Restoration Priorities for the Parker, Ipswich & Essex River Watersheds Action Plan - June 2019 Update

A primer on major ecological stressors affecting the region and opportunities to preserve, restore and monitor ecosystem health in the Great Marsh and its contributing watersheds.

Originally written by Ipswich River Watershed Association staff in February 2013
on behalf of the Parker-Ipswich-Essex Rivers (PIE-Rivers) Restoration Partnership

Summary

This report summarizes important opportunities to protect and restore the valuable aquatic resources of the PIE-Rivers region, which includes the combined watersheds and estuaries of the Parker, Ipswich and Essex Rivers in northeastern Massachusetts. Opportunities are presented in the form of specific **actions** that can be implemented by a range of partners. Actions were identified and prioritized by members of the PIE-Rivers Steering Committee and four Technical Sub-Committees, based on factors including ecological importance, time sensitivity, likelihood of success, and feasibility (fiscal, technical, and social). In 2019, the plan was updated to include the emerging issue of climate resiliency to reflect the critical role that natural resources play in this issue. Individual actions cover a range of topics, from scientific monitoring to resource management, from outreach initiatives to physical habitat restoration, but all share the common goal of protecting and restoring our rivers and water resources over the long-term.

The report also provides context regarding regional restoration and resiliency efforts. To this end we describe the importance of the region's aquatic resources, highlight some of the major ecological stressors threatening those resources, and provide background on the PIE-Rivers Partnership's approach.

The document provides a framework to facilitate the planning, coordination and tracking of resiliency and restoration efforts. The PIE-Rivers Partnership intends to treat this as a "living document", using it to monitor accomplishments and updating information on threats, necessary actions, and priorities as conditions require. We hope this document will be a valuable resource to a wide range of current and future partners working in the region including conservation organizations, municipalities, state and federal agencies, and private landowners.

For more information on the PIE-Rivers Partnership or to become involved please visit our website at www.pie-rivers.org

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PIE-Rivers Region

The PIE-Rivers region refers to the combined watersheds and estuaries of the Parker, Ipswich and Essex Rivers in northeastern Massachusetts (Figure 1). This area encompasses all or parts of 28 towns. The Parker, Ipswich and Essex River Watersheds and Great Marsh offer some of the most outstanding ecological resources in Massachusetts. The region includes large areas of permanently protected land, including a national wildlife refuge, several state parks and forests, and other publicly and privately held conservation lands. The watersheds include extensive state-designated high quality natural resources and several coldwater fisheries, which are rare in eastern Massachusetts. The estuaries of the 3 river basins constitute the first and largest designated Area of Critical Environmental Concern in the Commonwealth of Massachusetts.

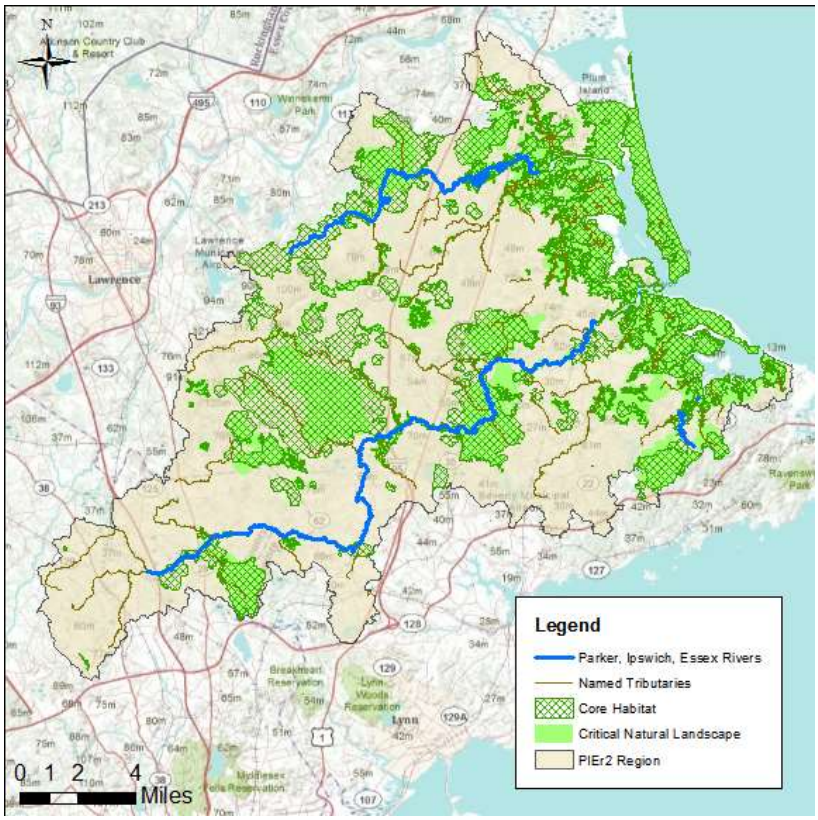

Figure 1. Map of the PIE-Rivers region showing major streams and BioMap2 core habitat and critical natural landscapes.

The Parker and Ipswich river basins make up the watershed of Plum Island Sound, the largest wetland-dominated estuary in New England, supporting extremely productive commercial and recreational soft-shell clam and striped bass fisheries. Together with the Essex, these rivers encompass the entire coastal watershed between the Merrimack River and Cape Ann. The coastal zone of the watersheds comprises much of the Great Marsh, the largest continuous salt marsh in New England.

The estuaries of the Great Marsh and their contributing watersheds also host a multitude of recreational and commercial activities including boating, sailing, angling, shellfishing, swimming, birding, kayaking and canoeing. The Parker River National Wildlife Refuge is a major ecological resource as well as an internationally known birding area. The entire project area is part of the Essex National Heritage Area, designated by Congress as a nationally important landscape.

These river basins are also the subject of an outstanding body of scientific research by the Marine Biological Laboratory at Woods Hole, the University of New Hampshire, the U.S. Geological Survey (USGS) and others.

Ecological Threats

Unfortunately the PIE-Rivers region is under significant stresses that threaten to undermine the long-term ecological integrity of the system. Substantial portions of the watersheds suffer from severe water losses that dry up the rivers causing fish kills and other environmental damage. Development in the watersheds increases polluted runoff and has fragmented some important wildlife habitats and natural areas. We are already experiencing the effects of global climate change, including heavy precipitation events, more intense storms, longer stretches of hot and dry days, coastal erosion, and rising sea level.

The migratory fisheries (including rainbow smelt, river herring, and American shad) are experiencing significant population declines and native freshwater fish populations are severely impacted. The Massachusetts Natural Heritage and Endangered Species Program has documented vulnerable and rare plant communities, as well as rare plant and animal species, in the project area.

The major ecological threats currently influencing the region include:

Low Flow

Rivers are naturally dynamic, or constantly changing, environments and river creatures can tolerate a wide range of flow conditions; however, extreme low-flow and no-flow conditions can cause considerable harm. Severe, frequent low-flow events stress fish and aquatic communities in the PIE-Rivers region, especially in the Parker and Ipswich Rivers. While a number of issues contribute to the frequency and severity of low-flow events, groundwater withdrawal for municipal and private use is a major driving factor. The most severe impacts are from summer groundwater withdrawals, which capture water that the rivers need to maintain flow. Withdrawals from reservoirs can also be damaging under some circumstances. The withdrawal impacts are often exacerbated by large water transfers out of the watershed or sub-basin, either for use in surrounding communities or as wastewater; this can represent a substantial net loss of water to the river system and the estuary.

