Richmond-West Stockbridge
Resilient Stormwater Action & Implementation Plan

June 2023

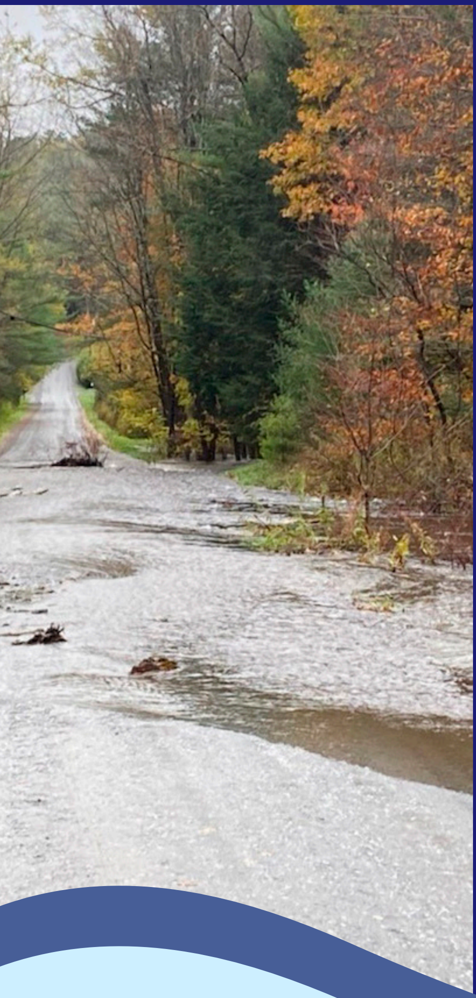

TABLE OF CONTENTS

LIST OF APPENDICES

EXECUTIVE SUMMARY

Weston & Sampson, on behalf of the Towns of Richmond, MA and West Stockbridge, MA ("The Towns") and in collaboration with Town staff and community stakeholders, generated this Climate Resilient Stormwater Action and Implementation Plan (RSAIP) based on the findings gathered during Municipal Vulnerability Preparedness (MVP) Planning and Action Grant activities, first initiated in 2020. This RSAIP addresses high priority action items to address climate change vulnerabilities recommended by the community in previous efforts, and it helps make climate resilience a primary guide in local projects and decision making for community infrastructure and roads for flood and stormwater mitigation.

The Towns face increasingly extreme riverine and stormwater flooding events on roads, floodplains, and adjacent properties due to climate change. Flooding, erosion, and stormwater runoff were identified as major issues in the Towns' Hazard Mitigation Plans, Richmond's MVP Workshops, the Road-Stream Crossing Management Plans (RSCMPs), and other community plans. To be more "Climate Ready," the Towns are hereby preparing for and lowering their risk to the impacts of climate change by identifying ways to make the community more resilient, through green infrastructure, low impact development, and nature-based solutions. The project also seeks to inform and mobilize members of the community to address stormwater on their own properties.

Through a series of tasks involving background research, field investigations, input from community members and Town staff, modeling, and development of conceptual design alternatives, Weston & Sampson worked with the Towns to identify a prioritized list of projects that are most beneficial and most feasible for addressing the environmental and infrastructure impacts of stormwater runoff in the communities. Funding opportunities and estimates of project timelines were identified in this implementation plan for these projects, to facilitate immediate action and improve community resilience.

The Towns have ongoing maintenance and replacement efforts underway to address dangerous flooding and erosion that can blow out roadways and culverts, damage public and private property, and degrade the natural environment. But local efforts and funding are not enough to keep up with current needs, let alone plan for increased impacts of climate change. The existence of this plan improves the Towns' eligibility for outside grant funding to implement priority projects and provides short- and long-term recommendations for dirt and gravel roads and stormwater management on public and private property.

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1.0 INTRODUCTION

Weston & Sampson, on behalf of the Towns of Richmond and West Stockbridge ("The Towns") and in collaboration with Town staff and community stakeholders, generated this Climate Resilient Stormwater Action and Implementation Plan (RSAIP) based on the findings gathered during Municipal Vulnerability Preparedness (MVP) Planning and Action Grant activities, first initiated in 2020. This RSAIP advances high priority action items to address climate change vulnerabilities that were previously recommended by the community, and it helps make climate resilience a primary guide in local projects and decision making for community infrastructure and roads for flood and stormwater mitigation.

1.1 Background and Drivers

Funded by the Massachusetts Executive Office of Energy and Environmental Affairs' Municipal Vulnerability Preparedness (MVP) Grant program, the Towns of Richmond and West Stockbridge initiated a one-year collaborative project to proactively reduce flooding, improve climate readiness, and address stormwater impacts across the two communities.

The Towns face increasingly extreme riverine and stormwater flooding events on roads, floodplains, and adjacent properties due to climate change. Flooding is a prevalent and serious natural hazard that threatens public safety and makes roadways, infrastructure, natural resources, and water quality highly vulnerable. In Berkshire County, due to climate change impacts, the frequency of 1" or greater rain events has increased. Recent intense storms have already washed-out roads and increased flooding on streets and private properties. Flooding also occurs where increased rainfall amounts have saturated the soil and cannot be fully absorbed. Polluted stormwater runoff results when rain or snow melt runs off of hard surfaces such as asphalt, pavement and roofs, picking up pollutants such as sediment, nutrients, motor oil, and dog waste along the way. Stormwater is often channeled to the nearest water body to prevent street flooding resulting in quickly rising river levels and increased pollutant loads. Greater stream volume and velocity results in bank erosion that can lead to loss of land, and higher flows can overwhelm or damage road-stream crossings.

Flooding, erosion, and stormwater runoff were identified as major issues in the Towns' Hazard Mitigation Plans (HMPs), Road-Stream Crossing Management Plans (RSCMPs), Regional Transportation Plan, Open Space and Recreation Plans, Richmond's Community Development Plan, Richmond Pond Management Plan, and West Stockbridge's Complete Streets Plan (see References for links). These plans indicate strong community support for prioritizing efforts to address stormwater, flooding, and erosion issues. In particular, a priority recommendation from the HMPs was to "develop a stormwater management plan (i.e. a list of opportunities for nature-based flood storage and stormwater infiltration using a model that incorporates future climate conditions)."

The Towns have ongoing maintenance and replacement efforts underway to address dangerous flooding and erosion that can blow out roadways and culverts, damage public and private property, and degrade the natural environment. But local efforts and funding are not enough to keep up with current needs, let alone plan for increased impacts of climate change.

1.2 Goals

1.2.1 MVP Program

This work is generously funded by the Massachusetts Executive Office of Energy and Environmental Affairs' Municipal Vulnerability Preparedness (MVP) Grant program, which provides support for cities and towns to plan for climate change and to implement projects to build local resiliency. More information about this program can be found at https://resilientma.mass.gov/mvp/. The MVP program has 9 core principles that guide funded projects:

1. Furthering a community identified priority action to address climate change impacts
2. Utilizing climate change data for a proactive solution
3. Employing Nature-Based Solutions (NBS)
4. Increasing equitable outcomes for and supporting strong partnerships with Environmental Justice (EJ) Populations and Climate Vulnerable Populations
5. Conducting robust community engagement
6. Achieving broad and multiple community benefits
7. Committing to monitoring project success and maintaining the project into the future
8. Utilizing regional solutions toward regional benefit
9. Pursuing innovative, transferable approaches

NATURE BASED SOLUTIONS (NBS) are adaptation measures focused on the protection, restoration, and/or management of ecological systems to safeguard public health, provide clean air and water, increase natural hazard resilience, and sequester carbon.

1.2.2 Town Goals and Scope

To become more "Climate Ready," the Towns initiated this project to prepare for and lower their risk to the impacts of climate change. The project sought to identify ways to make the community more resilient, through green infrastructure, low impact development, and nature-based solutions, and to inform and mobilize members of the community to address stormwater on their own properties.

Ultimately, the Towns sought an equitable, climate resilience-based approach to analyze and prioritize each town's resilience capital needs and prepare a plan for implementation. The Towns needed a prioritized list of projects that are most beneficial and most feasible for addressing the environmental and infrastructure impacts of stormwater runoff in the communities. Background research, field investigations, input from community members and Town staff, modeling, and development of conceptual design alternatives were to be used in generating this list.

The Climate Resilience Implementation Plans were designed to include:

- Information about key problem areas in both communities gathered from town officials, residential input, and expert field investigation led by Weston & Sampson
- Innovative and collaborative solutions to current and future stormwater management across both communities
- Selection of evaluation criteria under which each identified action will be ranked, reviewed by the project team.
- Information about operation and maintenance
- Development of an implementation strategy for prioritized actions, including a funding/financing assessment to include likely grant and loan programs that could assist with each project.

The implementation plan prepared under this grant provides each Town a stormwater action plan. This implementation plan will guide the Towns' efforts to modernize its stormwater and flood management approaches, help protect flood prone areas, while considering the need for available adequate funding.

The Towns could build on this plan by incorporating facilities and other infrastructure plans and associated schedule and cost to expand or incorporate the list into a formal capital plan.

2.0 SUMMARY OF ANALYSIS

In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Weston & Sampson, with assistance from Town staff, gathered and reviewed existing information, performed field investigations, built a stormwater model for the Towns' watersheds using detailed hydrologic and hydraulic (H&H) analyses, and engaged community members to better understand the existing and future local conditions of stormwater and flooding.

2.1 Data Collection

2.1.1 Existing Information

Existing information related to stormwater and flooding in current and future climate conditions (Subtask 3.1) was compiled from:

- Hazard Mitigation Planning to identify recurrent flooding areas, flood events, and vulnerabilities.
- Road-Stream Crossing Management Planning;
- Drainage system extent, condition, and operation and maintenance efforts;
- Known "Problem Areas;
- Capital Plans;
- Transportation Plans;
- Comprehensive or Master Plans;
- Economic Development Plans;
- Open Space Planning/ Acquisition Plans;
- Water Quality Data;
- Water Level Data;
- Critical roads for emergency response, evacuation, etc.;
- Agriculture/Farms/Forestry/Land Use; and
- For Richmond Pond, the Pond Management Plan.

Key information from these sources about recurrent flooding areas, flood events, water quality concerns, drinking water supplies, water level data, drainage system conditions, roads, dams, road-stream crossings, operations and maintenance efforts, and vulnerabilities supported field data collection (grant Subtask 3.2), Town-wide stormwater and watershed modeling (grant Subtask 3.3), development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of this plan (grant Subtask 3.5). This information was also used to facilitate qualitative validation of the modeling output.

Prioritization of solutions and the developed plan considered all town-prioritized problems and goals outlined in each of the plans identified. The following references were specifically used to support prioritization of those solutions and development of this plan (Subtask 3.5):

- Hazard Mitigation Planning: priority mitigation and adaptation actions
- Road-Stream Crossing Management Planning
- Drainage system extent, condition, and operation and maintenance efforts

- Known problem areas
- Capital plans
- Critical roads for emergency response, evacuation, etc.
- Transportation and Complete Streets plans
- Economic Development Plans
- Open Space Planning/ Acquisition Plans
- Richmond Pond Management Plan

Mitigation actions already identified and prioritized in these sources were incorporated into the RSAIP where appropriate. These included:

- Improving pedestrian infrastructure and condition of local roadways
- Actions related to water supply protection, flood protection, and stormwater management:
    - Outreach to property owners within the floodplain
    - Improve drainage for gravel roads and/or upgrading to paved roads
    - Identify priority repair and replacement projects for culverts and stormwater system elements using climate projections and green infrastructure
    - Mitigate erosion in known problem area near Richmond Pond.
    - Develop additional flood mitigation projects with attention to critical facilities
    - Add water conservation incentives for residents
- Work with the City of Pittsfield, the Richmond Pond Dam owner, and Richmond Pond Association to improve the condition of the Richmond Pond dam through a coordinated update of the pond and dam management plans

2.1.2 Field Investigation

In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson performed field investigations from October 10 to October 14, 2022, at locations where flooding has been reported to occur, where roadways experience erosion, stream crossings that were not previously inventoried or additional measurements were needed, and/or where additional data would improve accuracy of assessment of drainage infrastructure.

With the help of Town staff, the team mapped drainage infrastructure, took photographs, collected measurements, and noted observations at multiple stream crossings, dams, pre-determined problem areas, stream channels, and elements of structural drainage systems. Dams were inventoried and measured in the field for input into the model. In addition, during the field work, staff visited the West Stockbridge Town Hall to evaluate potential rain garden demonstration locations (Subtask 2.4). The goal of this field work was to support hydrologic and hydraulic (H&H) modeling of present and anticipated future climate conditions (Subtask 3.3) and understand existing conditions to support identification, evaluation, and prioritization of potential flood reduction and erosion solutions (Subtask 3.4).

Appendix B – Field Investigation Memorandum presents a summary of the field investigations related to the following:

- Dams
- Drainage Systems for Roadways
- "Problem Areas" (of Flooding, Erosion, and Stormwater Runoff)
- Road Stream Crossings
- Stream Channels
- West Stockbridge Town Hall Potential Rain Garden Demonstration Location(s)

Field investigations also included on-site evaluations of 40 "problem areas" that were identified by Town staff. Weston & Sampson staff visited each of the problem areas and collected information pertaining to existing conditions, including detailing the existing drainage systems, signs of roadside erosion, and flooding impacts. Town staff visited numerous problem areas with the field team and facilitated understanding of existing conditions. Each problem area was numbered for the purposes of mapping and notation, e.g., R.PA-1. See Figure 1 and 2 in Appendix B for the maps of problem areas.

Many of the problem areas have similar existing conditions, so to facilitate a rapid and wide-ranging assessment, they were grouped by type of problem. The generalized problem types include:

- Ineffective conveyance on steep slopes
- Ineffective drainage and ponding
- Storm drain networks
- Stream crossing issues, and
- Dam-related issues (manmade or beaver)

2.2 Town-Wide Stormwater and Watershed Modeling

In support of developing the Resilient Stormwater Action and Implementation Plan for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson performed detailed hydrologic and hydraulic (H&H) analyses of the three watersheds within the towns' limits: the Williams River, Alford Brook, and Richmond Pond. Those analyses were conducted through the development of a stormwater model, employing the EPA's Storm Water Management Model.

The stormwater model was developed through a combination of publicly available reports and GIS databases, existing information provided by the Towns, several studies and reports including a recent study by the Housatonic Valley Association, and through field measurements taken by Weston & Sampson. The model was subsequently calibrated against historical streamflow observations recorded by a USGS gage on the nearby Green River during Tropical Storm Irene and against anecdotal reports by town staff and residents of the location, magnitude, and frequency of known flood-prone areas.

Despite limitations of the stormwater model common to all such models and described in detail in Appendix C - Model Update, Integration, and Calibration, the model provides a reliable means to understand present and future flood risk in both Richmond and West Stockbridge and to test the efficacy of potential flood reduction solutions.

Evaluation of flooding impacts associated with baseline climate conditions and with a 2070 climate scenario are summarized in Appendix C - Model Update, Integration, and Calibration. The key findings of the stormwater model-based analyses are:

- Both communities experience flood risk and flood impacts in multiple watersheds, particularly during storm events with a recurrence interval of ten years or greater.
- The increased rainfall totals associated with a 2070 climate scenario appear not to have a significant effect on flooding impacts during the frequent 2-year design storms and have only a modest impact during 10-year design storms.
- During more extreme design storms, typified by the 100-year event, the simulated flood risk and anticipated impacts are dramatically greater under a 2070 climate scenario than they are under a baseline climate.

2.3 Public Engagement

2.3.1 Getting the Word Out and Collecting Input

In coordination with the technical investigations and solutions development, a multi-faceted public engagement strategy was deployed to get public input and feedback essential to this plan.

Six major strategies for public engagement were used in this project:

1. General public outreach on the overall project through articles, tabling events in the communities, and promotion through Town webpages, newsletters, flyers, and social media
2. Kickoff meeting with stakeholders to get input on project approach, and two additional stakeholder meetings to review modeling and solutions
3. Resident survey distributed in print and online
4. Webinar series for property owners on local climate change impacts and nature-based landscaping solutions
5. Targeted conversations with agricultural operators
6. Public presentation to seek input on draft RSAIP

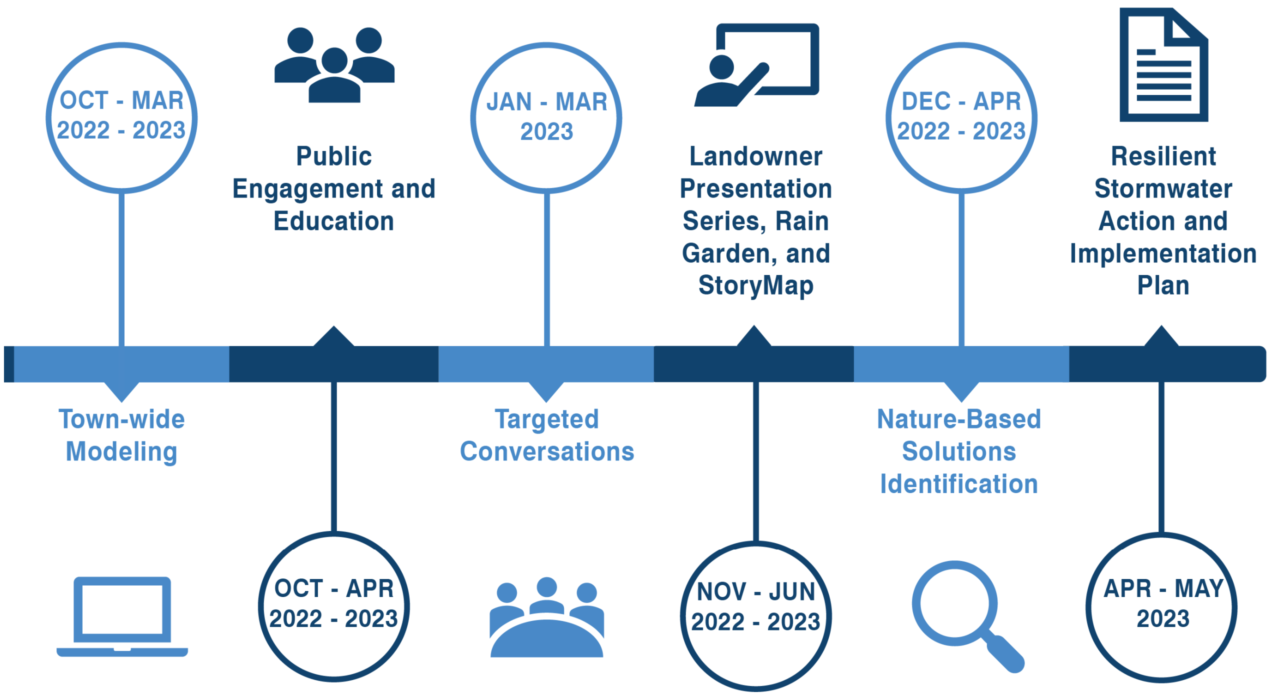


Figure 2-1. RSAIP Timeline

The Town, Weston & Sampson, Housatonic Valley Association, and MassAudubon, shared tips and resources for homeowners who want to be part of the solution throughout the duration of the project. In addition, to increase public awareness about green infrastructure and nature-based stormwater solutions, two additional educational tools were developed. A demonstration rain garden is being installed at West Stockbridge Town Hall and will be accompanied by an educational brochure, and a web-based map has been created of green infrastructure projects in Berkshire County.

