRWA, or the Massachusetts Division of Ecological Restoration.

Hazard Mitigation Plans. Under federal law (Code of Federal Regulations Title 44 – Emergency Management and Assistance) municipalities are required to submit Local Hazard Mitigation Plans to the Federal Emergency Management Agency (FEMA) to be eligible to apply FEMA Hazard Mitigation Assistance grants. These plans may be developed by several city or town departments or commissions, such as Sewer Commission, DPW or others. Stream crossing upgrades that would increase capacity to accommodate storm surges should be identified in these plans and may be eligible for funding assistance under FEMA. A guide for preparing local Hazard Mitigation Plans is available at: http://www.fema.gov/media-library/assets/documents/31598.

Assistance for Communities – Resources and Contacts

Sources of financial assistance:

Massachusetts Division of Ecological Restoration – grants and technical assistance

Coastal Pollution Remediation (CPR) Grants – Massachusetts Coastal Zone Management Program

Municipal Chapter 90 Funds – MassDOT

Transportation Alternative Program (TAP) funds – Federal Highway Administration

Section 319 Nonpoint Source Competitive Grants Program for projects that address prevention, control and abatement of nonpoint source pollution – Massachusetts Department of Environmental Protection

MassWorks Infrastructure Program for projects that support economic development, job creation and transportation safety issues in small rural communities

Southeast New England Estuary Program: Water Quality Management Grants for the Greater Narragansett Bay Watershed – Environmental Protection Agency

Data and Mapping Tools:

The **North Atlantic Aquatic Connectivity Collaborative Database** includes records from thousands of stream crossing assessments in the North Atlantic Region including the records referenced in this report. The records can be accessed by state, stream name or watershed. The link to this website is: http://www.streamcontinuity.org/cdb2

BioMap2 Town Maps provide information on Core Habitat Areas located in each municipality of the Commonwealth. They are available at: http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/biomap2.

Mapping and Prioritizing Parcels for Resilience (MAPPR) allows land conservationists to identify the parcels within an area of interest that are the highest priorities for protection based on habitat quality, climate change resilience, and other metrics such as parcel size and adjacency to existing protected parcels. Analyses are based on several resiliency models including The Nature Conservancy's Resilient Landscapes as well as BioMap2 and the UMass Conservation Assessment and Prioritization System (CAPS). www.massaudubon.org/mappr

The **Massachusetts Geographical Information System (GIS**) allows users to select any region of the Commonwealth and view maps with many choices of information layers, e.g., rivers and streams, wetlands, Core Habitat, NHESP Priority Habitat: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/. You can also use their online data viewer, OLIVER: http://maps.massgis.state.ma.us/map_ol/oliver.php

Supporting Organizations:

The **Mass Audubon Shaping the Future of Your Community Program** provides municipal officials and local citizens with the tools, techniques, and expertise to promote smart development and protect natural resources. It provides customized workshops and direct technical assistance. Contact: Stefanie Covino, Broad Meadow Brook Conservation Center and Wildlife Sanctuary, 414 Massasoit Rd, Worcester, MA 01604; 508-640-5618 or scovino@massaudubon.org, www.massaudubon.org/shapingthefuture.

The **Resilient Taunton Watershed Network** was formed in 2014 to promote the resiliency of the Taunton watershed in the face of climate change and development. Member groups include environmental organizations, EPA Region I, the Massachusetts Department of Environmental Protection and DER, SRPEDD and MAPC, among others. RTWN's goal is to identify and implement the most promising solutions that advance ecological and economic well-being and consider social and environmental justice issues as well. www.srpedd.org/rtwn

Taunton River Watershed Alliance, Inc. was formed in 1988 to protect and restore the rivers, streams and associated natural ecosystems in the Taunton River Watershed through education, policy advocacy, citizen action and water quality monitoring. Contact: Priscilla Chapman, 508-828-1101, trwa_staff@verizon.net, www.savethetaunton.org.

Government Agencies:

Environmental Protection Agency, Region I. Healthy Watersheds Program.
Contact: Trish Garrigan, garrigan.trish@epa.gov

Massachusetts Division of Ecological Restoration.
251 Causeway Street, Boston MA 02114; 617-626-1541.
Contact: Tim Chorey, timothy.chorey@state.ma.us

Massachusetts Department of Environmental Protection,
1 Winter Street, Boston, Massachusetts 02108
Contact: Lealdon Langley, Lealdon.langley@state.ma.us

Southeast Regional Planning and Economic Development District (SRPEDD)
88 Broadway, Taunton, MA 02780; 508-824-1367
Contact: Bill Napolitano, bnap@srpedd.org,

Old Colony Regional Planning Council (OCPC)
70 School Street, Brockton, MA 02301; 508-583-1833
Contact: James Watson, jwatson@ocpcrpa.org
Eric Arbeene, earbeene@ocpcrpa.org

Metropolitan Area Planning Council (MAPC)
60 Temple Place, Boston, MA 02111; 617- 933-0781
Contact: Anne Herbst, aherbst@mapc.org

Narragansett Bay Estuary Program (NBEP)
http://www.nbep.org/
235 Promenade Street, Suite 310, Providence, RI 02908; 401-633-0550