Figure 2. Ipswich River during drought conditions in 2003.

A large amount of water is also lost through groundwater seeping directly into sewer systems and flowing out of the basin without ever being used. Additionally, factors such as increased impervious surfaces and the development of groundwater recharge areas (see Development Impacts) further exacerbate the problem.

Water demand peaks during hot summer months as large numbers of people water lawns and fill swimming pools. This coincides with a period of naturally low flow, and increased water withdrawals cause the rivers to fall below safe levels. The upper Ipswich River would be pumped dry on a nearly annual basis prior to the Town of Reading's 2006 decision to discontinue using its municipal wells near the river. This decision, along with a number of water-saving measures employed by Reading and other towns, has improved conditions on the Ipswich River, but flow levels still regularly drop below ecological thresholds identified by the USGS (Armstrong et al.,

2001) and further improvements are needed. Tributaries such as Martins Brook, Lubbers Brook, Norris Brook, Emerson Brook, Idlewild Brook and Mile Brook continue to be pumped dry or heavily impacted. The upper Parker River is also significantly affected, and the Mill and Egypt-Rowley River sub-basins are severely impacted by water withdrawals (Gomez and Sullivan, 2003; EOEA, 2005). In 2019, there are new proposals to increase withdrawals from the Parker and Essex River Watersheds.

Consequences of Low Flow

Low flows reduce available river habitat by shrinking the overall water volume in the channel and dewatering important areas including riffles and channel margins (nearest the riverbanks). Channel habitat can become physically disconnected from critical spawning, rearing, and feeding habitats in side channels and wetlands that border on the river. In extreme cases, the channel itself can stop flowing and be reduced to a series of isolated pools.

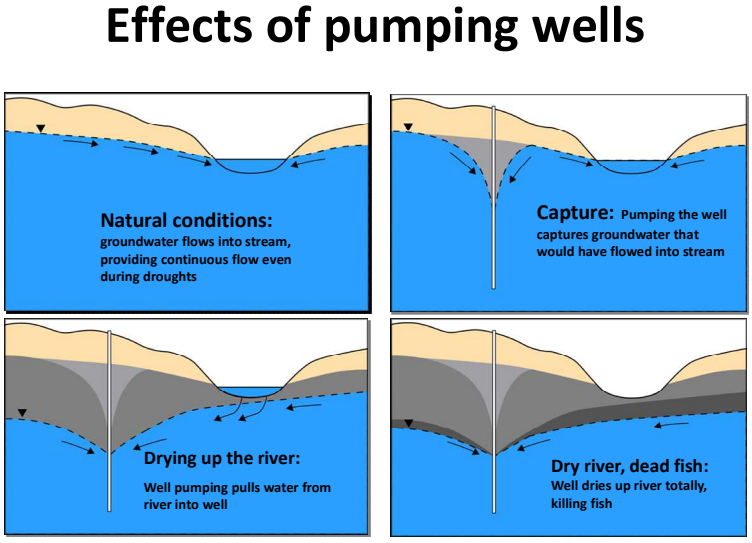

Figure 3. Schematic showing how water withdrawals from groundwater wells affect groundwater levels and river flow.

The smaller, slower moving volume of water in the river can also greatly influence water temperature and water quality. Reduced volume tends to result in more extreme water temperatures, higher in the summer and lower during winter low-flow events (possibly resulting in the stream freezing solid). High water temperature can kill organisms directly, and also decreases the amount of oxygen water will hold while simultaneously increasing the amount of oxygen fish and other organisms require for survival, resulting in lower dissolved oxygen. Temperature and dissolved oxygen conditions can further interact to degrade water quality by affecting how toxins and other chemicals behave.

As waters reach the estuary, lower river flow changes salinity, reduces sediment transport, and alters nutrient processes in the salt marshes. Saline water can encroach farther upstream, eliminating key spawning habitat and affecting water chemistry. These alterations can have a lasting impact on plant and animal communities that utilize the estuarine environment.

Migration Barriers

Diverse, well-connected habitat promotes healthy, resilient aquatic communities, by allowing fish and other wildlife to move to the best areas to meet particular needs in their life cycles (such as spawning and rearing) and providing refuges during extreme conditions. Reduced habitat connectivity is a clear problem for migratory species, but barriers can also strongly affect populations of less mobile organisms by harming habitat conditions or blocking the movement of animals they rely on.

Figure 4. The Ipswich Mills Dam, the furthest downstream of the Ipswich River Dams, inhibits migration for a variety of fish species.

Structures such as dams, weirs and culverts can break the important connections between habitats by blocking or slowing upstream and downstream migrations. Channelization, diking and other changes to the river banks can limit natural connections to adjacent wetlands and floodplains. Restrictions to the flow of tide water (such as undersized culverts, tide gates) can substantially alter the duration and frequency of tidal flooding in coastal areas.

In addition to the physical blockage of movement described above, structures and other factors such as water temperature, water chemistry and dissolved oxygen can act as barriers to many organisms even when passage appears possible. This is often the result of behavioral responses to unnatural or inhospitable habitat conditions.

The rivers of the PIE-Rivers region are fairly low gradient systems and, in their natural conditions, generally lacked permanent barriers to migration (like waterfalls). The construction of numerous dams and river crossings (bridges and culverts) has greatly limited habitat access for many species. Additionally, connections to river-side (or riparian) wetlands have been reduced and salt marsh characteristics have been greatly altered (through practices such as mosquito ditching).

Consequences of Migration Barriers

Habitat fragmentation can substantially reduce a river system's capacity to support populations of many aquatic species. In the case of diadromous (or sea run) fish species, migration barriers can essentially remove entire populations from the system. Migration barriers are listed as a key factor in the region-wide decline of diadromous species including river herring and "salter" brook trout. Many freshwater "resident" species migrate within a watershed either to complete specific portions of their life cycles (like spawning) or for more general purposes (such as following food sources, seeking shelter). The populations of many freshwater species including white sucker, Eastern brook trout and fallfish are reduced in the PIE-Rivers region due, in part, to reduced habitat connectivity in the watersheds.

Upland Development and Land Use

While generally thought of and managed separately from streams and wetlands, a watershed's uplands in many ways define the character of a river system. The development of uplands within a watershed can affect a wide range of important factors in aquatic systems, both directly and indirectly. Additionally, land use practices on both developed and undeveloped uplands can cause ecosystem stress and also impact a region's resiliency to enhanced climate impacts.

The low-flow and migration barrier stressors discussed above are clearly linked to development, as are numerous other stressors not individually listed. In many ways, development could be considered one of the primary stressors (or the ultimate causes of stress) with more specific issues such as low-flows, flooding, and reduced stream continuity representing symptoms caused by development. How waterways are affected by individual development projects varies widely based on factors such as geology, distance to channel, and development design, but some generalizations can be made.

Figure 5. Example of landscape changes as a result of suburban development.

Development can cause direct loss and fragmentation of both aquatic and upland habitat. These impacts tend to be particularly acute in situations where development is close to waterways, wetlands or active floodplains, but any development in the watershed can have serious consequences for the region's ecology.

A major issue with development is the increase in impervious surfaces within a watershed in the form of roofs, roads, parking lots, etc. Impervious surfaces impair groundwater recharge, as water tends to be quickly shunted via surface flow (stormwater) to streams, rivers and, in some cases, sewer systems. This has the combined effect of making streams "flashy" (that is prone to fast, extreme flooding events after precipitation) and more prone to low flows between precipitation events as groundwater aquifers are replenished at a slower rate. Since stormwater washes over impervious surfaces and doesn't percolate through the ground it often exhibits more extreme temperatures and carries higher concentrations of pollutants to rivers and streams.