2.3.2 Community Feedback Mechanisms

Several mechanisms were used for engagement during the project to generate feedback from the community and inform the RSAIP. Early in the project, residents and property owners in West Stockbridge and Richmond were invited to complete a short, 10-minute survey and provide feedback on locations that are known to flood, strategies that are used to reduce flooding, and priorities for future projects. A series of stakeholder meetings were also held with members of Town staff and relevant committees for the following purposes:

- To review project approach in November 2022
- To review model results and problem areas in December 2022
- To review proposed solutions in February 2023

Two webinars about expected climate change impacts and what are known as nature-based solutions were held on February 27 and March 29, 2023. These webinars were open to all and provided specific information for riverfront and lakefront homeowners about what can be done to reduce flooding and support a more climate resilient community.

Lastly, the Towns sought input on the draft "Resilient Stormwater Action and Implementation Plan" at a public presentation held on May 22, 2023. The presentation shared short- and long-term recommendations for culvert and drainage improvements, dirt and gravel roads, and stormwater management on public and private property and requested feedback from participants about their top concerns and priorities.

2.3.3 Community Priorities

Community input was useful in identifying problem areas early in the project. Survey respondents from both towns noted where they have noticed flooding of roads or properties from heavy precipitation events.

Commonly identified areas with flooding issues

Richmond Shores	West Alford Rd.
Lake Rd & Lake Rd. Ext.	East Alford Rd.
Dublin Rd.	Shaw Rd.
East Rd.	Cobb Rd.
Sleepy Hollow Rd.	Pixley Hill Rd./Route 41
Swamp Rd.	Other areas

Figure 2-2. Survey Responses on Flooding Areas

They also noted that problems - and solutions – occur on both public and private properties. Residents are already helping contribute to a more resilient watershed (including 17 survey respondents!) by adding vegetative buffers, rain gardens, and other stormwater best management practices on their properties.

Webinar participants expressed interest in installing solutions on their properties, including building rain gardens and infiltration trenches, using native plants, and removing invasives.

Community members expressed general support for stormwater solutions and specific preferences for the types of projects they wanted to see the Town pursue and install on their properties. In the survey, residents expressed the most interest in stormwater solutions that specifically benefit wildlife habitats, soil stabilization and hillside protection, safety, and water quality.

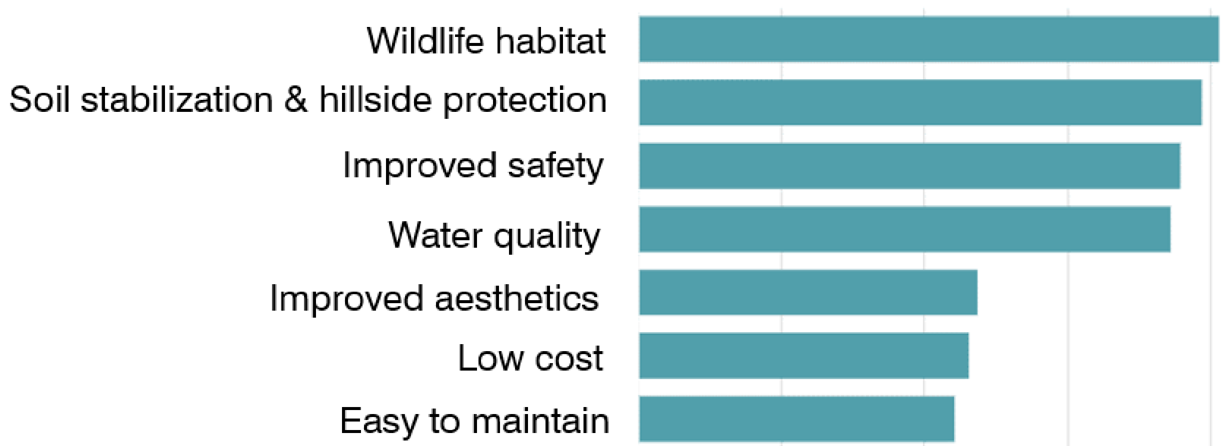


Figure 2-3. Survey Responses on Co-Benefits

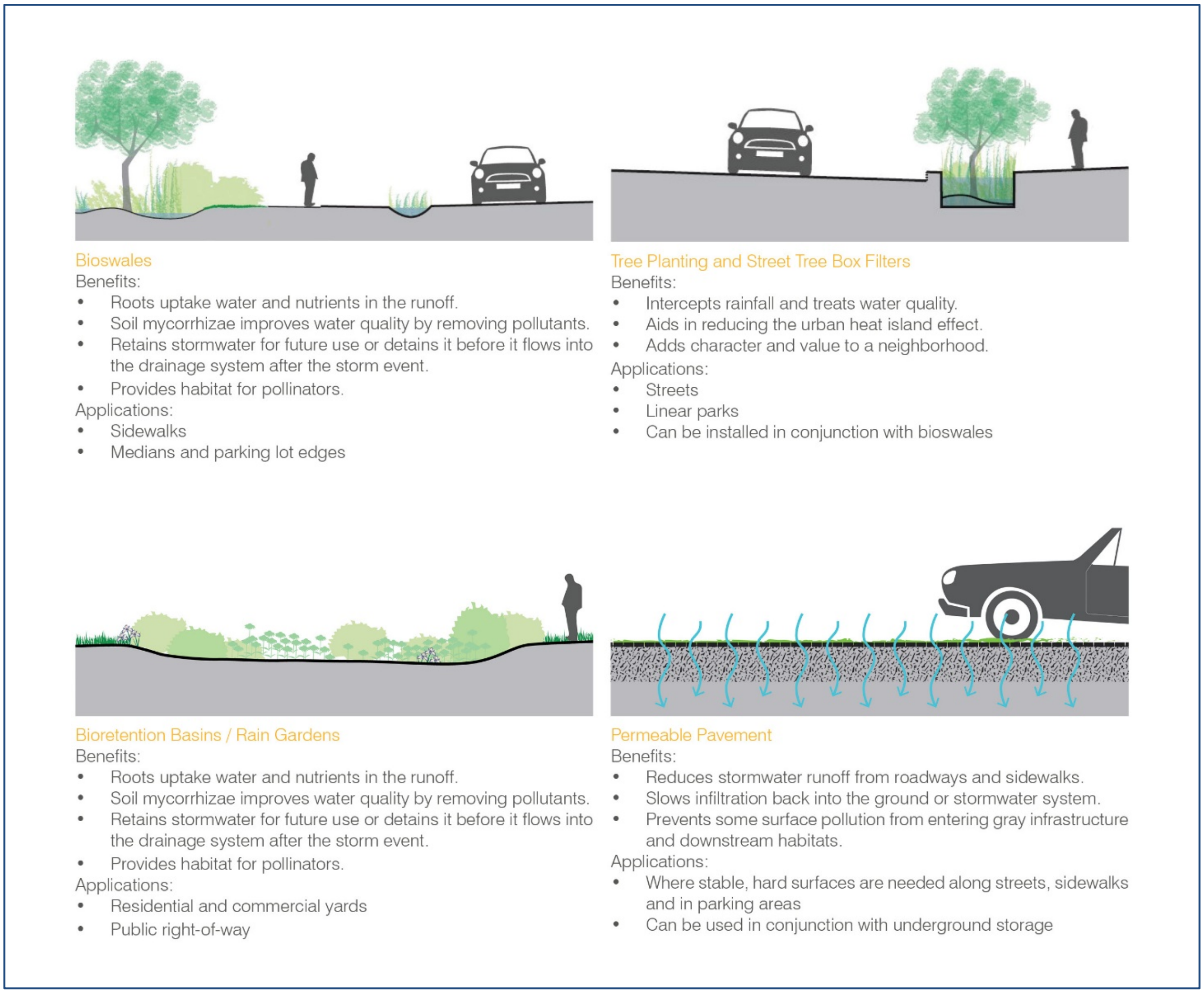
At the May public presentation, residents also expressed concerns and preferences, ranking soil and hill stabilization, water quality, and safety as top priorities and showing the most interest in gravel roads and culvert solutions. They also noted flooding and erosion issues at Cone Hill Road and the Whitewood Association in addition to areas identified before. These preferences were ultimately used to rank possible solutions in the prioritization matrix based on their community co-benefits.

3.0 ALTERNATIVES AND PRIORITIZATION

3.1 Development and Evaluation of Resilience Alternatives

Based on background research, field investigations, community input, and modeling, Weston & Sampson identified a wide range of climate resilience alternatives to address the issues and problem areas. These solutions ranged from the construction of additional flood storage, stream restoration, nature-based solutions, including the use of green infrastructure, and more.

Figure 3-1. Green Infrastructure Examples



In collaboration with the Towns, the proposed solutions were evaluated and prioritized to feature those that are most feasible to implement and most beneficial for addressing the environmental and infrastructure impacts of stormwater runoff in the communities.

3.1.1 Map of Projects Overlaid with Problem Areas

The potential solutions are shown below overlaid with known problem flooding areas, in Figure 3-2 for Richmond, and Figure 3-3 for West Stockbridge.

Figure 3-2 Map of Richmond Projects Overlaid with Problem Areas

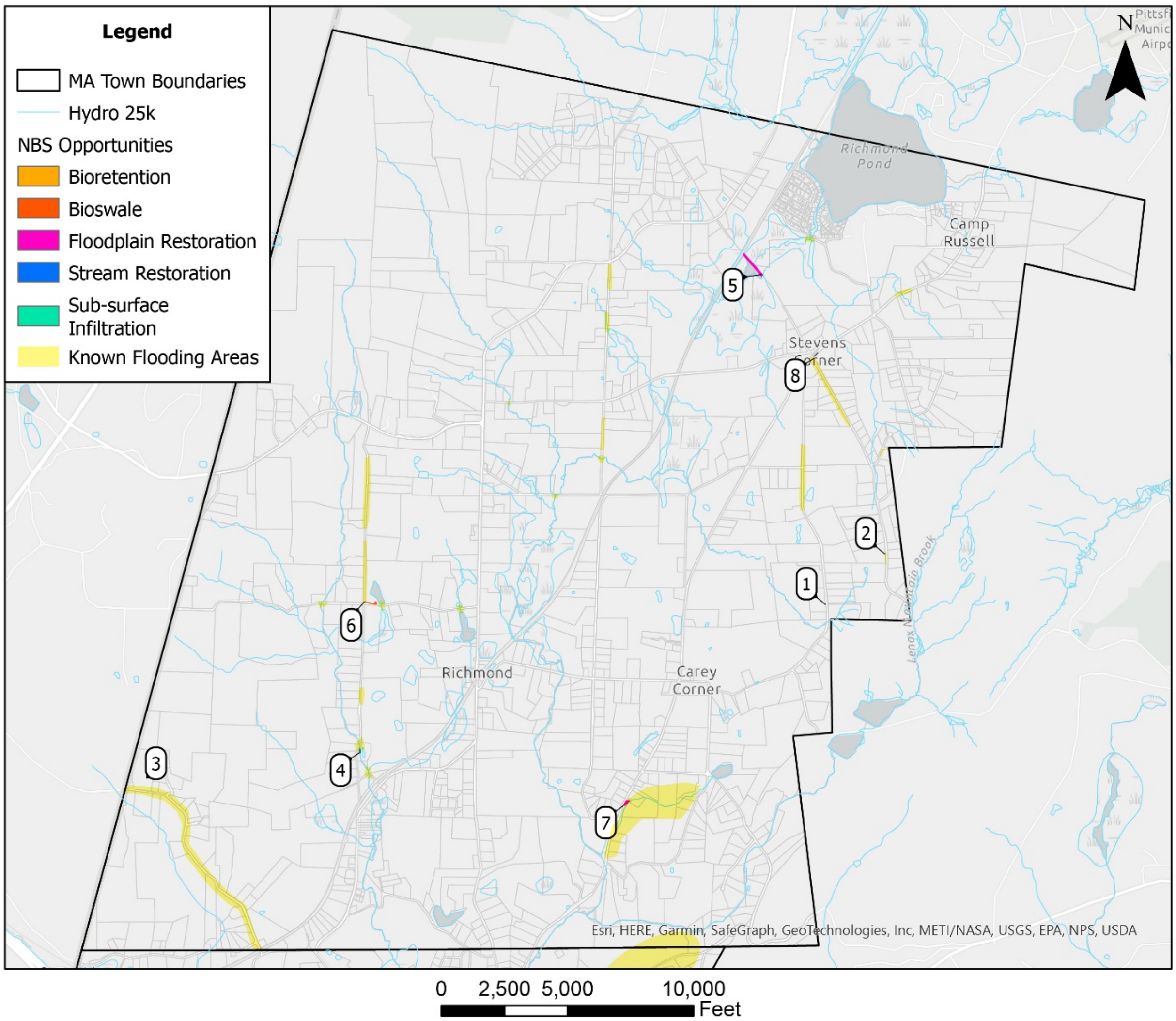
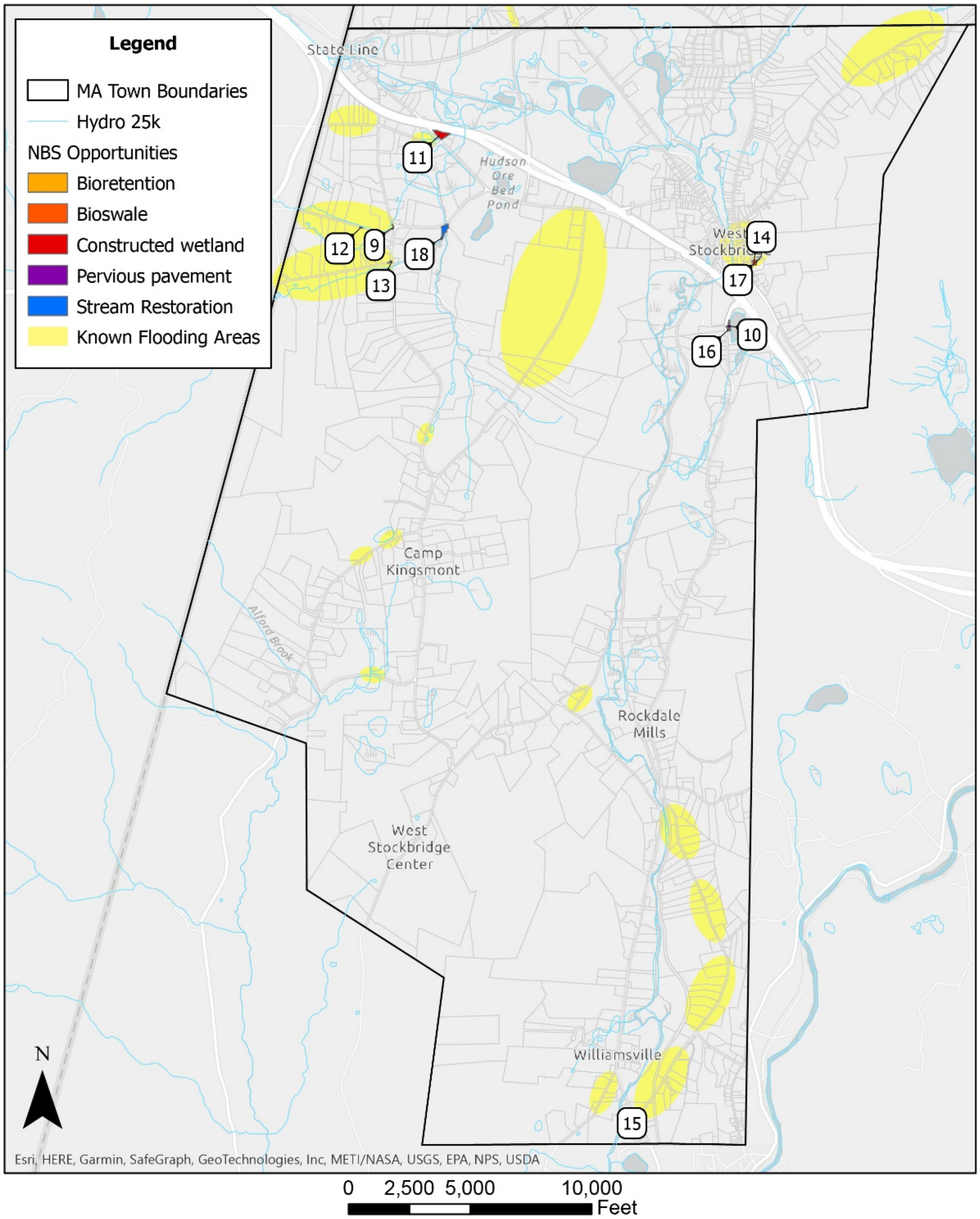


Figure 3-3 Map of West Stockbridge Projects Overlaid with Problem Areas



3.1.2 Flood Reduction and Resilience Alternatives

First, Weston & Sampson analyzed the effectiveness of the potential solutions for flood reduction. Stormwater reduction benefits to subcatchments were evaluated as well as their contribution to known problem areas.