Land use practices on already developed properties, agricultural lands, and other actively managed landscapes can have serious impacts on water quality. Excess nutrients, especially nitrogen and phosphorus from fertilizers, can cause eutrophication of the rivers and the estuaries. Similarly, certain pesticides, petroleum products and other chemicals can make their way to waterways if not properly handled on uplands. Land use decisions can also lead to the introduction and establishment of populations of invasive species that can serve as sources for the spread of these species to nearby areas.

Consequences of Development

In general, development within a watershed and intensive (or poorly managed) land use practices often lead to reductions in native aquatic communities through a combination of factors. A 2011

study by the USGS and MassWildlife found that for every 1% increase in imperviousness, there is a 3.7% decrease in the abundance of river (fluvial) fish (Armstrong et al., 2011). Careful planning and strict adherence to best management practices for development projects and land management can substantially limit many impacts. Even the best development methods employed on previously undeveloped parcels will result in a net negative impact (such as increased impervious surfaces or decreased infiltration). With this in mind, it is important to protect key land from development, and look to opportunities to improve conditions through retrofitting and during redevelopment of properties in order to improve overall development impacts in a watershed.

Disjointed Water Management

Watersheds are complex systems and are best managed with an approach that considers the interconnectedness of watershed resources. Human activities including water withdrawals and the management of stormwater and wastewater can cause substantial transfers of water within, between, and out of watersheds. These and other water movements must be considered together, on a watershed scale, in the context of the natural water cycle for the combined needs of area residents and ecological communities to be sustainably met. This concept of Integrated Watershed Management should be the goal going forward; otherwise communities are likely to find themselves without reliable, clean supplies of water to support drinking, agriculture, industry, recreation, and wildlife.

Currently, jurisdiction is highly fragmented and water management does not resemble this vision of cohesive, pragmatic process. Municipal governments actively manage water in a variety of ways (such as water withdrawals, stormwater, wastewater, land use restrictions) and in many cases, consider these issues separately. Even where municipalities take a more integrated approach, their control is limited by the fact that most watersheds (including those in the PIE-Rivers region) span many communities.

The framework of State and Federal regulation and oversight of water management issues is complex and disjointed with a host of agencies involved, each of which has unique authorities and operates under different mandates.

Figure 6. Incentive systems to encourage water conservation vary greatly throughout the region.

Consequences of Disjointed Water Management

The sum total of these factors is a water management system that, as a whole, does not take a systematic, integrated approach to allocating, managing and using water resources. As a result, portions of the PIE-Rivers region have streams that are severely flow-depleted, owing to a combination of issues including over-allocation, out of basin transfers, ineffective stormwater management and insufficient efficiency measures. These issues affect availability of adequate water to support some of the important native ecological communities in the region. This also has implications for the long term supply of water for human needs in communities that draw water from the PIE-Rivers watersheds.

Climate Change

Climate-driven threats around the globe and in the PIE-Rivers region are accelerating. In the coastal areas of our watersheds, sea levels are predicted to rise 1 to 4 feet by 2100 and potentially as much as 6.6 feet. (*Great Marsh Coastal Adaptation Plan*, page 4). In addition, as warming temperatures fuel larger and more frequent storms, storm surge will combine with sea level rise to push ocean flooding even further inland. As storm surge and sea level rise accelerate, the added stress to coastlines will lead to accelerating erosion rates and loss of coastline.

Other significant changes observed in Massachusetts and documented by the *Massachusetts Climate Change Adaptation Report* as impacting the PIE-Rivers region include reduced snowpack, earlier snow melt and spring peak flows, and an increase in the occurrence of consecutive days with temperatures above 90^0F. Based on data collected from 1958 to 2012, the amount of rain falling during extreme precipitation events has also increased by 71% in the Northeast – more than anywhere else in the country. Compared to historical levels, the North Shore, along with all of eastern Massachusetts, has already seen an increase in extreme precipitation events (defined as a storm dropping more than two inches of rain) which lead to damaging floods. During the famous Mother's Day flood in 2006, 15 in of rain fell over the course of about four days, overwhelming drainage systems, culverts, and bridges. These extreme precipitation events are predicted to increase by an additional 8% by 2050 and up to 13% by the end of the century. Due to projected increases in precipitation, by 2050, our region could experience the present-day "100-year" riverine flood as frequently as every two to three years and possibly once a year by 2100 (*Climate Change and Sea Level Rise Projections for Boston: The Boston Research Advisory Group Report,* prepared for the *Climate Ready Boston* project (Boston, MA, 2016).

<u>Consequences of Climate Change</u>

The combined impacts of freshwater flooding and sea level rise pose the greatest risk to coastal watersheds. In October of 2012, the communities in our region witnessed one of the most devastating hurricanes to ever hit the United States. When Hurricane Sandy slammed into the nation's heavily populated coastal areas, it was responsible for more than $71 billion in damages. While large storms like Sandy may become more common in the future, it is smaller but more regular storms that also cause significant damage to our communities and our region's natural systems. Additionally, ongoing development throughout the region has resulted in an increase in impervious surfaces and a reduction in the protective services of natural areas. These land use changes cause a variety of weather-related consequences; for example, during large storm events the stormwater storage capacity throughout the PIE-Rivers watersheds becomes easily overwhelmed and results in more widespread flooding. With climate change bringing more extreme precipitation events, which cause higher and heavier volumes of stormwater runoff, the impact of inland flooding on infrastructure, as well as the society, will become even more significant for our communities.

Additionally, predictions of temperature changes resulting from climate change show that both extreme cold in the winter and extreme heat in the summer will be in our future. Winter storms and high winds often trigger power outages, white-outs, and road closures throughout the North Shore. The summer of 2016 saw "extreme drought conditions" for the first time in the Massachusetts Drought Monitor's record. Drought conditions stress not only our water supplies and ecosystem health, but also our public safety.

Responding and adapting to climate threats is a critical component of all of the restoration and resiliency work of the PIE-Rivers Partnership. As the marshes and barrier beaches face increased

climate impacts, they are less able to be effective buffers to the lands, towns, roads, homes, and businesses that they protect. Healthy forests and healthy rivers are more resilient to storm damage and can help minimize destructive stormwater and inland flooding. Adapting to and preparing for further impacts is a necessity to ensure public safety and well-being, strengthen economies and communities, and protect critical natural areas that support a wide variety of wildlife and also provide protection for the human infrastructure alongside them.

The Partnership

A number of groups have been working to address the threats facing the PIE-Rivers watersheds, with some significant success over the years. Until recently, these efforts have not been conducted as part of a region-wide strategy, but rather by individual organizations or groups with varying levels of inter-organizational and inter-agency communication. The PIE-Rivers Partnership was formed to increase communication, coordination and collaboration between those involved in restoration, preservation, adaptation and management of the watersheds—from the coastal communities to the headwaters.

The individual work of our Partner organizations includes protecting land and wildlife, promoting low-impact development to reduce development impacts, advocating better water management regionally and statewide, helping communities save water to help address low-flow problems, removing dams and other river obstructions, educating the public about the values these rivers provide and the threats they face, organizing recreational programs, climate vulnerability assessment and adaptation, and conducting research and monitoring. Many organizations are working to help the region's communities be strong stewards of our water resources and ecosystems, and we have made significant progress.

Our Partnership's work includes looking at the big picture of how to restore these rivers and our region to the healthiest condition that we can realistically achieve. This means looking at a wide range of issues that are part of a comprehensive restoration and resiliency program.

In 2013, led by the National Wildlife Federation and the Ipswich River Watershed Association, members of the PIE-Rivers Partnership applied for and were granted funding from the Hurricane Sandy Coastal Resiliency Competitive Grant Program (administered by the National Fish and Wildlife Foundation) to complete a Great Marsh Vulnerability Assessment and Resiliency Planning Project for the six coastal communities in the watersheds. The final Great Marsh Coastal Adaption Plan was completed in December 2017 and includes regional adaptation strategies and recommendations. The Great Marsh project also included a thorough review of nearly 1,000 culverts, bridges, and dams–both coastal and inland, across the 28 communities in the PIE-Rivers watersheds–that are vulnerable to climate hazards. The final Great Marsh Barriers Report was completed in February 2018. Both reports can be found at www.greatmarshresiliency.org.

The strategies and actions identified by both of these recent resiliency plans have now been incorporated into the revised PIE-Rivers Action Plan Update completed in June, 2019.

PIE-Rivers Mission

To protect, restore and increase the resiliency of the valuable aquatic resources of the Parker, Ipswich and Essex River Watersheds.

Approach

PIE-Rivers works to achieve its mission by focusing on efforts that seek to address the following broad environmental **goals**:

- **Enough Fresh Water:** Restore and protect the natural flow regime to the extent technically feasible, so that our rivers and watersheds have enough water to sustainably support both human and ecological needs.

- **Clean Water:** Ensure that the water in the Parker, Ipswich and Essex watersheds and the Great Marsh estuary meets water quality standards and supports both aquatic life and human needs including recreational uses.

- **Healthy Ecosystems:** Restore, protect and increase the resiliency of natural resources that maintain ecosystem functions, support native biodiversity, and protect communities throughout the PIE-Rivers region.

Each PIE-Rivers Partner brings to the table a unique set of interests, abilities and expertise, allowing the partnership to leverage this diverse skill set to achieve its mission. Additionally, the federal, state and municipal partners each have their own jurisdictions and mandates within which they are able to work. The PIE-Rivers goal is to provide the communication forum and tools to allow Partners to work together better and understand how their ongoing or planned efforts fit in with the rest of the work in the region, and to function more effectively and strategically as a team than we could individually.

The Partnership scope includes building the river community, highlighting what is so special about the rivers and watersheds, addressing impacts on the region's water resources, and preparing for future changes so that our rivers and the region's ecological communities can be as healthy and resilient as possible.

Partners

The PIE-Rivers Partnership is open to representatives of municipalities (any municipality that has land within the region or whose water supply is in the watersheds), state and federal agencies, academic institutions, non-profits, and interested citizens. We hope that the list of active partners will continue to expand in the coming years.

The following is a list of Partners who have participated in the Partnership to date:

Non-Governmental Organizations
Greenbelt, Essex County's Land Trust
MassBays/Eight Towns & the Great Marsh
Mass Audubon
The Trustees
Trout Unlimited Nor'East Chapter
Parker River Clean Water Association
Ipswich River Watershed Association
Chebacco Lake and Watershed Association
Plum Island Estuary Long Term Ecological Research (PIE-LTER)
National Wildlife Federation
University of New Hampshire

Merrimac Valley Planning Commission
Metropolitan Area Planning Council

State and Federal Government
U.S. Fish and Wildlife Service Parker River National Wildlife Refuge
U.S. National Oceanic and Atmospheric Administration (NOAA)
MA Office of Coastal Zone Management (CZM)
MA Department of Fish and Game (DFG)
MA Division of Ecological Restoration (DER)
MA Division of Marine Fisheries (DMF)
MA Department of Conservation and Recreation (DCR)

Municipalities
Town of Ipswich
Town of Boxford
Town of North Andover
Town of Topsfield

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Restoration Framework[1]

The PIE-Rivers Steering Committee set out to identify a set of recommended **actions** that, if implemented, should improve ecological conditions and associated ecosystem services within the region. The group used the following framework to guide the process of developing the final list of actions presented in this document.

First, we developed a set of six primary **objectives** to pursue relative to the three PIE-Rivers Partnership goals described on page 9. These six objectives were:

1. **Natural Streamflow:** Promote more natural streamflow conditions to better support human and environmental water needs.
2. **Water Quality:** Promote efforts to protect and enhance surface and groundwater quality for the benefit of people and the environment.
3. **Ecosystem Restoration:** Promote efforts to protect and restore ecosystem function through habitat restoration, species protection and other available measures.
4. **Community Engagement:** Increase community involvement in and support for taking care of, restoring and protecting our rivers, watersheds and the Great Marsh.

[1] The structure of this process, including the Sub-committees and primary objectives were loosely based on the process used to develop the Piscataqua Region 2010 Comprehensive Management Plan (PREP et al., 2010).

5. **Responsible Water Management:** Ensure that decisions and actions affecting the PIE-Rivers region watersheds support the Partnership's goals.
6. **Land Management and Protection:** Ensure that development and land use practices support efforts to preserve and restore critical ecosystem services throughout the PIE-Rivers region.

The Steering Committee identified lists of more specific **sub-objectives** within each of the six primary objectives for this plan. Four Technical Sub-Committees (Water Resources, Living Resources and Habitat Restoration, Watershed Stewardship, Land Use and Habitat Protection) were formed to facilitate the process of developing actions. This allowed partners to meet in smaller groups and focus on developing actions within their individual areas of expertise. Each Sub-committee was tasked with addressing one or more of the objectives. A complete list of objectives, sub-objectives, and responsible subcommittees can be found in Appendix 1 (p. 21).

A total of 92 draft actions were identified during this initial process. Steering Committee members were all given the opportunity to prioritize the draft actions based on their impression of the action's relative importance, time sensitivity, and feasibility. The prioritized draft actions were consolidated into the 50 prioritized actions outlined in this report to eliminate overlap and redundancy. The original 2013 prioritized actions can be found in Appendix 2. Near-term priorities from this larger list of actions were determined by the Partnership in 2014 and 2019.

The Partnership's 2019 priorities have been defined by implementation plans that identify lead partners, supporting partners, tasks, timelines, progress metrics and deliverables These implementation plans focus on S.M.A.R.T. (Specific, Measurable, Attainable, Relevant, Time-bound) goals. Each implementation plan provides a clear roadmap for the Partnership to make progress on its near-term priorities.

All implementation plans will be available on the PIE-Rivers website: www.pie-rivers.org. As implementation action is taken and near-term priority goals are achieved, new near-term priorities will be selected by the Partnership and new implementation plans will be developed, providing a structure for ongoing prioritization, assessment, and progress.

Actions

The following is a complete list of the 50 actions identified through the process outlined above. These actions have been organized into one of six "toolkits" (or types of action) based on the nature of the suggested effort. Toolkits are groupings based on the nature of the proposed action rather than the specific ecological threats, goals and objectives they address. As a result, individual toolkits contain actions that address a wide variety of issues. Additionally, since this list of actions was consolidated from the original draft list of 92 actions, many actions address more than one objective. The PIE-Rivers Steering Committee and Technical Sub-Committees identified 50 actions that, if implemented would help protect, restore and increase the resiliency of the region's aquatic resources. Below are toolkit definitions identified by the PIE-Rivers sub-committees and their associated actions.

Toolkit 1: Community Involvement: These actions focus on education, outreach and partnership-building efforts that will increase restoration capacity.