The following metrics were used to assess the solutions' impact on stormwater reduction:

- Nature Based Solutions and Green Infrastructure
    - Flooding impact to problem areas
    - Volume reduction during a baseline present day 2-year storm event (2.95 inches/24 hrs.)
    - Volume reduction during a 2070 2-year storm event (4.0 inches/24 hrs.)
- Dams
    - Flooding impact to problem areas
    - Peak flood levels at dam during a present day 2-year storm event
    - Peak flood levels at dam during a 2070 2-year storm event
    - Peak flood levels upstream during a present day 2-year storm event
    - Peak flood levels upstream during a 2070 2-year storm event
    - Peak flood levels downstream during a present day 2-year storm event
    - Peak flood levels downstream during a 2070 2-year storm event
- Road-Stream Crossings
    - Flooding impact to problem areas
    - Decrease in peak flood level on road during a present 2-year storm event
    - Decrease in peak flood level on road during a 2070 2-year storm event

Modeling of solutions showed a range of flood reduction benefits spreading between "minimal" to "significant" reductions in peak and total flood volumes in the respective sub-watershed. Rankings of "Significant, Moderate, or Minimal" considered both the 2030 and 2070 magnitude of reductions in the peak and total runoff volumes as well as the subbasin (size, contribution) within which the project falls. There are exceptions primarily caused by the subbasins/locations of the projects, i.e., a project with a lower total volume reduction may still be considered significant when the subbasin is very large and has a high % impervious area. In addition to this score, an additional metric was used to determine whether the nearest known problem area was within the sub-watershed projected to benefit from the solution.

The flood reduction benefits of each project were integrated into an overall prioritization and ranking of projects, as described later in section 3.2.

3.1.3 List of Projects by Town

The following projects were explored and modeled to represent the flood reduction benefits to problem areas. Projects are listed here in descending order of the modeled flood reduction benefits to problem areas, for each town, with projects having the highest benefit to problem areas listed first. For additional description of the projects and their overall prioritization based on additional criteria, see Appendix D – Development and Evaluation of Nature Based Solutions.

Richmond Projects (Project ID in Parenthesis)

RICHMOND

Nature Based Solution Projects

- West Road at Rossiter Road (6)
- Osceola Road at Swamp Road (7)
- West Road near State Road at Furnace Brook (4)
- Swamp Road near Dublin Road (5)
- Town Beach Road/Richmond Fen Wildlife Management Area (8)

Culvert Projects

- Summit Road, near telephone pole MECO 36
- Former Swamp Road
- Swamp Road, quarter of a mile southwest of Swamp Road and Osceola Road intersection
- Sleepy Hollow Road, about halfway down Sleepy Hollow Road
- West Road, South, between red barn and railroad crossing at the beginning of West Road
- West Road, North, between a 15 sign and 951 West Road
- Dublin Road, next to 10 Dublin Road
- Summit Road, about 150 feet east of 477 Summit Road
- Lenox Road, by fire hydrant marked 14, and telephone pole 22

Dam Projects

- Unnamed Dam, on driveway for 350 West Road-dam removal candidate
- Sherrill Pond Dam (MA02203)-dam removal candidate
- Unnamed Dam, Pittsfield, near 98 Central Berkshire Boulevard-dam removal candidate
- Unnamed Dam, Richmond, behind 1018 Dublin Road-dam removal candidate
- Richmond Iron Works Dam (MA01045)-dam removal candidate
- Upper Root Reservoir Dam Drawdown (MA00019)-potential for increased storage
- Lower Root Reservoir Dam Drawdown (MA00018)-potential for increased storage
- Richmond Pond Dam Drawdown (MA00017)-potential for increased storage
- Richmond Iron Works Dam Drawdown (MA01045)-potential for increased storage

West Stockbridge Projects (Project ID in Parenthesis)

WEST STOCKBRIDGE

Nature Based Solution Projects

- West Center Road (18)
- State Line Road at Smith Road (11)
- Red Rock Road (12)
- Austerlitz Road (13)
- Woodruff at Red Rock Road (9)
- Pixley Hill Road (10)
- South Street-Bioswale (14)
- South Street-Stream Restoration (15)
- Great Barrington Road at Card Pond-Bioretention (16)
- Great Barrington Road at Card Pond-Pervious Pavement (17)

Downtown Green Infrastructure Projects

- Intersection of Harris Street and Moscow Road green space (4)
- Intersection of Hotel Street and Route 102 (5)
- Intersection of Lenox Road and Swamp Road (6)
- Downtown past Hotel Street (7)
- Intersection of Old Great Barrington Road and Route 102 (8)
- Intersection of Old Great Barrington Road and Route 102 (9)
- Gravel Parking down Route 102 before Depot Street (3)
- Parking Strip down Main Street past Oak Street toward Downtown (10)
- Intersection of Oak Street and Main Street (1)
- Down Main Street past Oak Street toward Downtown (2)

Culvert Projects

- West Alford Road (Adjacent to 15 West Alford Road driveway)
- Wilson Road (Between Alford Brook Club and telephone pole 7-84)
- Smith Road (South of 3 Smith Road)
- West Alford Road (Approximately 50 feet east of private driveway for 9 West Alford Road)
- Quarry Road (200 feet into Quarry Road, private, about 100 feet before gate)
- Baker Street (Adjacent to 22 Baker Street)

Dam Projects

- Kingsmont Dam (MA02223)-dam removal candidate
- Shaker Mill Pond Dam (MA00732)-dam removal candidate
- Unnamed Dam, West Stockbridge, adjacent to 245 Great Barrington Road-dam removal candidate

WEST STOCKBRIDGE

Dam Projects (continued)

- Shaker Mill Pond Dam (MA00732)-potential for increased storage
- Alford Brook Club Dam (MA02224)-dam removal candidate
- Rose Lower Dam (MA02631)-dam removal candidate
- Card Pond Dam (MA01047)-potential for increased storage
- Unnamed Dam, West Stockbridge, behind 46 Main Street-dam removal candidate
- Unnamed Dam, West Stockbridge, adjacent to 30 Great Barrington Road-dam removal candidate

Several projects were not incorporated into modeling, and therefore are not included in the list above of projects sorted by hydrologic results. First, a project was added based on discussions with the Town of West Stockbridge at a resident's request. A bioretention area on Iron Mine Road was included as an additional alternative storage opportunity. The Town is familiar with the flood benefits of this project as it was formerly a designed bioretention area before recent development.

In addition, several gravel roads solutions in Richmond were identified at a conceptual level to inform general types of issues, but without site level detail needed for modeling, and are therefore also not included in the list of projects sorted by hydrological results.

3.2 Prioritization of Solutions

To determine which opportunities should be prioritized for implementation, three overarching factors were considered:

(1) the impact of the opportunity on stormwater reduction;
(2) co-benefits of implementing the opportunity; and
(3) the feasibility of implementing the opportunity.

3.2.1 Prioritization and Impact Scoring

To determine which nature-based solution, road-stream crossing, and dam opportunities should be prioritized for implementation, several factors were considered, the impact of the opportunity on stormwater reduction, the feasibility of implementing the opportunity, and the co-benefits of implementing the opportunity. The following equation was used to come up with the final prioritization score.

Prioritization Score (S) = Impact on Stormwater Reduction (ISR) + Co-Benefits of Implementation (CB) + Feasibility of Implementation (FI)

Indicators under each of the three categories were weighted based on their relative importance to -the Towns. For example, projects which align with existing planned projects receive more weight under 'feasibility of implementation'. Definitions of each prioritization can be found below.

Impact on Stormwater Reduction

Impact on stormwater reduction was determined based on the model results and the solution's impact on known problem flooding areas, as discussed in Section 3.1.2. The impact on flooding used for prioritization are defined by the following attributes:

- Flood reduction shown in the model – solutions can reduce flooding as shown in the model analysis
- Flooding impact to problem areas – solutions can reduce flooding in known problem areas identified by the Towns

Co-Benefits from Community

Co-benefits of implementing the opportunity were considered for each project. Co-benefits are ways that the opportunities may positively influence the community and natural resources in Richmond and West Stockbridge. Co-benefits used to score the opportunities were selected based off community feedback gathered through stakeholder meetings and community surveys.

The co-benefits of implementation used for prioritization are defined by following attributes:

- Foster biodiversity, habitat, and pollinators – solutions can contribute to biodiversity by creating wildlife habitat, improving habitat quality, and enhancing pollination. Depending on the vegetation variety and type, this can positively contribute to the health of the ecosystem
- Water quality improvements – solutions can contribute to water quality improvements by reducing sediment loads, slowing water flows, and reducing pollution entering waterways.
- Safety improvements – solutions can contribute to safety improvements by improving road quality, reducing the need for staff to perform road repairs, improving structure resilience, and reducing emergencies.
- Contribution to soil stabilization and hillside protection – solutions can contribute to soil stabilization by reducing overland flow, erosion, and providing stability structures.

Benefits to Climate Vulnerable Populations

The identification of resilient stormwater solutions is also intended to benefit climate vulnerable populations. Climate vulnerable populations typically include environmental justice (EJ) communities, but in their absence, people living alone, in poverty, with limited mobility, or older adults are more vulnerable to impacts of climate change. Flood-based hazards that could restrict evacuation or emergency response were discussed in the identification of problem areas, and therefore additional criteria regarding these populations were not generated for the ranking of solutions. State Road, Richmond's stretch of Route 41, and West Stockbridge's adjoining Main Street to the south, contain several critical facilities and community lifelines including schools, a fire station, public works, a library, and local stores. While Main Street was identified as a known problem flooding area needing solutions, State Road does not typically experience flood conditions that would require stormwater mitigation actions.

Likelihood and Consequence of Failure

Another method for prioritizing climate resilience solutions is to consider the likelihood and consequence of failure of existing infrastructure. In this project's scope, this applies primarily to dams and culverts. Data sources on dam condition were used to prioritize solutions, and the selection of culverts for modeling utilized an evaluation of overtopping of road-stream crossings, which serves as a proxy for their likelihood and consequence of failure.

Feasibility of Implementation

The feasibility of implementing the opportunity was considered for each project. Feasibility includes how practical it would be to implement and maintain the opportunity based on costs, cost assistance, complexity, and effort to maintain. Feasibility of implementation used to score the opportunities were selected based on feedback gathered through stakeholder meetings and discussions with each Town.

The feasibility of implementation used for prioritization is defined by following attributes:

- Opinion of cost – the high-level opinion of cost.
- Funding availability – the funding availability and feasibility of the project. Includes evaluation of Town effort for funding implementation, need for outside assistance to secure funding, and ability to group of projects that is fundable as a package.
- Permitting difficulty – the permitting requirements in terms of effort to secure permits and the time it may take for permits to be issued.
- Land ownership – the land ownership of the project area was evaluated. Projects on private land may be less feasible to implement than those on public land, though there may be opportunities to benefit the landowner. For the purposes of this implementation plan, projects on private property were generally not included in the final listing in section 4.
- Maintenance frequency – the maintenance requirements in terms of effort of the strategy were evaluated based on a rough estimate of time of maintenance cycles.
- Maintenance effort – the effort requirements of maintaining the strategy were evaluated based on the type of equipment that must be available and the staff training/knowledge.

3.2.2 Basis of Cost Estimates

Conceptual-level costs were developed for all solutions identified.

Unit pricing by square foot or cubic foot was determined for the following opportunities: bioretention areas, bioswales, constructed wetlands, permeable pavement, floodplain restoration, stream restoration, and sub-surface storage. A materials and labor subtotal was obtained for each opportunity based on this unit pricing. In addition, costs for road stream crossings were developed based on the span of the crossing, and costs for dam removal and dam drawdown projects were developed based on the size of the dam and the magnitude of the project.

The unit pricing is summarized in Table 3-1 and further discussed below.

Table 3-1 Unit Pricing

Item	Size	Cost per Square Foot (SF)
Bioretention Areas	small	$60
	medium	$50
	large	$40
Bioswales	small	$50
	medium	$40
	large	$30
Constructed Wetland		$30
Permeable Pavement	small	$20
	medium	$15
	large	$12
Restore Floodplain		$30/CY*
Stream Restoration		$20
Sub-Surface Stormwater Storage		$30

*floodplain restoration is in cubic yard (CY) units

Unit costs were not developed for culvert projects. The cost of culvert projects is highly dependent on the site conditions and the span of the culvert. Therefore, costs were broadly estimated using the span of the road-stream crossing. Additionally, unit cost was not developed for any dam removal or dam drawdown projects. The cost of these projects is highly dependent on the site conditions and the scale of the dam. Finally, unit cost was also not developed for the gravel road solutions described as conceptual types, as they are also highly dependent on site conditions and design choices. Further studies are needed to develop an accurate Opinion of Probable Cost (OPC) for culvert, dam, and some gravel roads projects.

The following costs were added to the materials and labor subtotal for each opportunity to obtain a total materials and installation labor cost:

- A 3% mobilization/demobilization cost
- A 20% materials and labor contingency, to account for the high variability in prices over recent years
- A 20% contingency for unknowns

The following items were added to the materials and labor cost to obtain an overall subtotal cost for each opportunity:

- Daily surveying OPC
- Estimated permitting OPC
- Design and bidding OPC, based on experience with previous projects
- A lump sum item for construction administration, based on project size, which assumes work associated with construction over one to two months related to change order requests and field directives, part-time field oversight, review & approval of pay requests, and status meetings.
- Finally, a 20% general contingency was applied to the overall subtotal for each opportunity to account for any unknown costs that may be incurred, considering that these opportunities are still in the very early stages of design.

Please note that this is an engineer's OPC. Weston & Sampson has no control over the cost of availability of labor, equipment or materials, or over market conditions or a Contractor's method of pricing. The OPC has been developed based on Weston & Sampson's professional judgement and experience. Weston & Sampson makes no guarantee that bids or negotiated cost of any work will not vary from this OPC. Costs presented are considered concept/screening level and therefore have an estimated accuracy range of -30% to +50%. Costs are presented in June 2023 dollars.

The cost estimates for each opportunity were grouped so that the costs could be used in the project prioritization under Feasibility of Implementation. The cost estimate groupings are shown in Table 3-2, below. Appendix E shows the cost grouping for each solution.

Table 3-2 – Opinion of Cost Groupings	
Opinion of Cost	Description
$	<$100,000
$$	between $100,000 and $400,000
$$$	between $400,000 and $700,000
$$$$	between $700,000 and $1,000,000
$$$$$	>$1,000,000

3.2.3 Project Prioritization

The following tables outline the impact score definitions for the co-benefits of implementation (Table 3-3) and the feasibility of implementation (Table 3-4).

Table 3-3 – Co-Benefits of Implementation				
Score	Biodiversity/Habitat/ Pollinators	Water Quality Improvements	Safety Improvements	Soil Stabilization and Hillside Protection
0	Does not create biodiversity or habitat	No improvements	No improvements	No improvements
1	Provides low attributes of biodiversity/habitat	Improvements in TSS only	Minimal improvements	Minimal improvements
2				
3	Fulfills some attributes of biodiversity/habitat	Improvements in solids, nutrients, and other pollutants	Moderate improvements	Moderate improvements
4				
5	Fulfills all attributes of biodiversity/habitat	Improvements in large solids and nutrients	Large improvements-reduced road flooding, washouts, and erosion	Large improvements

Table 3-4 – Feasibility of Implementation						
Score	Opinion of Cost	Funding Available	Permitting Difficulty	Land Ownership	Maintenance Frequency	Maintenance Effort
0		Not fundable	Not compliant with permitting			
1	$$$$$	Least Fundable	more permits than just NOI	Private land-changing dam operations	4x per year	Hire out crew & equipment, rent equipment
2	$$$$			Private land-removing dams		
3	$$$	Moderately Fundable	ConCom jurisdiction and need NOI or RDA	State Land	2X per year	In-house available equipment, specific staff knowledge, full crew
4	$$					
5	$	Most likely fundable	No permitting	Public Land	Annual	In-house available equipment & general staff knowledge, 1/2 crew

3.2.4 Weighting

In addition to the basic scoring exercise, the co-benefits of implementation and the feasibility of implementation were weighted to determine their relative effect on the Prioritization Score. The Towns of Richmond and West Stockbridge each selected their own weighting designation based on the importance of attribute importance to the Town. The weights of the impact scores are shown in Table 3-5 and Table 3-6 on the next page.

3.2.5 Priority Project List

The final project prioritization and project prioritization scoring can be found in Appendix E.

Table 3-5 – Richmond Prioritization Weights												
	Impact on Flooding		Co-Benefits of Implementation				Feasibility of Implementation					
Attribute	Flooding Impact to Problem Areas Ranking	Model Flooding Ranking	Biodiversity/ Habitat/ Pollinators	Water Quality Improvements	Safety Improvements	Soil Stabilization and Hillside Protection	Opinion of Cost	Funding Availability	Permitting Difficulty	Land Ownership	Maintenance Frequency	Maintenance Effort
Weight	5	5	6	6	12	16	10	10	5	5	10	10
											Sum of Weights:	100

Table 3-6– West Stockbridge Prioritization Weights												
	Impact on Flooding		Co-Benefits of Implementation				Feasibility of Implementation					
Attribute	Flooding Impact to Problem Areas Ranking	Model Flooding Ranking	Biodiversity/ Habitat/ Pollinators	Water Quality Improvements	Safety Improvements	Soil Stabilization and Hillside Protection	Opinion of Cost	Funding Availability	Permitting Difficulty	Land Ownership	Maintenance Frequency	Maintenance Effort
Weight	5	5	8	8	12	12	15	5	5	5	10	10
											Sum of Weights:	100

4.0 IMPLEMENTATION PLAN

The 62 projects identified in Section 3 could theoretically be implemented over a 20-year period, based on Town priorities and funding available. This Climate Resilient Stormwater Action and Implementation Plan (RSAIP) provides here an initial planning tool for climate resilience solutions that could be implemented in the next 5-7 years. Starting on the following page, the highest-ranked projects from each project type are listed for each Town, with information about projected costs, timeline for implementation, and potential funding opportunities.