Action 1: Water Conservation Outreach

Continue and broaden regional outreach campaign, including water conservation website, highlighting the need for water conservation and promoting household and municipal water conservation measures. These measures could include, but not be limited to, water banks, use restrictions, billing incentives, and low impact landscaping. Increase capacity for municipalities to incorporate "water wise" practices (Levin, 2006).

Action 2: Expand PIE-Rivers

Expand and reinforce the PIE-Rivers partnership, seeking to engage broader representation (especially from municipalities, conservation organizations and the public)

Action 3: Citizen Stewardship

Develop a network of local citizen stewardship groups or stream teams throughout the region to improve capacity to implement measures at the community level.

Action 4: Water Quality Outreach

Increase outreach efforts to improve public understanding of the negative water quality effects of nutrients and other pollutants. Utilize public outreach campaigns (such as Greenscapes) to highlight how individual behaviors can impact drinking water quality and ecosystem health and encourage practices that reduce or eliminate contamination.

Action 5: Promote Low Impact Development

Promote the implementation of Low Impact Development (LID) techniques to reduced development impacts on factors including water use, groundwater recharge and stormwater induced flooding.

Action 6: Local Flow Awareness

Empower local leaders to consider the flow impacts of water-related decisions. Instill the approach of seeking to (1) avoid impacts where possible, (2) minimize impacts that cannot be avoided, and (3) mitigate those unavoidable impacts.

Action 7: Promote Restoration

Conduct outreach campaign, including public presentations, web content, etc. highlighting the importance of restoration efforts.

Action 8: Identify Target Audiences for Expanded Outreach

Assess current levels of community interest and involvement in watershed issues to identify groups that would benefit from increased outreach efforts. Develop and implement outreach strategies targeting these groups to build support and active participation in conservation and restoration initiatives.

Action 9: Link Ecosystem and Economics

Promote economic valuation of ecosystem services and functions in water management and publicize the mutual benefits of saving water and saving energy.

Action 10: Support Solutions for Regional/Global Issues

Provide support for local measures that seek to address factors contributing to the larger-scale stressors of climate change and sea level rise (for instance, measures to reduce greenhouse gas emissions). Engage community in resiliency discussions aimed at adapting to the unavoidable consequences of sea level rise, climate change and other externally-driven issues.

Toolkit 2: Restoration Science and Prioritization: *Includes research and survey work to ensure that restoration approaches and prioritization of projects are based on science.*

Action 11: Prioritize Conservation Land

Identify lands of high conservation value with respect to their influence on the PIE-Rivers environmental goals (enough water, clean water and healthy ecosystems) in the region. Areas of focus should include:

(1) existing floodplains and groundwater recharge areas that can attenuate extreme flows and increase resiliency,

(2) land that affects the quantity and quality of current and future drinking water sources, (3) headwaters and small streams,

(4) critical habitats such as wetlands, shorelands, and migration corridors.

*Note: This action provides information necessary to implement Action 39, "Regional Land Protection and Conservation Plan"

Action 12: Prioritize Aquatic Barriers

Identify and prioritize barriers including physical (dams, culverts, etc.) and "soft" barriers (temperature, DO, chemical, behavioral) that may be limiting critical aquatic organism migration. For physical barriers, include analysis of risk of infrastructure failure and impacts on flood risk (upstream and downstream) and community resiliency in prioritization where feasible and applicable.

*Note: This action provides information necessary to implement Action 44, "Remove Migration and Flow Barriers"

Action 13: Identify Factors Limiting Aquatic Species

Identify critical factors limiting abundance and community structure of important biota (including shellfish, fluvial fish (brook trout, etc), diadromous fish) and identify restoration methods to improve conditions in the project area.

*Note: This action provides information necessary to implement Action 45, "Implement Additional Aquatic Species Restoration"

Action 14: Identify Water Quality Problems

Expand water quality assessments to unmonitored areas (DEP Unassessed areas) and identify areas where water quality threatens important aquatic ecosystems using existing information and new research as necessary. Consider ecological and public health effects of trace chemicals such as pharmaceuticals that end up in surface and groundwater systems. Develop a list and proposed timeline to address high priority "Hot Spots" for degraded water quality in both the freshwater and estuarine zone.

Action 15: Identify Stormwater Priorities

Identify, monitor and prioritize areas where stormwater is degrading water quality and aquatic habitat conditions.

*Note: This action provides information that will aid implementation of Action 33, "Upgrade Stormwater Systems"

Action 16: Prioritize Degraded Habitats

Identify (and prioritize for restoration and/or mitigation) degraded habitats including freshwater wetlands, floodplains, shorelands and uplands with a special focus on sites where existing development is a particular threat to water resources.

*Note: This action provides information necessary to implement Action 49, "Restore Priority Degraded Habitat"

Action 17: Assess Climate Change Vulnerability

Identify vulnerabilities of upland, shoreline and aquatic habitats to anticipated impacts of climate change and sea level rise. Propose appropriate actions to mitigate or adapt to impacts.

Action 18: Research Water Conservation Economic Drivers

Conduct research on economic drivers of water use and conservation

*Note: This action would help inform the following actions:
- Action 9, "Link Ecosystem and Economics"
- Action 37, "Implement Economic Water Management Tools"

Action 19: Develop Bird Conservation Strategy

Identify strategies to counteract any concerning decreases in bird diversity and population stability that can be enacted on a regional level

Action 20: Assess Estuarine Habitat Limitation
Inventory eelgrass beds and other important estuarine habitats, identify factors limiting their distribution, and propose restoration measures to increase distribution and resilience of these habitats.

*Note: This action provides information necessary to implement Action 50, "Restore Estuarine Habitat Conditions"

Action 21: Research Stormwater Capture and Storage

Research options to capture and store stormwater runoff by natural or engineered means, such that flooding risk is reduced and water is conserved.

Toolkit 3: Monitoring and Technical Support: *Includes monitoring of ecological conditions and restoration progress. Also includes technical tools and support for municipalities and other entities to implement critical restoration measures.*

Action 22: Provide MS4 Support

Provide technical support to help municipalities comply with new Municipal Separate Storm Sewer Systems (MS4) permit requirements

Action 23: Monitor Aquatic Species

Survey populations and communities of ecologically and economically important biota in the region to identify areas of concern and monitor trends. This could include: (1) native diadromous fish including river herring, (2) bivalves (especially soft-shelled clams), (3) fluvial fish species including Eastern brook trout, (4) saltmarsh and breeding birds.

Action 24: Develop River Health Index

Develop a "River Health Index" or report card to help the public understand the health of our waters.

Action 25: Identify Ecological Restoration Targets

Develop science-based ecological targets that integrate water quality, water quantity and structural habitat requirements. Implement monitoring programs to gauge current conditions and restoration progress with respect to these targets.

Action 26: Monitor Invasive Species

Coordinate volunteer-based mapping and monitoring of invasive species distribution in the region to identify problem areas.

*Note: This action would inform implementation of Action 43, "Control Invasive Species"

Action 27: Provide Stewardship Tools

Develop and assemble tools and online resources to help communities, businesses and residents make informed decisions related to water use and watershed stewardship. This should include distilling science-based information about the PIE-Rivers region, guides to preferred best management practices (like the Water-Wise Communities Handbook), etc.

Action 28: Monitor River Flow

Monitor river flows at USGS gauges and other sites in the watersheds and examine for trends related to precipitation, water use, and land use

Action 29: Address Estuarine Pollution Sources

Work with coastal communities to identify and address high priority pollution sources for the estuarine environment

Action 30: Provide Mapping Technical Support

Assist communities in using existing planning and monitoring tools such as MassCAPS, GIS, BioMap2

Toolkit 4: Integrated Water Management: *Actions focused on integrated water management, including drinking water, stormwater and wastewater issues. Includes systemic and policy initiatives to improve water management locally and at the state level.*

Action 31: Incentivize Water Conservations

Reduce lawn watering and other non-essential water demand through a combined approach including use restrictions and billing incentives

Action 32: Create Model Municipal Integrated Water Resources Management Program

Create model municipal-level program that integrates water supply, wastewater, stormwater, habitat and land use management. Seek to implement and test program in one or more communities and use lessons learned to scale to a region-wide implementation of integrated water resource management (IRWM) principles.

Action 33: Upgrade Stormwater Systems

Upgrade stormwater systems that are identified as high priority.

*Note: This action relies on priorities identified in Action 15, "Identify Stormwater Priorities"

Action 34: Limit Withdrawals from Sensitive Areas

Optimize water supply operations to minimize environmental damage by discontinuing or limiting withdrawals from sensitive sub-basins and streamside wells. This might include adopting flow-triggered measures to limit and prioritize withdrawals and developing alternative water sources to replace or relieve pressure from the most damaging sources (from particular sub-basins and streamside wells).

Action 35: Develop Water Conservation Program

Develop a regional water conservation program staffed with a stewardship coordinator

Action 36: Identify Water Protection Gaps

Identify the strengths and gaps in water (including drinking water) protection in each community including review of Source Water Assessment and Protection (SWAP) reports and local zoning ordinances/bylaws.

Action 37: Implement Economic Water Management Tools

Implement management tools that link water resource protection with economic drivers (e.g. progressive rates, fees for water, water banks, stormwater utilities)

*Note: This action would be enhanced by information from Action 18, "Research Water Conservation Economic Drivers"

Action 38: Water Resources Legislation

Advocate for passage of legislation (like the Sustainable Water Resources Act) that requires environmentally relevant streamflow standards, enables easier removal of unnecessary dams and authorizes waterbanking (allowing communities to assess fees for water conservation and sustainability measures)

Toolkit 5: Land Protection and Management: *Actions dealing with land acquisition, zoning, land management, and land use issues that influence aquatic systems.*

Action 39: Regional Land Protection Conservation Plan

Develop and implement land conservation plan for northeastern Massachusetts' coastal watersheds. An emphasis should be placed on protecting lands of high conservation value with respect to their influence on flood resilience, water quantity, water quality and ecosystem integrity (including rare species) in the region.

*Note: This action depends on priorities developed in Action 11, "Prioritize Conservation Land"

Action 40: Improve Land Use Bylaws

Develop and implement bylaws and incentive systems at the municipal level to encourage landowners to make land use decisions that improve flood capacity, water quality and quantity conditions (including Low Impact Development (LID), zero-runoff ordinances, etc.). Special attention should be given to implementing measures on existing developments.

Action 41: Improve Conservation Land Stewardship

Support land stewardship and land management actions for conservation lands and key areas that maximize quality habitat and watershed services.

Action 42: Protect Drinking Water Sources

Protect the quality and quantity of current and future drinking water supplies through land use education, incentives and regulation.

Action 43: Control Invasive Species

Develop protocols for volunteer-based control of invasive species. Implement invasive species control measures on problem areas seeking to use volunteers as appropriate

*Note: This action would be informed by Action 26 "Monitor Invasive Species"

Toolkit 6: Habitat Restoration: *Physical habitat and ecosystem restoration projects.*

Action 44: Remove Migration and Flow Barriers

Improve aquatic habitat connectivity and restore natural flow regime through various methods including dam removal, culvert replacement/upgrade, and fishways as necessary with focus on barriers identified as high priority for both habitat and flooding impacts. Changes in flow capacity for structures such as culverts and bridges should take into account position in the watershed and potential effects on upstream and downstream structures.

*Note: This action relies on priorities identified in Action 12, "Prioritize Aquatic Barriers"

Action 45: Implement Additional Aquatic Species Restoration Measures

Implement aquatic species restoration measures identified in Action 13 that are not already underway

*Note: This action relies on the results of Action 13, "Identify Factors Limiting Aquatic Species"

Action 46: Implement Demonstration Restoration Projects

Implement at least 3 restoration projects in the next 5 years that can be used as demonstration projects (local proof of concept) – publicize all stages of the projects and seek a high level of community involvement at all stages (implementation, monitoring, etc)

Action 47: Restore Vegetative Buffers and Floodplains

Restore natural vegetative buffers along tidal shorelands, riparian zones of all stream orders, and wetlands. Where feasible, seek to "undevelop" and reconnect floodplains where flood storage has been lost and consider removal and relocation of structures and/or infrastructure that are highly flood susceptible or worsen flooding, in order to allow natural movement of marsh and vegetative buffers to accommodate sea level rise.

Action 48: Restore Salt Marshes

Restore or enhance impaired salt marshes through approaches including removal of tidal restrictions and invasive species management. Consider the influence of sea-level rise on long-term marsh viability in prioritization of projects. Where possible, incorporate opportunities to mitigate future marsh losses to sea-level rise by providing space for marshes to migrate up slope.

Action 49: Restore Priority Degraded Habitat

Restore high priority degraded habitats identified in Action 16 using appropriate measures.
*Note: This action relies on priorities identified in Action 16, "Prioritize Degraded Habitats"

Action 50: Restore Estuarine Habitat Conditions

Restore eelgrass beds and other important estuarine habitats through the implementation of restoration measures identified in Action 20.
*Note: This action relies on the results of Action 20, "Assess Estuarine Habitat Limitation"

Glossary

Diadromous – Fish species that migrate between freshwater and seawater to complete some portion of their life cycle.

Eutrophication - The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication

is a natural, slow-aging process for a water body, but human activity greatly speeds up the process. - Art, 1993. http://toxics.usgs.gov/definitions/eutrophication.html

Estuary - An estuary is a partially enclosed body of water along the coast where freshwater from rivers and streams meets and mixes with salt water from the ocean. Estuaries and the lands surrounding them are places of transition from land to sea and freshwater to salt water. Although influenced by the tides, they are protected from the full force of ocean waves, winds, and storms by such land forms as barrier islands or peninsulas. (from http://water.epa.gov/)

Impervious Surface - A barrier through which rainfall cannot pass or be absorbed, such as roads, rooftops, paved parking lots, sidewalks, etc.

Integrate Water Resources Management (IWRM) - Water withdrawals, wastewater, and stormwater are the three major human impacts that significantly affect a watershed's water cycle, impacting water quantity and quality. Integrated Water Resources Management looks at water supply, wastewater, and stormwater together in order to "balance the water budget" and maintain water quality.

Low-Impact Development (LID) - An approach to environmentally-friendly land use. LID includes landscaping and site design techniques to maintain the natural drainage of a site. LID techniques capture water on site, filter it through vegetation, and let it soak into the ground where it can replenish the local water table rather than being lost as surface runoff. An important LID principle includes the idea that stormwater is not merely a waste product to be disposed of, but is a resource.

Watershed - An area of land that drains, or "sheds" water, into a river, stream, pond, lake, wetland, or estuary. A watershed includes both surface water and groundwater.