Information about costs for each project was generated as described in Section 3.2.2. The projected timelines for each project are based on expert opinion of similar projects completed in the recent past. Potential funding sources have been screened to include those that may be appropriate for each project type, but there is no guarantee of funding as these are competitive grant programs.

In the subsequent section, general recommendations for implementation are summarized, including alignment with existing Town plans and projects, and implementation and funding strategies. These strategies include a range of funding types and programmatic opportunities, including partnerships and incentives programs for local residents and businesses.

4.1 Richmond Implementation Plan

4.1.1 Top Projects

In Table 4-1, the top ranked projects from each project type are described in terms of potential costs, timeline, and funding opportunities. The final projects to include for implementation were selected in conversation with the Towns, and several projects on private property described in Subtask 3.4 were excluded for feasibility concerns. An initial set of conceptual solutions for gravel roads are included in the list of top projects, but these are not ranked (NR) using the criteria because of their limitations for flood modeling.

Table 4-1. Top Projects for Richmond

Project (ID)	Overall Rank	Estimated Cost	Estimated Timeline	Funding Opportunities
Nature Based Solutions				
Osceola Rd at Swamp Rd (7) – bioswale on gravel road	1	$100,000-400,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, Chapter 90, Complete Streets, FHA PROTECT, PDM, Rural and Small Town, Transportation Alternatives
West Rd at Rossiter Rd (6) – bioswale on gravel road	2	$700,000-$1M	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, Chapter 90, Complete Streets, FHA PROTECT, PDM, Rural and Small Town, Transportation Alternatives
West Road @ Furnace Brook (4) – Stream Restoration	3	$400,000-700,000	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	MVP, DER Priority Project, Massachusetts Environmental Trust, NFWF Urban Waters Restoration Grant, PDM
Swamp Rd near Dublin Rd (5) Floodplain restoration	4	$100,000-400,000	3-6 years (Design: 1-2 Permit: 1-2 Construct: 1-2)	MVP, DER Priority Project, NFWF Urban Waters Restoration Grant, Rural and Small Town

Table 4-1. Top Projects for Richmond				
Project (ID)	Overall Rank	Estimated Cost	Estimated Timeline	Funding Opportunities
Culverts/Road-Stream Crossings				
Former Swamp Road (CR5) – upsize culvert	6	$1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, DER Culvert, Chapter 90, FHA PROTECT, MassDOT Small Bridge, PDM, Rural and Small Town, Transportation Alternatives
Summit Road (CR6) - upsize culvert	7	$1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, DER Culvert, Chapter 90, FHA PROTECT, MassDOT Small Bridge, PDM, Rural and Small Town, Transportation Alternatives
Dams				
Upper Root Reservoir Dam (D1) – increased storage	16	$400,000-700,000	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	MVP, FMA, Dam and Seawall Repair or Removal Program, DER Priority Project, USACE Flood Damage Reduction
Lower Root Reservoir Dam (D2) – increased storage	17	$400,000-700,000	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	FMA, USACE Flood Damage Reduction
Richmond Pond Dam (D3) – increased storage	17	$400,000-700,000	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	FMA, USACE Flood Damage Reduction

Table 4-1. Top Projects for Richmond				
Project (ID)	Overall Rank	Estimated Cost	Estimated Timeline	Funding Opportunities
Other Gravel Roads Improvements				
East Road (1) – elevation, piped drainage, French mattress, and/or swales and storage	NR	$100,000-1,000,000+[1]	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, FHA PROTECT, Small Town and Rural, Transportation Alternatives
Upper Osceola Road (2) - Improve conveyance/storage, and/or velocity controls	NR	$100,000-1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, HMP, FHA PROTECT, Small Town and Rural, Transportation Alternatives
Dean Hill Road (3) - Bioretention and forebay; swale enhancement, and/or hardening	NR	$100,000-1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, HMP, FHA PROTECT, Small Town and Rural, Transportation Alternatives

4.1.2 Potential Timeline for Grant Funding

Based on the projected timeline for implementation of each top project, using the typical timeline of the MVP grant program, a funding strategy for Richmond could follow the example in Table 4-2.

[1] Cost estimates for the gravel roads projects at East, Upper Osceola, and Dean Hill Road are very preliminary and are shown as a range that includes costs associated with all potential solutions recommended. Actual costs will depend on which solutions are ultimately selected for implementation at each site.

As a reminder, estimated costs are provided using the breakdown below. All costs are estimates and need to be updated at the time of design or construction. When applicable, costs have been divided between preliminary designs, permitting, and construction.

$: <$100,000
$$: $100,000-$400,000
$$$: $400,000-$700,000
$$$$: $700,000-$1,000,000
$$$$$: >$1,000,000

Table 4-2 Example Funding Strategy (Richmond)					
Project	2024	2025	2026	2027	2028
Osceola Rd at Swamp Rd (7) - bioswale	Design and permit: $	Start construction: $$	Construction ends: $$		
West Rd at Rossiter Rd (6) - bioswale	Design and permit: $$	Permit: $$	Permit and Construction: $$	Construction ends: $	
West Road @ Furnace Brook (4) – Stream Restoration	Design starts: $	Design continues and permit starts: $	Permit: $	Permit: $	Permitting ends and start construction: $$
Swamp Rd near Dublin Rd (5) Floodplain restoration		Design: $	Design: $	Permit: $	Permit: $
Culvert project	Design: $$	Design continues and permit starts: $	Permit: $	Permitting ends and start construction: $$	Construction: $$
Gravel roads improvements (annual expenses)	Design: $$ Enhanced Maintenance: $	Permit: $$$ Design: $$ Maintenance: $	Construction: $$$ Permit: $$ Design: $ Maintenance: $	Construction: $$$ Permit: $$ Design: $$ Maintenance: $	Construction: $$$ Permit: $$ Design: $$ Maintenance: $
Total Request This Year	$1,300,000	$1,800,000	$1,900,000	$1,800,000	$1,800,000
Matching funds needed (25%)	$325,000	$450,000	$475,000	$450,000	$450,000

Assumptions in the proposed funding strategy:

1. Annual MVP Action Grant funding cycles typically start with Expressions of Interest due in February, grant applications due in May, and awards distributed in September of each year that must be spent by June of the next year. In 2024, this assumes the Town will apply for a grant in May and receive funds in September to expend by June 2025. For a two-year project (e.g., Osceola Rd at Swamp Rd), design work would begin in September 2024, and construction would finish by June 2026.
2. The Town may pursue one culvert project at a time, but each project would have a similar duration and overall funding timeline.
3. Gravel roads improvements could include a range of redesign projects (like those described for East Road, Upper Osceola Road, and Dean Hill Road) and enhanced gravel roads maintenance activities. Recommendations for gravel roads maintenance described in the Solutions memo (Subtask 3.4) may require more funding than the Town currently spends each year on road work. See Section 4.3.4 for recommendations regarding improving cost estimates and funding needs for gravel roads.
4. MVP Grants require a 25% match of in-kind and cash contributions. Matching cash funds could be obtained through a combination of federal or private grants and/or municipal funds. Other grant sources may have higher or lower match requirements.

Year 1 (2024):

- DER Culvert project (if awarded) – Sleepy Hollow Culvert Redesign/Construction
- Apply for MVP funding
- Develop funding strategy for other grants/matching funds
- Start first round of projects

Year 2 (2025):

- Apply for MVP and other funding sources
- Continue to do projects

Year 3 (2026):

- Apply for MVP and other funding sources
- Continue projects

Year 4 (2027):

- Apply for MVP and other funding sources
- Continue projects

Year 5 (2028):

- Apply for MVP and other funding sources
- Continue projects

4.2 West Stockbridge Implementation Plan

In Table 4-3, the top ranked projects from each project type are described in terms of potential costs, timeline, and funding opportunities. The final projects to include for implementation were selected in conversation with the Towns, and several projects on private property described in Subtask 3.4 were excluded for feasibility concerns.

4.2.1 Top Projects

Table 4-3. Top Projects for West Stockbridge

Project (ID)	Overall Rank	Estimated Cost	Estimated timeline	Funding Opportunities
Nature Based Solutions				
West Center Rd (18) – Stream Restoration	1	$1,000,000+	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	MVP, General Fund, DER Priority Project, NFWF Urban Waters Restoration, PDM
Woodruff at Red Rock Rd (9) – Bioretention on gravel road	4	$100,000-400,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, Chapter 90, Complete Streets, FHA PROTECT, PDM, Rural and Small Town, Transportation Alternatives
South Street (15) – Stream Restoration	5	$700,000-1,000,000	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	MVP, Massachusetts Environmental Trust, DER Priority Project, NFWF Urban Waters Restoration, PDM
Austerlitz Rd (13) – Bioswale	8	$100,000-400,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, Complete Streets, FHA PROTECT, Rural and Small Town, Transportation Alternatives, PDM

Table 4-3. Top Projects for West Stockbridge				
Project (ID)	Overall Rank	Estimated Cost	Estimated timeline	Funding Opportunities
Downtown Green Infrastructure				
Intersection of Old Great Barrington & 102 (GI8 & GI9) – Bioretention, Rain Garden, Mini Forest, Tree Pits, Infiltration Trench	2 & 6	$100,000-400,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, FHA PROTECT, PDM, Section 319
Intersection of Lenox & Swamp Rd (GI6) – Bioretention	3	<$100,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, FHA PROTECT, PDM, Section 319
Intersection of Oak St & Main St (GI1)	7	<$100,000	1-2 years (Design: 6 months Permit: 2-3 months Construct: 6 months)	MVP, General Fund, FHA PROTECT, PDM, Section 319
Culverts/Road-Stream Crossings				
West Alford Rd (CWS2) – upsize culvert	21	$1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, DER Culvert, Chapter 90, FHA PROTECT, MassDOT Small Bridge, PDM, MassWorks, Rural and Small Town, Transportation Alternatives
Willson Road (CWS5) - upsize culvert	24	$1,000,000+	3-4 years (Design: 1 Permit: 1-2 Construct: 1)	MVP, DER Culvert, Chapter 90, FHA PROTECT, MassDOT Small Bridge, PDM, MassWorks, Rural and Small Town, Transportation Alternatives
Dams				
Shaker Mill Pond Dam – removal	18	$1,000,000+	4-7 years (Design: 1-2 Permit: 2-3 Construct: 1-2)	MVP, Dam and Seawall Repair or Removal Program, DER Priority Project

4.2.2 Projected Timeline for Grant Funding

Based on the projected timeline for implementation of each top project, using the typical timeline of the MVP grant program, a funding strategy for West Stockbridge could follow the example in Table 4-4. As a reminder, estimated costs are provided using the breakdown below. All costs are estimates and need to be updated at the time of design or construction. When applicable, costs have been divided between preliminary designs, permitting, and construction.

$: <$100,000
$$: $100,000-$400,000
$$$: $400,000-$700,000
$$$$: $700,000-$1,000,000
$$$$$: >$1,000,000

Table 4-4 Example Funding Strategy (West Stockbridge)

Project	2024	2025	2026	2027	2028
West Center Rd (18) – Stream Restoration	Design starts: $$	Design continues and permit starts: $$	Permit: $	Permit: $	Finalize permits and start construction: $$$
Woodruff at Red Rock Rd (9) – Bioretention on gravel road	Design and permit: $	Start construction: $$	Construction ends: $		
Intersection of Old Great Barrington & 102 (GI8 & GI9)	Design and permit: $	Start construction: $	Construction ends: $		
Intersection of Lenox & Swamp Rd (GI6) – Bioretention		Design and permit: $	Start construction: $	Construction ends: $	
Culvert project	Design: $$	Design continues and permit starts: $	Permit: $	Permitting ends and start construction: $$	Construction: $$
Gravel roads improvements (annual expenses)	Design: $$$ Enhanced Maintenance: $	Permit: $$ Design: $$ Maintenance: $	Construction: $$$ Permit: $$ Design: $ Maintenance: $	Construction: $$$ Permit: $$ Design: $$ Maintenance: $	Construction: $$$ Permit: $$ Design: $$ Maintenance: $
Total Request	$1,100,000	$1,300,000	$1,300,000	$1,600,000	$1,800,000
Matching funds needed	$275,000	$325,000	$325,000	$400,000	$450,000

Assumptions in the proposed funding strategy:

1. Annual MVP Action Grant funding cycles typically start with Expressions of Interest due in February, grant applications due in May, and awards distributed in September of each year that must be spent by June of the next year. In 2024, this assumes the Town will apply for a grant in May and receive funds in September to expend by June 2025. For a two-year project (e.g., Woodruff at Redrock Rd), design work would begin in September 2024, and construction would finish by June 2026.
2. The Town may pursue one culvert project at a time, but each project would have a similar duration and overall funding timeline.
3. Gravel roads improvements could include a range of redesign projects and enhanced gravel roads maintenance activities. Recommendations for gravel roads maintenance described in the Solutions memo (Subtask 3.4) may require more funding than the Town currently spends each year on road work. See Section 4.3.4 for recommendations regarding improving cost estimates and funding needs for gravel roads.
4. MVP Grants require a 25% match of in-kind and cash contributions. Matching cash funds could be obtained through a combination of federal or private grants and municipal funds.

Year 1 (2024):

- Apply for MVP funding
- Develop funding strategy for other grants/matching funds
- Start first round of projects

Year 2 (2025):

- Apply for MVP funding
- Continue projects

4.3 Recommendations for Next Steps

4.3.1 Alignment with Existing Plans and Planned Work

Richmond and West Stockbridge have other plans that will have opportunities for integrating these stormwater projects into their implementation. This stormwater implementation plan should be consulted for opportunities to coordinate as the Towns move forward on implementation for the following plans:

- Hazard Mitigation Plans
- Road-Stream Crossing Management
- Transportation and Complete Streets plans
- Economic Development Plans
- Open Space Plans
- Richmond Pond Management Plan
- West Stockbridge Master Plan
- West Stockbridge capital plan. Three planned projects may overlap with RSAIP recommendations:
    - the water line extension on Moscow Road
    - the Swamp Road water main project
    - the architectural/site planning for the Public Service Building

Critically, as the Towns undertake any future municipal facility and roadway projects, they should be integrating recommendations from this project.

The stormwater action plan prepared here could be used to further develop or enhance a capital plan for each Town. The Towns could build on this plan by incorporating facilities and other infrastructure plans and associated schedule and cost to expand the list into a formal capital plan.

4.3.2 In-House vs Contracted Work

While outside funding will typically be needed to obtain contractor support or for projects that require specialized equipment, the Towns' in-house staff have much of the equipment and knowledge required for tasks involved in digging up and redesigning roads, adding basic drainage, installing geogrids, and grading. Major road projects that could draw significant amounts of staff time for implementation away from ongoing maintenance duties, or would require buying equipment for a short period of time, would benefit from additional equipment and manpower, best obtained through grant or additional funding sources. These are also opportunities for regional collaboration, where the Towns might seek to obtain funding together or in partnership with other nearby communities facing similar issues.

4.3.3 Operations and Maintenance

Recommendations for operations and maintenance of specific solutions are provided in the Solutions memo (Subtask 3.4). Richmond and West Stockbridge staff make great use of their existing staff and operations for maintenance of existing infrastructure. However, staff are mostly focused on reactive work to address problems and prevent worsening conditions. Both communities would benefit from considering investing in GIS mapping and asset management approaches that utilize a formal work order system to be more climate ready and resilient. This approach would provide a tool for interactive mapping, documenting progress, evaluating frequency of proactive and reactive work, and very importantly, making a case to the community and decision-makers for increased funding. Showing statistics and maps from such a system could demonstrate the significant amount of operations and maintenance work performed by Public Works employees.

4.3.4 Analysis of Gravel Roads Costs

Overall, Town staff are well informed about best practices for gravel roads but are limited by local budgets for maintenance and capital investments. Each season, Town Highway staff strategically determines where to retrofit gravel roads and use new materials, where to address the extensive ongoing operation and maintenance needs, and which areas are less urgent and must be put off for the future. As changing climate patterns introduce more extreme storms, precipitation, and drought, the Towns recognize the need for a more comprehensive and dedicated approach to addressing gravel road problems caused by stormwater going forward.

To obtain an accurate estimate of annual budget needs for increasing gravel roads operational and capital (design, permitting, and construction) costs, an economic analysis is needed of projected gravel roads maintenance costs and costs to retrofit gravel roads with more resilient solutions. This analysis would consider existing need, projected future need, and the degradation of the roads, and how frequently new projects would be needed to address those issues. Based on this estimate, the Town could more effectively determine the appropriate funding strategy to sustain the work required.

4.3.5 Funding Sources

There are a number of grant, loan, and local funding sources that may support implementation of this work:

- General fund
- Grants such as MassWords STRAP, Clean Water Act Section 319, Clean Water Act Section 604(b), MVP Action Grants, FHA PROTECT Bipartisan Infrastructure Law, and FEMA BRIC
- Clean Water State Revolving Loans
- New stormwater enterprise fund

<u>General Fund</u>

Traditional funding sources within the Towns, such as funding from the operating and capital budgets, may be able to cover some of the costs associated with the action items detailed in the implementation plan. This has been noted as General Fund in the Potential Funding Sources column.

The Divisions responsible for the Towns' roadways and stormwater system are not enterprise funded and do not have the ability to generate revenue through user fees. Although the Town funds an annual operation and maintenance budget, it does not provide any funding for roadway or stormwater capital improvement projects. Instead, they rely entirely on funds from the state received through the Chapter 90 program for roadway and stormwater capital improvement projects. This does not support much work outside of small-scale paving projects.

The Towns currently fund Stormwater Management activities primarily through the General Fund, and by using the General Fund as a source of matching funds to leverage outside funding sources. However, because of limited municipal revenues and other community needs for investment, the general fund may not be a reliable source of money for resilient stormwater projects in the future.

Grant Programs

Grant funding can be a source of funding for resilient stormwater projects. See Appendix F for information about the grant sources listed in the implementation plan, including project eligibility, award amounts, and matching funds requirements. The identification of funding sources herein is preliminary, and actual funding availability varies depending on numerous factors. These factors include, but are not limited to, if a project is conceptual or has been studied, evaluated, or designed. In most cases, the project will require a combination of funding sources. The funding sources identified are not a guarantee that a specific project will be eligible for, or receive, funding. The local representatives responsible for implementation should explore potential funding sources in more detail.

State revolving funds and other no- or low-interest loans may also be of interest. There is a great variety of funding available for Massachusetts municipalities, both through the state and federal governments. A full list of funding opportunities can be found on the Community Grant Finder webpage: https://www.mass.gov/lists/community-grant-finder#community-development-. The Community Grant finder provides a streamlined interface where municipalities can easily learn about grant opportunities.

Stormwater Fee/Enterprise Fund

As climate change contributes to more frequent extreme precipitation events in the Northeast, repeatedly repairing damaged roads and culverts can become extremely costly for rural New England towns. Many towns are looking to new funding mechanisms to create more sustainable funding for stormwater projects. In lieu of adding funding to the DPW's current budget from the general fund, the Towns may consider establishing an enterprise fund and charging users a stormwater fee. A stormwater utility or stormwater enterprise fund can produce a dedicated stream of revenue for resilient stormwater projects.

The current general fund set-asides are insufficient for the Towns' ongoing stormwater resilience needs and will certainly require additional funding to address the new priorities for flood mitigation identified in this Resilient Stormwater Action and Implementation Plan. By relying on the General Fund, stormwater management must compete with other budgets and is often not prioritized when compared with other highly visible or acute problems, like public safety and schools. However, when conditions necessitate funding for safety and protecting natural resources, the Town must reallocate funds to stormwater management, which limits funding for other departments. Certain stormwater system improvements can be financed through other external finance mechanisms; however, none are specifically for stormwater management or guaranteed long-term funding sources. Capital funding grants are for capital improvement projects such as highway construction, preservation and improvement projects.

Facing aging drainage systems and roadways, increasing climate change, and tight municipal budgets, many communities have moved to a fee-for-service system, or enterprise fund, to pay for their stormwater needs. An enterprise fund is a fund generated through stormwater utility fees, which offers a reliable and equitable funding mechanism to meet municipal stormwater management needs compared to other funding sources. There are many communities in the northeast region that have stormwater fee systems in place, and several other communities in the area are actively working to develop stormwater funding mechanisms.

In Massachusetts, legislation allows municipalities to set up a stormwater management utility and charge user fees for managing stormwater: MGL Chapter 83 Section 16 and MGL Chapter 40 Section 1A. Massachusetts municipalities are authorized to establish an Enterprise Fund specifically under MGL Chapter 44, Section 53F½.

FUNDING	PROS	CONS
General Fund	Protocol is already in place. Guaranteed source of funding.	New cost burdens from the MS4 Permit would increase the amount of funding going towards stormwater from the general fund, which could limit funding for other departments. Not all properties are taxed.
Grants	Brings funding from outside of the Town.	Grants are only for specific types of projects and are not guaranteed.
Stormwater Fund	Guaranteed source of funding. A more equitable fee based on impact to stormwater system. Can be used to leverage grants.	Initial time and effort involved in implementation and oversight going forward.

"The concept of establishing a drainage service fee, whether administered under a new stormwater utility entity or existing department, has proven to provide a stable and equitable source of financing for stormwater programs." - MAPC Stormwater Financing Utility Kit

If the Towns are interested in considering this funding mechanism for stormwater, we recommend conducting a financing assessment of a stormwater and climate resiliency utility (enterprise fund), which will enable conversations with decision-makers and community members about a path forward.

4.3.6 What Residents Can Do

In addition to supporting the Towns as they go forward in trying to fund, design, and implement the priority projects, there are opportunities for residents to contribute to implementing climate resilient recommendations in this Plan. Private property contributes to stormwater problems – and solutions – because of how the landscape is managed.

Property owners can make changes to implement nature-based solutions on their properties. Adding rain gardens, infiltration ditches, permeable pavement, and other solutions to your property, ideally in collaboration with the Towns, will make a huge difference in being able to address the worst problem areas. Information is available through the Town and other sources for landowners that want to manage their landscapes with resilient stormwater solutions.

<u>Partner with town on swales/stormwater solutions, or dam removal if interested.</u>

There are opportunities in the towns for private landowners to implement resilient stormwater solutions, especially in locations where gravel roads drainage is constrained by abutting private property. Projects on private property were generally not included in the final implementation plan, but several solutions have been identified as potential projects involving private land. Landowners who are interested in exploring resilient stormwater projects on their property should reach out to the towns to discuss possible collaborations.

<u>Rain barrel program</u>

The Towns may wish to consider developing a municipal rain barrel program aimed at promoting water conservation and sustainable practices by Town residents and businesses.

A municipal rain barrel program involves the Town(s) distributing rain barrels to residents and providing education on their installation and usage. Funding for such a program could come from direct payments by residents for the rain barrels, and subsidized rain barrel programs can be funded through partnerships. Similar programs have been started in nearby towns, including Lee, Massachusetts.

Education would inform residents about the benefits of rain barrels and teach proper installation and maintenance techniques, possibly through workshops and informational sessions. The program's benefits would include enhanced water conservation, stormwater management, cost savings to residents, community engagement, and environmental benefits. By collecting rainwater for non-potable uses, residents can reduce their water bills, minimize stormwater runoff, and contribute to a more sustainable and resilient community.

Figure 4-1: Rain Barrel (Massachusetts Clean Water Handbook)

Rain Barrels

A rain barrel is a container designed to collect and store rainwater from the roof of a building through the gutter and downspout. The barrels have a spigot for hose attachment, and an overflow hose to direct excess rainwater away from the building. The collected water can be used for watering gardens and lawns, reduces the demand on public water supply, and helps capture stormwater runoff that can pollute waterways and cause erosion and flooding.

4.3.7 Regional Partnerships

Mitigating stormwater is not a strictly local issue. The roads and drainage systems that serve communities are often complex systems owned and operated by a wide variety of agencies, including Massachusetts Department of Transportation (MassDOT), Massachusetts Emergency Management Association (MEMA), and the Department of Conservation and Recreation (DCR). The planning, construction, operation, and maintenance of these structures are integral to the hazard mitigation and climate adaptation efforts of multiple communities.

The Towns can share and obtain vulnerability data in coordination with nearby towns and these agencies. State agencies also operate with budgetary and staffing constraints, like communities. Similarly to municipalities, they must make decisions about numerous competing priorities. In order to implement many of the mitigation measures identified by the Town, all parties will need to work together towards a mutually beneficial solution.

The Towns also have strong working relationships with the Berkshire Natural Resources Council (BNRC) and the Berkshire Regional Planning Commission (BRPC), which have supported past projects to address regional issues and solutions. Regional entities will also be key partners in implementing measures from this plan.

5.0 REFERENCES

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APPENDIX A

Existing Information Memorandum

MEMORANDUM

TO:	Town of Richmond & Town of West Stockbridge
FROM:	Joanna Nadeau, AICP, Project Manager and Weston & Sampson Project Team
DATE:	December 12, 2022
SUBJECT:	A Climate Ready Culvert Design and Comprehensive Stormwater Plan Task 3: Resilient Stormwater Action and Implementation Plan (RSAIP) for Richmond and West Stockbridge Sub-task 3.1 Deliverable: Aggregate Relevant Information

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In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Weston & Sampson with assistance from Town staff has gathered and reviewed existing information related to stormwater and flooding in current and future climate conditions. This includes:

- Hazard Mitigation Planning;
- Road-Stream Crossing Management Planning;
- Drainage system extent, condition, and operation and maintenance efforts;
- Known "Problem Areas";
- Capital Plans;
- Transportation Plans;
- Comprehensive or Master Plans;
- Economic Development Plans;
- Open Space Planning/ Acquisition Plans;
- Water Quality Data;
- Water Level Data;
- Critical roads for emergency response, evacuation, etc.;
- Agriculture/Farms/Forestry/Land Use; and
- For Richmond Pond, the Pond Management Plan.

The following presents a summary by town and by relevant topic/reference document as it pertains to field data collection (grant Subtask 3.2), Town-wide stormwater and watershed modeling (grant Subtask 3.3), development and evaluation of nature-based solutions (grant Subtask 3.4), and/or prioritization of those solutions and development of a resilient stormwater action and implementation plan (grant Subtask 3.5). Each section includes a note shown in ***bold blue italics*** that explains how the relevant information will be used in the remainder of the project work.

TOWN OF RICHMOND SOURCES

Hazard Mitigation Plan

The Town of Richmond released a Hazard Mitigation Plan (HMP)[1] in 2021, funded through MVP and prepared by Weston & Sampson. The following information about recurrent flooding areas, flood events and vulnerabilities, and priority mitigation and climate adaptation actions is pulled from the HMP.

The following highlights from the HMP about recurrent flooding areas, flood events, and vulnerabilities support Town-wide stormwater and watershed modeling (grant Subtask 3.3). This information can be used to facilitate qualitative validation of the modeling output (i.e., general comparison of conditions predicted vs. observed).

Recurrent Flooding Areas

Flooding in Richmond primarily occurs as riverine flooding along Furnace Brook, Sleepy Hollow Brook, around Richmond Pond, and Quarry Pond. Locally identified areas of flooding have also been identified along Lenox Mountain Road, West Road, Town Beach Road, Dublin Road, and Furnace Road (see Table 4-2 from the HMP, reproduced below). Areas with a 1% annual chance of flooding (and a 26% chance of flooding over the life of a 30-year mortgage), also known as FEMA Zone A, surrounds most of the water bodies and wetlands areas listed above, including Furnace Brook, Cone Brook, and the headwaters of Richmond Pond (Ford and Royes Brooks). There is no designated Zone X (or moderate flooding areas within the 0.2-percent-annual-chance (or 500-year) flood) in Richmond.

There are no repetitive loss properties in Richmond. As defined by FEMA and the NFIP, a repetitive loss property is any insured property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978.

In Richmond, several culverts are undersized and structurally deficient, and the Town has undertaken a road/stream crossing assessment to identify priorities for repair and replacement with assistance from the Housatonic Valley Association. Find more on the **Road-Stream Crossing Management Plan** in the next section.

The areas listed below have been noted to flood during a significant rain event (Table 4-2 from the HMP). This is often due to topography and/or insufficient drainage.

[1] Town of Richmond Hazard Mitigation Plan, 2021
https://cms6.revize.com/revize/richmondma/Richmond%20HMP-MVP.pdf

Table 4-2. Locally Identified Areas of Flooding

Location	Description
Lenox Mountain Road at Cone Brook	In flood zone
West Road at Furnace Brook	In flood zone
Town Beach Road at Richmond Pond	In flood zone
Dublin Road at Fairfield Brook	In flood zone
Location	Description
Sleepy Hollow Brook	Partially in flood zone
Rossiter Rd, right off of Rt 41	Partially in flood zone

Flood Events

Between 2000 and 2020, the Town of Richmond had four floods and flash flood events that are identified below in Table 4-3 from the HMP. Although the event in March 2008 caused $4,000 in property damages, there were no deaths or injuries reported at any of these events.

Table 4-3: Richmond Flooding Events 2000-2020

Event Date	Type of Flooding	Description
3/8/2008	Flood	The combination of heavy rainfall (one to three inches), frozen ground, and snowmelt led to flooding and closure of several secondary roads in Richmond.
7/27/2009	Flash Flood	A warm, humid and unstable airmass was in place as a weakening cold front moved across the area. In addition, a strong upper-level disturbance moved over the region, triggering widespread thunderstorms. Numerous roads were closed due to flash flooding.
7/31/2009	Flash Flood	Slow moving thunderstorms, some producing very heavy downpours, moved across Berkshire County. Generally, 1 1/4 to 1 1/2 inches of rain was reported across the northeast portion of Berkshire County. This, coupled with previous heavy rainfall, created waterlogged ground and exacerbated high river and stream levels. A washout was reported on West Road in Richmond.
6/3/2014	Flash Flood	Slow moving showers and thunderstorms developed with some producing very heavy rain in a short period of time. In addition, strong wind gusts were experienced in some locations, causing damage to trees and power lines. Lenox Road in Richmond was reportedly closed due to flash flooding from heavy rainfall and drainage issues.

(NOAA, 2020b, data downloaded 12/2020)

Flood Vulnerabilities

People, property, and infrastructure including critical facilities located near waterbodies and floodzones, or in areas that are prone to flooding, can be vulnerable. People may be injured and infrastructure damaged from high volumes of water and debris caught in the flow. A flood exposure analysis was conducted for critical facilities and vulnerable populations throughout the municipality utilizing MassGIS data, FEMA flood maps, and information gathered from the municipality. Table 4-5 below displays critical facilities in Richmond that are located within the 100-year FEMA flood zone.

Table 4-5. Critical Facilities Located within the FEMA Flood Zone

Facility	Address	100-Year Flood Zone
Richmond Free Public Library	2821 State Road	X
Richmond Pond Dam	N/A	X
Richmond Iron Works Dam	N/A	X
Sherrill Pond Dam	N/A	X
Strong Pond Dam	N/A	X

The following excerpt from the HMP supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Dams will need to be inventoried and measured in the field for input into the model.

According to the Massachusetts Department of Conservation and Recreation's (DCR) Office of Dam Safety, there are five non-jurisdictional dams in Richmond. Dam failure is classified as a very low frequency event in the Town.

Mitigation Actions

The following excerpts from the HMP support development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of a plan (grant Subtask 3.5). Mitigation actions already identified and prioritized should be incorporated into the RSAIP where appropriate.

The HMP notes that the Town has recently made some repairs to the stormwater system on Stevens Glen and West Roads, improved drainage, and made several other updates to reduce the impact of flood events. The HMP specifically provides a status report on the mitigation measures outlined in the previous 2012 Plan. The following items relevant to stormwater/flooding were completed or noted as incomplete:

- Completed: Replace culverts along Steven's Glen Road, Dean Hill Road, and West Roads with larger culverts to reduce risk of flooding.
- Completed: Work with Con Comm to establish procedures for streamlined and expedited permitting for stormwater control features
- Completed: Get easements for undeveloped areas which have or need stormwater swales
- Completed: Educate the public on the benefits of stormwater systems and responsibilities of owners to keep system clear
- Incomplete: Create and implement a stormwater control bylaw to reduce flooding potential due to new development and work with Planning Board to be more involved in building process and implementation of stormwater systems; amend to assess whether a new bylaw is needed or if the existing wetland bylaw should be improved and add to list of priorities.

The HMP identifies priority hazard mitigation and climate adaptation actions for the future to address stormwater/flooding problems in Richmond.

The HMP outlines the following hazard mitigation actions to improve ongoing activities specifically related to water supply protection and stormwater management:

- Continue participation in the National Flood Insurance Program, administered by FEMA enabling property owners to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages. Increase outreach to property owners within the floodplain.
- Once the new FEMA FIRMs are finished, update regulations referencing the old map as needed and identify/prioritize mitigation projects. Consider requiring regulatory controls to account for climate change.
- Improve drainage for gravel roads and/or upgrade gravel roads to paved. The Department of Public Works is responsible for maintaining paved and gravel roads. Gravel roads are regularly maintained to prevent washouts from flooding, and the Town spends significant resources to maintain and clear the roads.
- Upcoming map and inventory culverts and outfalls from stream crossing assessment will identify priority repair and replacement projects. Continue to repair and replace stormwater system elements using climate projections and green infrastructure where possible.
- Mitigate erosion in known problem area near Richmond Pond.
- Pursue waiver for small MS4 area adjacent to Richmond Pond through NPDES Phase II Stormwater Program.
- Land acquisitions for water supply protection: continue to purchase land and preserve natural resources.
- Water conservation: add water conservation incentives to encourage residents to follow guidelines.

The HMP also identifies priority hazard mitigation and climate adaptation actions for the future. The following items relevant to stormwater/flooding were outlined:

- Design and construct culvert rehabilitations and replacements to Dublin Road and Sleepy Hollow Road, anticipating future expected storm events, and other priority projects based on VA Road Stream Crossing Management Plans (a culvert and bridge assessment) – *1-3 years*
- Enforce zoning requirements for building permits to ensure Conservation Commission and Planning Board involved in permitting process for stormwater/floodplain management (Continued from 2012 HMP) – *1-3 years*
- Develop a stormwater management plan (i.e. a list of opportunities for nature-based flood storage and stormwater infiltration using a model that incorporates future climate conditions) – *1-3 years*
- Work with the City of Pittsfield, the Richmond Pond Dam owner, and Richmond Pond Association to improve the condition of the Richmond Pond dam through a coordinated update of the pond and dam management plans (Continued from 2012 HMP) – *3-5 years*
- Update the FEMA FIRMs and evaluate vulnerability and risks within new flood hazard areas to develop additional flood mitigation projects, with specific attention to critical facilities. – *1-3 years*
- Review Floodplain Overlay District and other bylaws to ensure compliance with the NFIP policies. – *1-3 years*

- Evaluate and update current Wetlands Bylaw for climate resilience and reducing flooding risk, especially in comparison to MACC's recommendations (e.g. riparian buffers/riverfront resource areas, erosion protections, green infrastructure, and/or resilient design specifications for re/development) – *1-3 years*

Road-Stream Crossing Management Plan

The Town of Richmond Road-Stream Crossing Management Plan (RSCMP), produced by the Housatonic Valley Association, was released in 2022. The Town of Richmond has 40 miles of streams and rivers, and 68 miles of roads and other transportation corridors such as driveways and railroads. More than half of the roads in town are gravel roads. At every intersection between these two linear networks, there is a bridge, culvert, or some other mechanism for carrying the road over the stream. Collectively, these structures are referred to as "road-stream crossings." The RSCMP investigation evaluated 76 road-stream crossings in the Town of Richmond alone.

The RSCMP is intended to help communities identify the highest priority replacement projects based on conservation value, flood risk, and maintenance need.

The RSCMP report inventory and modeling supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Road-Stream crossings not previously inventoried may need to be inventoried and measured in the field for input into the model. The information about flood risk can be used to facilitate qualitative validation of the modeling output (i.e., general comparison of conditions predicted vs. observed). In addition, these results will be included in prioritization of solutions and development of the RSAIP (grant Subtask 3.5).

This report identifies high-priority road-stream crossings for flood risks, conservation, condition, and based on town feedback.[2] This information in combination with HVA's field data informed the prioritization of culverts based on probability of flooding.