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Appendix 1: Objectives

The following is a complete list of the six **objectives** and associated **sub-objectives** that the PIE-Rivers partners identified and used to guide development of the recommended **actions**. The four technical sub-committees (Water Resources, Living Resources and Habitat Restoration, Watershed Stewardship, Land Use and Habitat Protection) were each assigned one or more objectives to develop draft actions for. A total of 92 draft actions were identified during this initial process. Steering Committee members were all given the opportunity to prioritize the draft actions based on their impression of the action's relative importance, time sensitivity, and feasibility. The prioritized draft actions were consolidated into the 50 prioritized actions outlined in this report to eliminate overlap and redundancy. The following is a complete list of the goals and objectives the committees used to develop the actions.

Objective 1: Natural Streamflow

Promote more natural streamflow conditions to better support human and environmental water needs.

Sub-Committee: Water Resources

Addressed by Actions: 1, 5-6, 9-10, 12, 21, 28, 31, 34-35, 37-40, 44, 47

Sub-objective 1.1. Meet human water needs in the most environmentally protective way that we can and manage water supplies sustainably to maintain ecological functions

a) Promote efficient water use and regional water conservation
b) Reduce the negative ecological effects of water supply withdrawals

Sub-objective 1.2. Maintain streamflows and groundwater levels that support fish and other river life, recreation, navigation, and the ecological functions of coastal streams and rivers.

a) Restore and protect the amount of freshwater in the rivers and entering the Great Marsh estuary
b) Restore the natural seasonal variability of flows to the extent technically feasible

Sub-objective 1.3. Minimize the risks of extreme floods through improved resilience.

c) Retrofit existing development to reduce runoff and improve groundwater replenishment by implementing Low Impact Development (LID) principles
b) Improve capacity of existing infrastructure to cope with extreme precipitation events
c) Preserve natural landscapes, vegetation and drainage patterns (including floodplains and groundwater recharge areas)
d) Encourage regional support and participation in initiatives that relate to climate and flooding

Sub-objective 1.4. Seek opportunities to mitigate existing impacts to river flow.

Objective 2: Water Quality

Promote efforts to protect and enhance surface and groundwater quality for the benefit of people and the environment.

Sub-Committee: Water Resources

Addressed by Actions: 4, 11, 14-15, 22, 24, 29, 33, 36, 39-40

Sub-objective 2.1. Help communities protect drinking water quality.

Sub-objective 2.2. Protect and restore water quality to support aquatic ecosystems, recreation and sustainable consumptive uses.

a) Identify and address stormwater impacts on water quality
b) Influence the implementation of development and land use practices that minimize water quality impacts.

Sub-objective 2.3. Reduce pollution in the estuaries to meet water quality standards to allow shellfish harvesting, minimize coastal beach closures and support healthy estuarine ecosystems.

Sub-objective 2.4. Monitor and document water quality, pollution loads and the fate of pollutants.

Objective 3: Ecosystem Restoration

Promote efforts to protect and restore ecosystem function through habitat restoration, species protection and other available measures.

Sub-Committee: Living Resources and Habitat Restoration

Addressed by Actions: 2, 7, 12-13, 16-17, 19-20, 23, 25-26, 43-50

Sub-objective 3.1. Restore habitat connectivity to support robust native aquatic communities including diadromous and freshwater "resident" fishes.

Sub-objective 3.2. Protect and restore key habitat for ecologically and commercially valuable biota.

Sub-objective 3.3. Monitor and control invasive species throughout the project area.

Sub-objective 3.4. Protect and restore native fish and shellfish populations.

Sub-objective 3.5. Maintain a stable and diverse population of shorebirds and saltmarsh breeding birds in Great Marsh.

Sub-objective 3.6. Improve implementation capacity for restoration projects.

Objective 4: Community Engagement

Increase community involvement in and support for taking care of, restoring and protecting our rivers, watersheds and the Great Marsh

Sub-Committee: Watershed Stewardship

Addressed by Actions: 2, 3, 5, 8, 35

Sub-objective 4.1. Increase public awareness of the value of water and develop a regional conservation ethic that highly values our natural waters.

Sub-objective 4.2. Build a stronger stewardship capacity.

Objective 5: Responsible Water Management

Ensure that decisions and actions affecting the PIE-Rivers region watersheds support the Partnership's goals.

Sub-Committee: Watershed Stewardship

Addressed by Actions: 1, 9, 18, 25, 27, 30, 32, 36-37

Sub-objective 5.1. Provide tools and resources to help communities, businesses and residents be "water-wise".

Sub-objective 5.2. Promote integrated water resource management.

Sub-objective 5.3. Use economic tools more effectively to manage water sustainably.

Sub-objective 5.4. Improve state and local capacity to develop and enforce measures that protect and restore aquatic habitats in focus area.

Objective 6: Land Management and Protection

Ensure that development and land use practices support efforts to preserve and restore critical ecosystem services throughout the PIE-Rivers region

Sub-Committee: Land Use and Habitat Protection

Addressed by Actions: 11, 16, 32, 39-43, 49

Sub-objective 6.1. Improve development patterns and practices to better protect water resources.

Sub-objective 6.2. Restore and maintain ecosystem functions and resilience services provided by wetlands, floodplains, and shorelands.

Sub-objective 6.3. Protect key upland areas that sustain important plant and animal communities and/or provide watershed services to maintain aquatic habitats and water quality.

Appendix 2: 2013 Prioritized Actions

The PIE-Rivers Steering Committee and Technical Sub-Committees identified 50 actions that, if implemented would help protect and restore the region's aquatic resources. These actions have been organized into one of six "toolkits" (or types of action) based on the nature of the suggested effort. Below are the prioritized lists of actions for each toolkit identified by the PIE-Rivers committees along with more detailed explanations of each toolkit's three highest priority[2] actions for near-term implementation. The 16 highest-ranking actions regardless of toolkit are identified as "immediate priority" actions. The complete, detailed list of actions with descriptions begins on page 11.

Toolkit 1: Community Involvement (Ten actions, five of immediate priority)

These actions focus on education, outreach and partnership-building efforts that will increase restoration capacity.

- **Action 1: Water Conservation Outreach** - Continue and broaden regional outreach campaign, including water conservation website, highlighting the need for water conservation and promoting household and municipal water conservation measures. These measures could include, but not be limited to, water banks, use restrictions, billing incentives, and low impact landscaping. Increase capacity for municipalities to incorporate "water wise" practices (Levin, 2006).
- **Action 2: Expand PIE-Rivers** - Expand and reinforce the PIE-Rivers partnership, seeking to engage broader representation (especially from municipalities, conservation organizations and the public).
- **Action 3: Citizen Stewardship** - Develop a network of local citizen stewardship groups or stream teams throughout the region to improve capacity to implement measures at the community level.

Table 1. Prioritized actions for Community Involvement toolkit.

Action Name (Action #)	Immediate Priority	Rank
Water Conservation Outreach (1)	Yes	1
Expand PIE-r-squared (2)	Yes	2
Citizen Stewardship (3)	Yes	3
Water Quality Outreach (4)	Yes	4
Promote Low Impact Development (5)	Yes	4
Local Flow Awareness (6)		6
Promote Restoration (7)		6
Identify Target Audiences for Expanded Outreach (8)		8
Link Ecosystem and Economics (9)		9
Support Solutions for Regional/Global Issues (10)		10

[2] Relative priority rankings are given for actions within each toolkit. These rankings are provided to help guide planning and should not be interpreted as a measure of absolute importance. See page 15 for more details on action rank.

Toolkit 2: Restoration Science and Prioritization (Eleven actions, four of immediate priority)

Includes research and survey work to ensure that restoration approaches and prioritization of projects are based on science.