Tables reproduced below show the highest priority results of the effort for the Town of Richmond.

Top 9 Crossings for Flood Risk

This chart is a summary of town-managed road-stream crossings with the shortest flood intervals (i.e. most likely to flood the road) based on modeling performed by the University of Connecticut. Note: Only closed-bottomed structures (e.g., culverts) were modeled for risk of failure.

Photo	Flood Interval	Structure #	Road	Map Key	Crossing Code
A	2	29	Dean Hill Road	4A	xy4235702073396000
B	2	52	East Road	4D	xy4237246073341940
C	2	38	Rossiter Road	4B	xy4237922473387778
D	10	10	Swamp Road	2E	xy4240864073314750
E	25	35 pages 264 - 265	Meadowview Lane (private)	4B	xy4237429773368575
F	25	14	Sleepy Hollow Road	3C	xy4238821173359291
G	25	27	Swamp Road	3D	xy4240438573321758
H	25	9	Cemetery Road	2E	xy4240811973314679
I	50	22	Osceola Road	3D	xy4238850873324584

[2] Shen, X., & Anagnostou, E. N. (2017). A framework to improve hyper-resolution hydrological simulation in snow-affected regions. Journal of Hydrology, 552, 1–12.

The report also provides an overall ranking based on related to barrier status, flood risk, condition, conservation value, and town priority.

Top 9 Crossings for Flood Risk with Town Response
(provided during Prioritization Workshop 11/10/2021)
Meeting Notes available in Appendix C

Photo	Structure #	Road	Town Information
A	29	Dean Hill Road	Town has not experienced any issues ever with this crossing. Not a candidate for replacement
B	52	East Road	Town does not consider this a true crossing, but says it is more like a drainage ditch. Crossing has not been known to ever overtop. Only issue has been ice on the roadside. Some maintenance is needed, some pooling occurs. Culvert works as long as the road is reshaped. It will need to be replaced at some time, because it is a corrugated metal pipe.
C	38	Rossiter Road	If this road-stream crossing failed, only one house would be impacted – long driveway up into the woods. Since this culvert was assessed, an extension has been added. The downstream channel has silted in. The downstream water level is an issue, not the size of the pipe. On the replacement timeline, it would likely be slated for the 7 – 10 year plan.
D	10	Swamp Road	Highest traffic road in the town. Functions fine, provided the vegetation is kept trimmed and the swale maintained. No plans to work on this in the next five years.
E	35 pages 264 - 265	Meadowview Lane	Meadowview Lane is a private road. Main issue at this crossing is due to beaver activity. Lower priority. There is a new property owner.
F	14	Sleepy Hollow Road	Town moved this crossing up to the top priority. In 2021, HVA completed the field survey work and a preliminary design has been prepared and included in this document
G	27	Swamp Road	This crossing only sees a small amount of water and does not present any concern to the town. It does not carry Ford Brook, but an unnamed tributary.
H	9	Cemetery Road	This was originally a 6 foot, open bottom arch culvert (note made in the database) which met stream crossing standards. Designed by Foresight Land Services and installed sometime after 2010. Since then it has silted in and requires maintenance. Does not ever overtop the road. Low traffic flow on Cemetery Road, a gravel road gravel.
I	22	Osceola Road	Town does not have concerns with this crossing. It is a metal corrugated pipe which at some time will fail and it should be replaced – maybe could be included in 5 year plan. Only 5 houses past this crossing. If it washes out there is another road that loops around that provides access.

Town Prioritization Workshop Results

November 10, 2021

The following road-stream crossings were specifically highlighted as town priorities in 2020. These priorities were reviewed with town officials again in November 2021. In determining priorities, the Town of Richmond considered the following questions.

Guiding Questions:

- Which structures regularly flood the road?
- Has water over the road or other crossing failure blocked access for Town residents to essential services, such as Fire/EMS?
- Which structures require regular sediment, debris and/or ice removal?

Meeting minutes can be found in Appendix C.

Photo	Structure #	Map Key	Road	Crossing Code	Town Notes
A	14	3C	Sleepy Hollow Road	xy4238821173359291	Beaver Issues, This one overflowed the road on Christmas Day 2020. In 2021, HVA surveyed this structure and a preliminary culvert replacement design is complete
B	19	3C	Summit Road	xy4239565073364284	It is also in the Top 10 for safety. It has overtopped the road at least 2 x in the past 3 years and 2 x in July 2021. It was sliplined and in the process reduced from 4 foot pipe to a 2 foot pipe.Flash floods result in debris-clogged inlet Part of the road was lost in 2019. Problem is, there is no fish - it tends to run underground until a significant rain occurs - Highly travelled road (cut through). Top 5% in MA Climate Action Tool
C	34	4B	West Road	xy4236798373380589	Lost both this and xy4236579573379619 2 x in one week in 2014 resulting in loss of access to several houses. Summer 2021, overtopped (road remained passable) 2x and headwall washed out both times. When debris clogs inlet, it exacerbates the issue.Furnace Brook a major stream in town.
D	33	4B	West Road	xy4236579573379619	Lost both this and xy4236798373380589 2 x in one week in 2014 resulting in loss of access to several houses
E	5	2C	Dublin Road	xy4241946873350313	Degrading pipes. Town applied for, but did not receive MA DER funding (2018). Did not overtop in 2021, despite heavy rains. On the Town's 5-yr replacement plan.
F	48	4C	Lenox Road	xy4237381373358467	Would like to replace within 5 years. Beaver issues, but none recently. Overtopped the road following an ice blockage, but flow restored once ice removed.
G	50	4D	Lenox Road	xy4235998673337146	Someone may have created a pond upstream - or there is a sediment dam/or dam. The majority of Lenox Mountain Brook flows through this structure, it blew out in 2012 or 2014 with a hurricane, but otherwise no issues. Issue could arise if the Lenox Reservoir dam breached

Drainage System Extent, Condition, and Operation and Maintenance Efforts

The following narrative of information collected from Town staff supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Critical drainage system components will need to be located and inventoried in the field for input into the model.

A major focus of this project is investigating the existing drainage systems for the Towns' roadways, which include conveyances designed for collecting or transporting stormwater (runoff from precipitation and snow melt). Drainage systems include catch basins/drop inlets, manholes, pipes, and outfalls as well as gutters, ditches, and man-made channels, as well as pipes that act as a culvert crossing a roadway where there is no stream (called "cross culverts").

According to information from Town staff, the Town of Richmond has very limited traditional drainage systems except on Deer Hill Road and East Slope Road, which are subdivisions. There are, however, numerous cross culverts with inlets / catch basins throughout the municipality. Condition of these elements is largely unknown. Town staff spend a large portion of the year maintaining gravel roads and ditches/ man-made channels and the cross culverts to minimize flooding on private property.

Known "Problem Areas"

Town staff have shared a list and marked up maps showing areas with various problems related to flooding (i.e. "known problem areas") including:

- Steep gravel roads
- Ponding/low slope/ineffective surface drainage
- Undersized stream-roadway crossings / bridges
- Stormwater systems
- Beavers

Field data collection (grant Subtask 3.2) of these areas will be completed. These areas are further documented in the memorandum associated with Subtask 3.2

Findings about problem areas will aid in the Town-wide stormwater and watershed modeling (grant Subtask 3.3), development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of the RSAIP (grant Subtask 3.5).

Capital Plans

The Town of Richmond does not have a formal capital plan. *The implementation plan prepared under this grant (grant Subtask 3.5) will provide a stormwater action plan. The Town could build on this plan by incorporating facilities and other infrastructure plans and associated schedule and cost to expand the list into a formal capital plan.*

Critical Roads for Emergency Response and Evacuation

Critical roads will be considered as priorities as part of development and evaluation of nature-based solutions (grant Subtask 3.4), prioritization of those solutions, and development of a plan (grant Subtask 3.5).

The Hazard Mitigation Plan for the Town of Richmond provides the following information on transportation infrastructure. Richmond is located between I-90, US Route 20, and NY State Route 22. In addition to these highways, services to the Richmond area could be disrupted if critical local roadways and bridges are flooded.

The 2019 Richmond Comprehensive Emergency Management Plan provides further details on the critical roadway infrastructure. Richmond contains several primary and secondary roadways. These include MA Route 41, running North/South, Route 29S, running west from MA Route 41 accessing Columbia County NY, and Swamp Rd running North/South. An Amtrak rail and a freight rail line also run through town. Berkshire Regional Transit Authority is the nearest public transit service with a bus line in Lenox.

Transportation Plans

The Town of Richmond is served by the greater Berkshire Regional Planning Commission (BRPC). The BRCP released the long-range Regional Transportation Plan in 2020[3]. A Transportation Needs survey was distributed to residents across all the municipalities within the region and had over 700 respondents. Key local priorities in the survey include the following:

- Expand public transportation (BRTA) routes and hours of operation
- Improve pedestrian infrastructure and condition of local roadways
- Increase the number of alternative and affordable transportation options
- Expand regional connectivity
- Improve North/South access within Berkshire County

The Town of Richmond has 53.60 miles of road; 7.87 miles are managed by MassDOT, 38.92 miles are local, and 6.81 miles are under unknown jurisdiction.

Of the approximately 787 total workers in Richmond, 86% commute by truck, car, or van. 0% of workers reported commuting using public transportation, less than 1% commuted on bicycle, and less than 2% commuted by walking. Because roads are critical infrastructure for community access and economic activity, this plan confirms the importance of improving condition of local roadways (as stated in HMP and other plans).

The RTP confirms the need to address roadway issues, but transportation planning detail in the RTP is unlikely to add value in development and evaluation of nature-based solutions (grant Subtask 3.4),

[3] https://berkshireplanning.org/wp-content/uploads/2020/08/2020_BERKSHIRE_RTP_-_FINAL.pdf

prioritization of those solutions and/or development of the RSAIP (grant Subtask 3.5) and will not be explored in further detail.

Comprehensive or Master Plans

Richmond's zoning bylaw guides preservation and management of land use, but the Town does not have a recent Comprehensive or Master Plan. *The current zoning bylaws are unlikely to aid in development and evaluation of nature-based solutions or development of the RSAIP and will not be explored in further detail. However, land use controls are a non-structural control to manage long-term flooding and are considered in identification and development of solutions (grant Subtask 3.4).*

Economic Development Plans

The following narrative describing economic development plans supports prioritization of solutions and development of the RSAIP (grant Subtask 3.5). Funds invested by the municipality in infrastructure projects may inform funding priorities and grant opportunities for stormwater projects.

The Town of Richmond published a Community Development Plan (CDP) in 2003 in coordination with the Berkshire Regional Planning Commission. The Community Development Plan addresses how the community will accomplish its development objectives for four areas: housing, economic and community development, transportation, and open space. [4] Environmental goals outlined in the CDP that relate to the Resilient Stormwater Action and Implementation Plan included "to implement recommendations to address sources of stormwater and erosion around the lake."

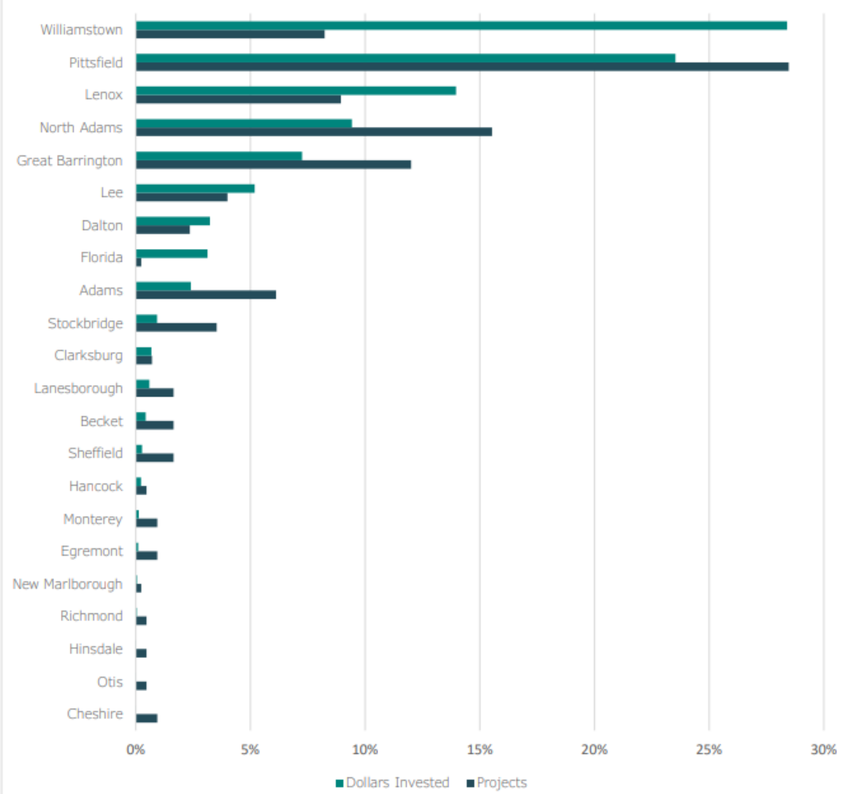
In 2021, BRPC released the Annual Comprehensive Economic Development Strategy (CEDS) plan. The Comprehensive Economic Development Strategy (CEDS) planning process is an ongoing regional economic development effort focused on identifying regional economic goals and priorities, identifying strategies for and facilitating implementation, and measuring progress in the region. Of the 22 municipalities in the region, Richmond has one of the lowest values for "Projects and Dollars Invested by Municipality" based on the regional investment database (2006 – 2021) (See figure). Despite Richmond's attempts to identify available funding sources through the Commonwealth, the Town is rarely eligible for economic development funding sources, which tend to be more geared towards urban areas. It is important to note that this database is not fully comprehensive or exhaustive, and it does not include investments under $100,000; however it is the most complete database that exists for the county at this time.

[4] https://www.01254.org/wp-content/uploads/2021/03/2003-Community-Development-Plan.pdf

Geographic Distribution

Projects and investment dollars tended to be concentrated in the most populated municipalities (Pittsfield, North Adams, Adams, and Williamstown) and those municipalities with strong hospitality sectors (Lenox, Great Barrington, Stockbridge). It should be noted that several extremely large dollar amount projects account for much of the dollars invested in some municipalities such as the $90,000,000 Hoosac Wind Power Project in Florida and the nearly $500,000,000 invested by Williams College in Williamstown. *See Figure 17.*

Figure 17. Projects and Dollars Invested by Municipality



Open Space Planning/ Acquisition Plans

The following narrative of Open Space goals and plans supports development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of the RSAIP (grant Subtask 3.5). The outlined efforts, priorities and goals in this plan will directly inform those outlined by this project.

The Town of Richmond released their Open Space and Recreation Plan (OSRP)[5] in 2022, based on information compiled between 2016 and 2022. The OSRP was prepared by BRPC and the Richmond Open Space Advisory Committee. By completing and adopting this plan, the Town of Richmond is eligible to compete in two state grant programs: the LAND (Local Acquisitions for Natural Diversity) and PARC (Parkland Acquisitions and Renovations for Communities) grant program. These two grant programs could help with the implementation of many of the recommended items found in the 7-year action plan (2016 to 2022). The Town has several related goals to stormwater management, including

[5] https://cms6.revize.com/revize/richmondma/Bylaws%20&%20Regulations/Richmond_OSRP_-_11-9.pdf

a goal to protect an additional 1,000 acres of unprotected land (roughly doubling the protected land in the town). The other relevant goals are listed below in orange with associated actions following each one.

Protect an additional 1000 acres of unprotected land (roughly doubling protected land in the town)	Suggested Leadership	Anticipated Funding	2016	2017	2018	2019	2020	2021	2022
Continue to enforce regulations to protect the town's sensitive ecosystems and wildlife habitats.	Con. Com.								
Continue to collaborate with local land trusts, landowners, and surrounding towns on potential land acquisition and other projects related to conservation or recreation.	RLT, BNRC, Town Admin., Select Board,								
Prioritize conservation and recreation projects related to endangered species habitats and state listed priority conservation areas as well as agricultural lands and early successional forests.	Select Board, Con. Com.								
Contact landowners with unprotected land containing priority conservation areas, priority natural communities or core habitat with a letter outlining the significance of their property.	Con. Com., Assessor								
Hold a public forum or open house to educate residents about available land conservation programs and incentives.	Con. Com., RLT, BNRC								
Hold a public forum or open house to educate residents (particularly Chapter 61 landowners) about integrating ecological goals into their forest management plans.	Con. Com.								

Permanently protect all town owned recreation lands from future development	Suggested Leadership	2016	2017	2018	2019	2020	2021	2022
Permanently protect existing recreation areas such as the town beach, Tennis Courts, and Richmond Consolidated School playground under Mass. General Law Chapter 45.	Select Board							
Ensure future town owned recreation areas are protected through conservation restrictions or MGL Chapter 45.	Select Board							

Maintain drinking water quality and work to reduce non-point source pollution	Suggested Leadership	Anticipated Funding	Anticipated Schedule (2016-2022)
Continue to enforce regulations to protect Richmond's drinking water resources as well as those of surrounding towns.	BOH, Con. Com.		Ongoing
Work with and educate upland landowners and farmers to adopt best management practices (i.e. vegetative buffers) to reduce non-point source pollutants.	Con. Com.		2018-2019
Continue to use alternative de-icing chemicals and methods.	DPW		Ongoing
Continue to notify residents about local hazardous waste collection events and locations.	Town Administrator		Ongoing
Provide the text of the wetland bylaw on the town website.	Town Administrator, Con. Com		2016-2017
Review the wetland bylaw for potential updates and work to implement changes if identified.	Con. Com.		Ongoing
Collaborate with surrounding towns on water resource related projects and issues.	Con. Com, Select Board		Ongoing

Protect and manage Richmond Pond as an important recreation and natural resource	Suggested Leadership	Anticipated Funding	Anticipated Schedule (2016-2022)
Continue to fund studies and regular testing related to the ecology, water quality, and management of Richmond pond.	Con. Com, Select Board, RPA		Ongoing
Continue to implement the aquatic vegetation management plan to address Eurasian Milfoil and other invasive species on Richmond Pond.	Con. Con., Select Board, Town Admin.		Ongoing
Continue to fund the boat ramp monitor program on Richmond Pond.	Select Board		Ongoing
Continue the yearly drawdown of Richmond Pond as a tool to manage invasive species and assist with downstream flood control.	Con. Com.		Ongoing
Work with the City of Pittsfield and the Commonwealth of Massachusetts to secure funding, technical assistance, or other resources to help manage the Richmond Pond Dam.	Select Board, RPA, Town Admin.		2018-2019

Another primary goal identified in the plan is **to protect the town's water resources and the ongoing management of Richmond Pond.** The Richmond Pond Association was formed to help coordinate the management of the pond because it is located within two municipalities. One of the reasons for forming this group was to discuss land acquisitions, such as that for the Camp Marion White property. The Pond Association has also taken the lead in examining and studying Richmond Pond to promote better management. Recently the RPA funded a bathymetry study for the pond and is working to update a management plan for the water body.