- **Action 11: Prioritize Conservation Land**[3] - Identify lands of high conservation value with respect to their influence on the PIE-Rivers environmental goals (enough water, clean water and health ecosystems) in the region. Areas of focus should include:
- existing floodplains and groundwater recharge areas that can attenuate extreme flows,
- land that affects the quantity and quality of current and future drinking water sources,
- headwaters and small streams,
- critical habitats such as wetlands, shorelands, and migration corridors.
- **Action 12: Prioritize Aquatic Barriers**[4] - Identify and prioritize barriers including physical (dams, culverts, etc.) and "soft" barriers (temperature, DO, chemical, behavioral) that may be limiting critical aquatic organism migration. For physical barriers, include analysis of risk of infrastructure failure and impacts on flood risk (upstream and downstream) in prioritization where feasible and applicable.
- **Action 13: Identify Factors Limiting Aquatic Species**[5] **–** Identify critical factors limiting abundance and community structure of important biota (including shellfish, fluvial fish (brook trout, etc), diadromous fish) and identify restoration methods to improve conditions in the project area.

Table 2. Prioritized actions for Restoration Science and Prioritization toolkit.

Action Name (Action #)	Immediate Priority	Rank
Prioritize Conservation Land (11)	Yes	1
Prioritize Aquatic Barriers (12)	Yes	2
Identify Factors Limiting Aquatic Species (13)	Yes	3
Identify Water Quality Problems (14)	Yes	4
Identify Stormwater Priorities (15)		5
Prioritize Degraded Habitats (16)		6
Assess Climate Change Vulnerability (17)		7
Research Water Conservation Economic Drivers (18)		8
Develop Bird Conservation Strategy (19)		9
Assess Estuarine Habitat Limitation (20)		10
Research Stormwater Capture and Storage (21)		11

[3] Provides information needed to implement Action 39, "Regional Land Protection and Conservation Plan"
[4] Provides information needed to implement Action 44, "Remove Migration and Flow Barriers"
[5] Provides information needed to implement Action 45, "Implement Additional Aquatic Species Restoration Measures"

Toolkit 3: Monitoring and Technical Support (Nine actions, one of immediate priority)
Includes monitoring of ecological conditions and restoration progress. Also includes technical tools and support for municipalities and other entities to implement critical restoration measures.

- **Action 22: Provide MS4 Support -** Provide technical support to help municipalities comply with new Municipal Separate Storm Sewer Systems (MS4) permit requirements.
- **Action 23: Monitor Aquatic Species -** Survey populations and communities of ecologically and economically important biota in the region to identify areas of concern and monitor trends. This could include:
  1) native diadromous fish including river herring,
  2) bivalves (especially soft-shelled clams),
  3) fluvial fish species including Eastern brook trout,
  4) saltmarsh and breeding birds
- **Action 24: Develop River Health Index –** Develop a "River Health Index" or report card to help the public understand the health of our waters.

Table 3. Prioritized actions for Monitoring and Technical Support toolkit.

Action Name (Action #)	Immediate Priority	Rank
Provide MS4 Support (22)	Yes	1
Monitor Aquatic Species (23)		2
Develop River Health Index (24)		3
Identify Ecological Restoration Targets (25)		4
Monitor Invasive Species (26)		5
Provide Stewardship Tools (27)		6
Monitor River Flow (28)		6
Address Estuarine Pollution Sources (29)		8
Provide Mapping Technical Support (30)		8

Toolkit 4: Integrated Water Management (Eight actions, three of immediate priority)
Actions focused on integrated water management, including drinking water, stormwater and wastewater issues. Includes systemic and policy initiatives to improve water management locally and at the state level.

- **Action 31: Incentivize Water Conservation -** Reduce lawn watering and other non-essential water demand through a combined approach including use restrictions and billing incentives.
- **Action 32: Create Model Municipal Integrated Water Resources Management (IWRM) Program -** Create model municipal-level program that integrates water supply, wastewater, stormwater, habitat and land use management. Seek to implement and test program in one or more communities and use lessons learned to scale to a region-wide implementation of integrated water resource management (IRWM) principles.
- **Action 33: Upgrade Stormwater Systems -** Upgrade stormwater systems that are identified as high priority.

Table 4. Prioritized actions for the Integrated Water Management toolkit.

Action Name (Action #)	Immediate Priority	Rank
Incentivize Water Conservation (31)	Yes	1
Create Model Municipal Integrated Water Resources Management Program (32)	Yes	2
Upgrade Stormwater Systems (33)	Yes	3
Limit Water Withdrawals from Sensitive Areas (34)		4
Develop Water Conservation Program (35)		5
Identify Water Protection Gaps (36)		5
Implement Economic Water Management Tools (37)		5
Water Resources Legislation (38)		8

Toolkit 5: Land Protection and Management (Five actions, one of immediate priority)

Actions dealing with land acquisition, zoning, land management, and land use issues that influence aquatic systems.

- **Action 39: Regional Land Protection and Conservation Plan**[6] - Develop and implement land conservation plan for northeastern Massachusetts' coastal watersheds. An emphasis should be placed on protecting lands of high conservation value with respect to their influence on water quantity, water quality and ecosystem integrity (including rare species) in the region. Set goal to protect half the lands identified as Conservation Focus areas by 2025.
- **Action 40: Improve Land Use Bylaws** - Develop and implement bylaws and incentive systems at the municipal level to encourage landowners to make land use decisions that improve water quality and quantity conditions (including Low Impact Development (LID), zero-runoff ordinances, etc.). Special attention should be given to implementing measures on existing developments.
- **Action 41: Improve Conservation Land Stewardship -** Support land stewardship and land management actions for conservation lands and key areas that maximize quality habitat and watershed services.

Table 5. Prioritized actions for the Land Protection and Management toolkit.

Action Name (Action #)	Immediate Priority	Rank
Regional Land Protection and Conservation Plan (39)	Yes	1
Improve Land Use Bylaws (40)		2
Improve Conservation Land Stewardship (41)		3
Protect Drinking Water Sources (42)		4
Control Invasive Species (43)		5

[6] Dependent on Action 11, "Prioritize Conservation Land"

Toolkit 6: Habitat Restoration (Seven actions, two of immediate priority)

Physical habitat and ecosystem restoration projects

- **Action 44: Remove Migration and Flow Barriers[7] -** Improve aquatic habitat connectivity and restore natural flow regime through various methods including dam removal, culvert replacement/upgrade, and fishways as necessary with focus on barriers identified as high priority for both habitat and flooding impacts. Changes in flow capacity for structures such as culverts and bridges should take into account position in the watershed and potential effects on upstream and downstream structures.
- **Action 45: Implement Additional Aquatic Species Restoration Measures[8] -** Implement aquatic species restoration measures identified in Action 13 that are not already underway.
- **Action 46: Implement Demonstration Restoration Projects** - Implement at least 3 restoration projects in the next 5 years that can be used as demonstration projects (local proof of concept) – publicize all stages of the projects and seek a high level of community involvement at all stages (implementation, monitoring, etc).

Table 6. Prioritized actions for the Habitat Restoration toolkit.

Action Name (Action #)	Immediate Priority	Rank
Remove Migration and Flow Barriers (44)	Yes	1
Implement Additional Aquatic Species Restoration Measures (45)	Yes	2
Implement Demonstration Restoration Projects (46)		3
Restore Vegetative Buffers and Floodplains (47)		4
Restore Salt Marshes (48)		5
Restore Priority Degraded Habitat (49)		6
Restore Estuarine Habitat Conditions (50)		7

[7] Dependent on Action 12, "Prioritize Aquatic Barriers"

[8] Dependent on Action 13, "Identify Factors Limiting Aquatic Species"