Water Quality Data

Surface Water

The Final Massachusetts Integrated List of Waters for the Clean Water Act 2018/2020 Reporting Cycle[6] indicates the following waterbody has water quality concerns:

- Richmond Pond (MA21088), which covers 228 acres, has impairments caused by Brittle Naiad (Najas Minor), Curly-leaf Pondweed, and Eurasian Water Milfoil (Myriophyllum Spicatum).

The Richmond Open Space and Recreation Plan notes that these invasive species can crowd out native aquatic plant species and create a nuisance for boaters and anglers. It also notes that Richmond Pond does not have Zebra Mussels (Dreissena polymorpha), which have negatively impacted other local water bodies. The Town funds a boat ramp monitor program to help keep Zebra Mussels and other invasive species out of the pond.

These above-described water quality concerns need to be considered during development and evaluation of nature-based solutions (grant Task 3.4) such that solutions located in the watershed of this waterbody work to reduce nutrients, mostly phosphorus, which are partially a contributor to the presence of these species.

The following waterbodies attain some of the designated uses (e.g., habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation) but not all of them. Generally, these waterbodies likely have limited water quality concerns. The following waterbodies meet fish and other aquatic life and wildlife uses, but have not been assessed for aesthetics, fish consumption, primary or secondary contact recreation, or shellfish harvesting.

- Cone Brook (MA21-76), the 4.6 miles from the headwaters (confluence of Sleepy Hollow and Fairfield brooks, Richmond) to mouth at inlet Shaker Mill Pond, West Stockbridge.
- Furnace Brook (MA21-21), the 3.7 miles from the headwaters (perennial portion, south of Route 295 (Canaan Road), Richmond) to mouth at inlet Mud Ponds, West Stockbridge.
- Lenox Mountain Brook (MA21-47), the 2.1 miles from the outlet of the Lenox Reservoir, Lenox to mouth at confluence with Cone Brook, Richmond.
- Mount Lebanon Brook (MA21-70), the 3 miles from the headwaters (north of Lebanon Mountain Road (Route 20), Hancock) to mouth at inlet Richmond Pond, Richmond
- Scace Brook (MA21-71), the 1.5 miles from the headwaters (perennial portion, north of East Slope Road, Richmond) to mouth at confluence with Mount Lebanon Brook, Hancock.

At a minimum, nature-based solutions identified and evaluated (grant Subtask 3.4) need to protect or improve fish and other aquatic life and wildlife uses such that these waterbodies continue to attain the designated use.

[6] https://www.mass.gov/doc/final-massachusetts-integrated-list-of-waters-for-the-clean-water-act-20182020-reporting-cycle/download

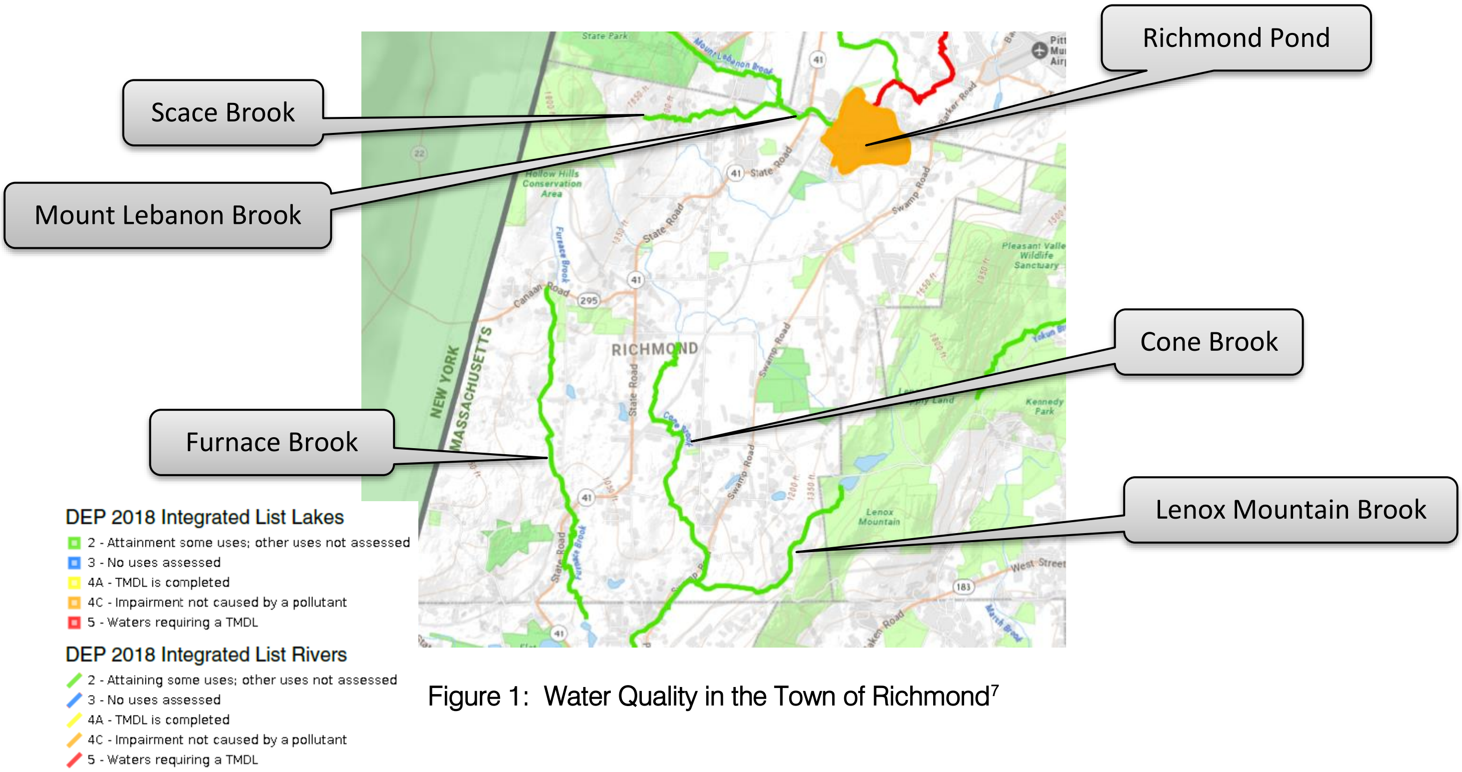


Figure 1: Water Quality in the Town of Richmond[7]

As described on the Department of Public Health (DPH) website, "the Environmental Toxicology Program tests for waterborne health hazards at ocean and freshwater beaches across Massachusetts. To minimize illness and injury associated with swimming, and to notify the public about the quality of beach water, the DPH collects beach water quality data from local health departments and the Massachusetts Department of Conservation and Recreation (DCR). All public and semi-public bathing beaches in Massachusetts are monitored for fecal indicator bacteria, and on occasion, harmful algae. Monitoring occurs during the beach season, which begins when the school year finishes in mid-June and ends during the weekend of Labor Day."[8]

The following three public beaches are sampled in the Town of Richmond:

- Camp Russell
- Richmond Pond Association
- Richmond Town Beach

Monitoring results are available on the DPH website.

During development and evaluation of nature-based solutions (grant subtask 3.4), solutions located in the watershed of each of the waterbodies on which these beaches are located need to reflect bacteria and pathogen reduction approaches.

[7] Map created using MassMapper and Final Integrated List of Waters Information as of December 2022 https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html
[8] https://www.mass.gov/lists/water-quality-at-massachusetts-swimming-beaches#2021-

Groundwater

There are no drinking water supply wells owned or operated by the Town of Richmond. However, there is one public water supply (View Drive Water Association) and are ten non-community groundwater wells in Richmond. The Richmond Open Space and Recreation Plan list these sources (see Table 4.1 from that plan, reproduced on the right).

Table 4.1 - Public Drinking Water Wells in Richmond, MA		
Source: Mass GIS Public Water Supplies 2014		
Source_ID	Site Name	Type
1249008-01G	WELL 1	GW
1249012-01G	CAMP RUSSELL	TNC
1249010-01G	BRANCH FARM CONDO ASSN	TNC
1249005-01G	CAMP MARION WHITE	TNC
1249004-02G	RICHMOND CONSOLIDATED SCHOOL	NTNC
1249006-01G	PEIRSON PLACE	TNC
1249009-01G	SOMA CATERING	TNC
1249000-01G	RICHMOND TOWN HALL	TNC
1249012-02G	CAMP RUSSELL	TNC
1249011-01G	BARTLETTS ORCHARD LLC	TNC
1249013-01G	HILLTOP ORCHARD AND FURNACE BROOK WINERY	TNC

GW = Community Groundwater Well, serves multiple homeowners (quasi-public)
TNC = Transient Non-Community Well, serve fewer than 25 people daily, such as at a camp or restaurant
NTNC = Non-Transient Non-community Well, regularly serves more than 25 people daily for more than 6 months of the year
Note: Public well data is from 2014. Some business names may have changed.

All of these sources have Wellhead Protection Areas in the form of a Zone I (the protective radius required around a public water supply well or wellfield which is depending on the type of well and approved yield and is no less than a radius of 100 feet) and either an Approved Wellhead Protection Area (Zone II[9]) or an Interim Wellhead Protection Area[10].

Note that a figure has not been included to protect the information related to drinking water well supply.

Locations of the Wellhead Protection Areas for these drinking water supplies will be considered during identification and development of solutions (grant Subtask 3.4) as, per the Massachusetts Stormwater Handbook and Stormwater Standards[11], " Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply…require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply."

Water Level Data

Water level data is necessary for H&H modeling (grant Subtask 3.3).

USGS Gages[12] are available to support water level data for modeling. The gage(s) that will be utilized for modeling will be further discussed in the deliverable for that work. No other local water level data was identified.

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[9] As stated in 310 CMR 22.02, a Zone II is: "That area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at safe yield, with no recharge from precipitation). It is bounded by the groundwater divides which result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone IIs shall extend up gradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock , or a recharge boundary)."
[10] In the absence of an approved Zone II, DEP has adopted the Interim Wellhead Protection Area (IWPA) as the primary, protected recharge area for PWS groundwater sources.
[11] https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards
[12] https://waterwatch.usgs.gov/?m=real&r=ma

Agriculture/Farms/Forestry/Land Use

As documented in the Town's Open Space and Recreation Plan, as of 1999, 21.74% of the total land in Richmond was dedicated to agriculture. The following table shows the shift in land use away from farms and agriculture (4% loss) toward residential properties (23% increase) from 1971 through 1999.

Table 3.5 - Land Use Change in Richmond 1971-1999

Source: Mass. GIS Land Use 1951-1999

	1971 (acres)	**1971** (% of Total Land)	**1985** (acres)	**1985** (% of Total Land)	**1999** (acres)	**1999** (% of Total Land)	**% Change in acreage 1971-1999**
Agriculture	2752.59	22.60%	2647.75	21.74%	2647.75	21.74%	-3.96%
Commercial	4.63	0.04%	4.63	0.04%	4.63	0.04%	-0.01%
Forest	7856.61	64.51%	7753.37	63.66%	7753.37	63.66%	-1.33%
Industrial	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00%
Institutional	4.08	0.03%	7.50	0.06%	7.50	0.06%	45.55%
Mining / Waste Disposal	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00%
Recreation	20.54	0.17%	20.54	0.17%	20.54	0.17%	0.00%
Residential	712.76	5.85%	929.68	7.63%	929.68	7.63%	23.33%
Transportation*	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00%
Vacant**	241.67	1.98%	229.42	1.88%	229.42	1.88%	-5.34%
Water	178.20	1.46%	178.20	1.46%	178.20	1.46%	0.00%
Wetland	408.40	3.35%	408.40	3.35%	408.40	3.35%	0.00%
Total	12179.49	100%	12179.49	100%	12179.49	100%	

*Transportation category includes large divided highways or areas like airports and docks. Smaller roadways have not been calculated.

**Vacant land category includes abandoned agriculture, areas like power lines, or areas of no vegetation.

De- and re-forestation have potential to affect runoff rates and volumes entering the stream system and/or developed areas, thereby impacting culverts and roadways. As of 1999, 63.66% of the total land is Richmond was forest land. However, between 1971 and 1999 there was a -1.33% change in acreage. Forest harvesting activity in the area occurs at the rate of approximately one property a year, according to the Department of Conservation and Recreation's Regional Forester.

At this rate, changes in land use are not significant enough to affect modeling parameters (grant Subtask 3.3). In addition, based on discussions with Town staff, runoff from agriculture, farms, and/or forestry practices do not appear to cause an impact to flooding in the community.

Richmond Pond BMP Plan/Guidance Document

The Town of Richmond and the Richmond Pond Association (RPA) released the Richmond Pond Management Plan (Plan) in 2016. The plan provides background information on the lake and its watershed, a brief description of "stakeholder" organizations, a brief review of past and current lake preservation initiatives, a discussion of current and future issues and concerns, a statement of goals for dealing with the issues, and a set of recommendations for management actions to ameliorate the identified issues.

The following issues are identified in the plan and require constant monitoring and action:

- Macrophytes;
- Water quality;
- Failing septic systems;
- Lake recreation safety;
- Zebra mussels;
- Drawdown; and
- Richmond Pond Dam.

The following goals for Richmond Pond were identified in the Pond Management Plan:

1. Protect and manage the pond using the best means available
2. Explore options for responsible management through cooperation with other interested entities
3. Identify gaps between current procedures and desired outcomes
4. Help ensure that sufficient funding is available, and seek supplementary funding through grant proposals
5. Enhance the collaboration between RPA, Town of Richmond and City of Pittsfield
6. Maximize use of available resources, including RPA website as an educational resource
7. Maximize public input into the development of this and other plans with communication and invitations to RPA meetings

The Plan notes "The RPA has also been working to identify and mitigate impact from storm water runoff that causes erosion, sedimentation and lake pollution. In 2002, the Town of Richmond was awarded a matching grant under Section 319 of the Clean Water Act of 1987, in the form of federal funds administered in Massachusetts by the Department of Environmental Protection and awarded to towns to control non-point sources of water pollution. The RPA worked in cooperation with the Town of Richmond for the 60/40 match, providing volunteer manpower to do much of the necessary work planting trees, bushes, monitoring the installation of drop inlets (catch basins), providing rip-rap to storm water erosion channels, monitoring the construction of detention basins, and working with engineers who designed the structures."

The Plan identifies the following recommendations (2016 through 2021) and are intended to serve as a guide for the RPA's annual action plans on the short term.

During development and evaluation of nature-based solutions (grant Subtask 3.4), past work related to stormwater management as well as methods to improve water quality of the pond will be considered. Drawdown may be considered in both developing nature-based solutions and/or in modeling (grant Subtask 3.3). RPA's goals for the Pond will be considered in development of the RSAIP (grant Subtask 3.5).

TOWN OF WEST STOCKBRIDGE SOURCES

Hazard Mitigation Plan

The following highlights from the HMP about recurrent flooding areas, flood events, and vulnerabilities support Town-wide stormwater and watershed modeling (grant Subtask 3.3). This information can be used to facilitate qualitative validation of the modeling output (i.e., general comparison of conditions predicted vs. observed).

Dams not previously inventoried may need to be inventoried and measured in the field for input into the model.

Flood Events

The Town of West Stockbridge completed a Hazard Mitigation Plan, funded by the Federal Emergency Management Agency (FEMA). The plan was adopted by the town in January 2022. As defined by FEMA, hazard mitigation is "any sustained action taken to reduce or eliminate the long-term risk to life and property from hazards."

West Stockbridge is covered by approximately 1,050 acres of floodplain, equating to about 8.8% of the town's total land area. The current 100-year flood zone surrounds most of the water bodies in West Stockbridge. The waterbody covering the greatest area in town is the Williams River, fed by Shaker Mill Pond and upland water bodies. The 500-year flood zone surrounds these waterbodies.

People, property, and infrastructure including critical facilities located near waterbodies and floodzones, or in areas that are prone to flooding, can be vulnerable. People may be injured and infrastructure damaged from high volumes of water and debris caught in the flow. In West Stockbridge, there are approximately 2.5 miles of Town roads that travel through the 100-year floodplain, which is approximately 7.14% of the Town's total number of road miles. There are 15 bridges in the town that cross over bodies of water, and the town's Wastewater Treatment Facility in located just outside of the flood zone.

The following highlights from the HMP about flood events support Town-wide stormwater and watershed modeling (grant Subtask 3.3). This information can be used to facilitate qualitative validation of the modeling output (i.e., general comparison of conditions predicted vs. observed).

Table 3.3 of the HMP presents a list of previous flooding occurrences. Of note during the last 20 years:

- March 2010: A storm brought heavy rainfall of 1.5 to 3" across the region, with roads closed due to flooding.
- August 2011: Tropical Storm Irene tracked over the region bringing widespread flooding and damaging winds. Riverine and flash flooding resulted from an average of 3 to 6 inches
- July 2014: A cluster of strong to severe thunderstorms broke out causing 3 to 6" of rainfall and flash flooding.

In addition to physical damage, flooding and other natural hazards can also impact the town's economy. Economic loss may include damage to buildings and their contents, infrastructure, agricultural loss, business interruptions, impacts on tourism, and impacts on the tax base.

The following excerpt from the HMP supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Dams will need to be inventoried and measured in the field for input into the model.

Secondary impacts from flooding can also occur, including fluvial erosion, riverbank erosion, and landslides affecting infrastructure and other assets built within historic floodplains. Dam failures, defined as uncontrolled releases of impounded water due to structural deficiencies in the dam, can occur from and increase in the impoundment behind the dam from heavy rain and/or snowmelt. Shaker Mill Dam is the only high-hazard dam in West Stockbridge, defined as a dam located where structural failure will likely cause loss of life and serious damage to infrastructure. However, there are additional dams located in adjacent towns that would likely impact West Stockbridge if they were to fail.

Table 1. Dams Located within West Stockbridge Town Boundary

Dam Name	Water Body	Hazard Level (per MassODS)
Shaker Mill Pond Dam	Shaker Mill Pond/Williams River	High
Card Pond Dam	Card Pond	Low
Rose Lower Dam		N/A
Kingsmont Dam	Alford Brook	N/A
Alford Brook Club Dam	Alford Brook	N/A

Table 2. Dams Located Outside Town Boundary, but with the Potential to Impact Town Properties

Dam Name, TOWN	Water Body	Hazard Level (per MassODS)
Upper Root Reservoir, LENOX	Upper Lenox Reservoir	High
Lower Root Reservoir, LENOX	Lenox Reservoir	High
Richmond Iron Works Dam, RICHMOND	Furnace Brook	N/A

Mitigation Actions

The following excerpts from the HMP support development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of a plan (grant Subtask 3.5). Mitigation actions already identified and prioritized should be incorporated into the RAISP where appropriate.

The West Stockbridge HMP identifies priority hazard mitigation actions that address future flooding and stormwater concerns. The following mitigation actions are included in the plan:

- Upgrade bridges noted as structurally deficient (goal: 2024).
- Replace or upgrade culverts that are undersized and prone to flooding as reported from the Town Road-Crossing Study conducted by HVA (goal: 2026).
- Upgrade Town-wide drainage conveyances (goal: 2026).
- Continue enforcement of flood mitigation bylaws (goal: 2026).
- Continue to mow and maintain large beaver dams; breach as needed (goal: 2024).
- Continue to prioritize roadway improvements (goal: 2024).
- Major transportation routes in inundated areas for dams of high or significant hazards have been determined; continue to update as needed (goal: 2024).
- Encourage use of low-impact development techniques, especially in flood-prone areas (goal: 2024).
- Conduct loss estimation for inundation areas (goal: 2024).
- Continue work to inform property owners in the floodplain about grant programs available to retrofit and/or flood proof structures (goal: 2024).

Road-Stream Crossing Management Plan

The work completed to prepare the report supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Road-Stream crossings not previously inventoried may need to be inventoried and measured in the field for input into the model.

The Town of West Stockbridge Road-Stream Crossing Management Plan[13], produced by the Housatonic Valley Association, was released in 2022. The Town of West Stockbridge has 76 miles of streams and rivers, and 28 miles of roads and other transportation corridors. At every intersection between these two linear networks, there is a bridge, culvert, or some other mechanism for carrying the road over the stream. Collectively, these structures are referred to as "road-stream crossings." There are 59 road-stream crossings in the Town of West Stockbridge alone. This report identifies high-priority road-stream crossings for flood risks and based on town feedback. A surface water runoff model developed by the University of Connecticut[14] in combination with HVA's field data informed the prioritization of culverts based on probability of flooding.

The following narrative supports H&H modeling. This information can be used to facilitate qualitative validation of the modeling output (i.e., general comparison of conditions predicted vs. observed). In addition, these results will be included in prioritization of those solutions and development of a plan (grant Subtask 3.5).

Tables reproduced below show the highest priority results of the effort for the Town of West Stockbridge.

[13] Town of Richmond Road-Stream Crossing Management Plan, 2022

[14] Shen, X., & Anagnostou, E. N. (2017). A framework to improve hyper-resolution hydrological simulation in snow-affected regions. Journal of Hydrology, 552, 1–12.

Top 5 Crossings for Flood Risk

This chart is a summary of town-managed road-stream crossings with the shortest flood intervals (i.e. most likely to flood the road) based on modeling performed by the University of Connecticut. Note: Only closed-bottomed structures (e.g., culverts) were modeled for risk of failure.

Photo	Flood Interval	Structure #	Road	Map Key	Crossing Code
A	2	39	Great Barrington Road	4D	xy4227925873377435
B	2	41	Cobb Road	4D	xy4229032073379770
C	10	31	Great Barrington Road	3D	xy4229820073374840
D	25	25	West Alford Road	3B	xy4230764073408930
E	200	17	Baker Street	2C	xy4234505073391100

November 12, 2021 Update

HVA reviewed these crossings with the Town of West Stockbridge staff and town officials. Town advised that the crossings on Great Barrington Road are not a Town priority. Structure #39 xy4227925873377435 was installed in 1986/87 and the stormwater management renovated with a curtain drain system installed.

Town Prioritization Results

updated November 10, 2021

The following road-stream crossings were specifically highlighted as town priorities in 2020. In determining priorities, highway managers from the Town of West Stockbridge considered the following questions.

Guiding Questions:

- Which structures regularly flood the road?
- Has water over the road or other crossing failure blocked access for Town residents to essential services, such as Fire/EMS?
- Which structures require regular sediment, debris and/or ice removal?

Photo	Structure #	Map Key	Road	Crossing Code	Notes
A	22	3B	Willson Road	xy4229773273408268	#1 Priority - Beaver issues are 98% of the problem (no deceiver); Road floods and it is undermining the road; This was a bacteria monitoring site and the water level is consistently almost at the road level; On MA OLIVER as a CFR; Alford Brook Club maintains a trout pond for its members (downstream of this crossing); Alford Brook Club owns property adjacent to the crossing which floods almost to the basement windows of the structure; Willson Road is scheduled for repaving in 2022/23. Must be replaced in the next two years. Less traffic voume on Wilson Road than Baker Street.
B	16	2C	Baker Street	xy4234464173390891	#2 Priority - Flooding/ high water elevation issues, primately due to downstream beaver activity; The crossing just north is for a tributary seperate from Flat Brook that also flows under Baker Street; Flat Brook is a major tribtary of the Williams River and it flows through Wildlife Management Area; Baker Street is in the middle of this Wildlife Management Area; top 5% in MA Climate Action Tool
C	15	2C	Smith Road	xy4234225573402368	#3 Priority, This is a double pipe, concrete culvert. There are deep sink holes evident in the grassy edge and the pipe has separated. Beaver issues generally result in spring and fall flooding of the road (from State Road to the crossing). It is a town managed crossing.
D	25	3B	West Alford Road	xy4230764073408930	#4 Priority - This moved up in priority from #5 to #4 from the prioritization conversation that occurred in October 2020. Downstream of this structure flooded, because the beaver dam broke. Flows into Alford Brook.
E	27	3C	West Alford Road	xy4230886073406040	#5 Priority -Road floods frequently (1 – 2 times/ year; once in 2021). Floods over the road, mostly spring thaw and with intense storms. Property owner complains; upstream of this crossing more stormwater volume has been diverted and channeled into this stream making this a problem culvert; Flows into Alford Brook

Town Prioritization Results

updated November 10, 2021

Photo	Structure #	Map Key	Road	Crossing Code	Notes
F	1	1C	Cross Road	xy4235159773397034	#6 Priority: Road floods frequently (1 – 2 times/ year; once in 2021). Floods over the road, mostly spring thaw and with intense storms. Property owner complains; upstream of this crossing more stormwater volume has been diverted and chan-neled into this stream making this a problem culvert. Flooding video taken July 2021: https://www.youtube.com/shorts/x_PsNXs8ds0
G	12	2C	West Center Road	xy4233538473399773	#7 Priority, Box culvert/bridge is structurally sound but is beginning to fail. Sediment deposition indicates it could be undersized. Stormwater/debris clogs up the crossing
H	44	5D	Great Barrington Road	xy4226874573379942	#8 Priority, Seasonal flow, but is undersized. Have beaver deceiver on the inlet. Town wonders if an different inlet could work better. While it is on Route 41, this stretch is town-owned.
I	6	1E	Lenox Road	xy4234539073356710	#9 Priority, This is an intermittent flow – storm-water from mountain runoff. Crossing is on a steep slope; development higher up the mountain has resulted in increased volume being channeled. Pipe is rotted. Interns documented severe erosion, town concurred. Should be replaced in the next couple of years. Not key aquatic habitat.

Drainage System Extent, Condition, and Operation and Maintenance Efforts

The following narrative supports field data collection (grant Subtask 3.2) and Town-wide stormwater and watershed modeling (grant Subtask 3.3). Critical drainage system components will need to be located and inventoried in the field for input into the model.

A major focus of this study is the existing drainage systems for the Towns' roadways, which include conveyances designed for collecting or transporting stormwater (runoff from precipitation and snow melt). Drainage systems include catch basins/drop inlets, manholes, pipes, and outfalls as well as gutters, ditches, and man-made channels, as well as pipes that act as a culvert crossing a roadway where there is no stream (called "cross culverts").

According to information from Town staff, West Stockbridge has traditional drainage systems in the downtown area and a few other locations. There are also numerous cross culverts with inlets / catch basins throughout the municipality. Condition is largely unknown. Town staff spend large portion of the year maintaining gravel roads and ditches/ man-made channels and the cross culverts to minimize flooding on private property.

Known "Problem Areas"

Town staff have shared a list and marked up maps showing areas with various problems related to flooding (i.e. "known problem areas) including:

- Steep gravel roads
- Ponding/low slope/ineffective surface drainage
- Undersized stream-roadway crossings / bridges
- Stormwater systems
- Beavers

Field data collection (grant Subtask 3.2) of these areas will be completed. These areas are further documented in the memorandum associated with Task 3.2

Findings will aid in the Town-wide stormwater and watershed modeling (grant Subtask 3.3), development and evaluation of nature-based solutions (grant Subtask 3.4), and prioritization of those solutions and development of a plan (grant Subtask 3.5).

Capital Plans

The Town of West Stockbridge has recently drafted a capital plan. Three planned projects may overlap with RSAIP recommendations:

- the water line extension on Moscow Road
- the Swamp Road water main project
- the architectural/site planning for the Public Service Building

These projects will be considered in evaluation of nature-based solutions (grant Subtask 3.4), prioritization of those solutions, and development of a plan (grant Subtask 3.5).

Critical Roads for Emergency Response and Evacuation

Critical roads will be considered as priorities as part of development and evaluation of nature-based solutions (grant Task 3.4), prioritization of those solutions, and development of a plan (grant Subtask 3.5).

The West Stockbridge Hazard Mitigation Plan, adopted in 2021, identifies primary and secondary roads critical for emergency response and evacuation. Primary roads are:

- Stockbridge Road (State Rt. 102),
- State Line Road (State Rt. 102),
- Great Barrington Road (State Rt. 41), and
- Albany Road (State Rt. 41).

Secondary roads are:

- Swamp Road,

- Lenox Road, and
- West Center Road.

Transportation Plans

The Town of West Stockbridge is a part of the greater Berkshire Regional Planning Commission (BRPC). The BRCP released the long-range Regional Transportation Plan in 2020[15]. A Transportation Needs survey was distributed to residents across all the municipalities within the region and had over 700 respondents. Key findings of the survey include the following:

- Expand public transportation (BRTA) routes and hours of operation
- Improve pedestrian infrastructure and condition of local roadways
- Increase the number of alternative and affordable transportation options
- Expand regional connectivity
- Improve North/South access within Berkshire County

The Town of West Stockbridge has 54.08 miles of road; 12.08 miles are managed by MassDOT, 36.11 miles are local, and 5.90 miles are under unknown jurisdiction.

Of the approximately 648 total workers in West Stockbridge, 81.9% commute by truck, car, or van, 0.2% of workers reported commuting using public transportation, and 2.4% commuted by walking. Because roads are critical infrastructure for community access and economic activity, this plan confirms the importance of improving condition of local roadways (as stated in HMP and other plans).

In this plan, West Stockbridge also identifies a potential project awaiting a funding source: The widening and rehabilitation of Route 41/102 and Main Street, with a project cost of $1,250,000. *This project may impact prioritization of solutions and development of a plan (grant Subtask 3.5). Otherwise, this transportation planning is not likely to be included in development and evaluation of nature-based solutions, prioritization, or plan development.*

West Stockbridge Complete Streets Plan

According to BRPC's website, "BRPC is providing professional services to develop a town wide complete streets plan which will set the direction of implementing complete streets concepts to the town's transportation network." A complete streets plan offers the Town with an opportunity to consider not only safer corridors for pedestrians and cyclists, but also inclusion of stormwater management and mitigation of potential heat island impacts.

Complete street plans need to be considered in development and evaluation of nature-based solutions (grant Subtask 3.4) such that there are not conflicts between proposed street work and stormwater management. Complete street priorities should be reflected in developing the final plan (grant Subtask 3.5).

[15] Berkshire Regional Transportation Plan, 2020
https://berkshireplanning.org/wp-content/uploads/2020/08/2020_BERKSHIRE_RTP_-_FINAL.pdf

West Stockbridge Master Plan

West Stockbridge is in the process of developing a Master Plan.[16] This plan has not been released yet, however based on meeting minutes from the Master Plan Steering Committee, it appears that drafting of plan chapters and community engagement for the plan are ongoing. Economic Development is to be included in the master plan.

Survey results posted online[17] indicate that almost 80% of respondents consider trails and green space important town assets. This survey also indicated 37% of respondents would more parks and outdoor seating areas in the town center.

Because of the timing and progress of the Master Plan, it is unclear if chapters or more information will be released in time for inclusion into the RAISP. Instead, the draft RAISP (grant Subtask 3.5) may inform some actions in the Master Plan.

Open Space Planning/ Acquisition Plans

The Town of West Stockbridge released a Draft of their Open Space and Recreation Plan[18] (OSRP) in May of 2021, including a summary of findings and a seven-year action plan. The West Stockbridge OSRP Working Group, made of volunteers from the Parks and Recreation Committee, Select Board, Master Plan Steering Committee, and Conservation Commission drafted goals and actions that reflect the importance of protecting the rural and natural resources of the town while also protecting recreational opportunities. Three overarching goals emerged as part of the planning process, as derived from the public process:

1. West Stockbridge's rural and natural landscape is protected and maintained; careful development does not impair this landscape.
2. West Stockbridge's water resources are protected and of high quality.
3. Residents of all abilities have access to outdoor recreational opportunities, while respecting and maintaining the natural landscape in which these are set.

The goals listed above will inform prioritization of actions in developing the final plan (grant Subtask 3.5).

In this report, residents also indicated that Card Pond and Shaker Mill Pond are widely known and beloved water resources. Card Pond rated highly as a favorite spot in West Stockbridge. The report set the following goals:

- Develop a long-term pond management plan for Card Pond, with a focus on measures to control invasive aquatic plant growth and reduce goose visitation at the Town beach.

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[16] https://www.weststockbridge-ma.gov/sites/g/files/vyhlif4031/f/news/master_plan_survey_results.pdf
[17] https://www.weststockbridge-ma.gov/sites/g/files/vyhlif4031/f/news/master_plan_survey_results.pdf
[18] https://www.weststockbridge-ma.gov/sites/g/files/vyhlif4031/f/uploads/open_space_rec_plan_-_summary_of_needs_actions_revised_-_june_1.pdf#:~:text=The%202022%20West%20Stockbridge%20Open,residents%20and%20generations%20to%20come.

- Conduct a detailed survey to map the extent and densities of native and invasive plant communities within Shaker Mill Pond and along its shoreline; work with the Massachusetts Natural Heritage & Endangered Species Program (NHESP) to develop a pond management plan for the pond that addresses invasive plant species while also being protective of the rare species that inhabit the pond.
- Protect aquatic habitat connectivity and reduce erosion and sedimentation in streams by conducting stream-road crossing improvements recommended in the Town's Hazard Mitigation Plan and Road-Stream Crossing Inventory. The stream-road crossing at Baker Road is a high priority.

The above-listed actions need to be considered in development and evaluation of nature-based solutions (grant Subtask 3.4).

Water Quality Data

Surface Water

The final Massachusetts Integrated List of Waters for the Clean Water Act 2018/2020 Reporting Cycle[19] indicates the following two waterbodies in West Stockbridge that have water quality concerns:

- Shaker Mill Pond (MA21094), which covers 27 acres, has impairments caused by Curly-leaf Pondweed, Eurasian Water Milfoil (Myriophyllum Spicatum), and water chestnut.
- Williams River (MA21-06), 11 miles from the headwaters (outlet Shaker Mill Pond, West Stockbridge) to mouth at confluence with Housatonic River, Great Barrington, is impaired due to temperature.

These water quality concerns need to be considered during development and evaluation of nature-based solutions (grant Subtask 3.4) such that solutions located in the watershed of these waterbodies work to reduce nutrients and temperature impacts.

The following waterbodies attain some of the designated uses (e.g., habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation) but not all of them. Generally, these waterbodies likely have limited water quality concerns:

- Alford Brook (MA21-44), the 6.3 miles from the headwaters (outlet small unnamed pond north of Wilson Road, West Stockbridge) to mouth at confluence with Seekonk Brook, Alford
- Baldwin Brook (MA21-48), the 1.9 miles from the NY/MA border in West Stockbridge to mouth at confluence with Flat Brook, West Stockbridge
- Cone Brook (MA21-76), the 4.6 miles from the headwaters (confluence of Sleepy Hollow and Fairfield brooks, Richmond) to mouth at inlet Shaker Mill Pond, West Stockbridge.
- Furnace Brook (MA21-21), the 3.7 miles from the headwaters (perennial portion, south of Route 295 (Canaan Road), Richmond) to mouth at inlet Mud Ponds, West Stockbridge.

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[19] https://www.mass.gov/doc/final-massachusetts-integrated-list-of-waters-for-the-clean-water-act-20182020-reporting-cycle/download

The following two ponds have not been assessed:

- Card Pond (MA21015), which covers 11 acres.
- Crane Lake (MA21025), which covers 27 acres

At a minimum, nature-based solutions identified and evaluated (grant Subtask 3.4) need to protect or improve fish and other aquatic life and wildlife uses such that these waterbodies continue to attain the designated use.

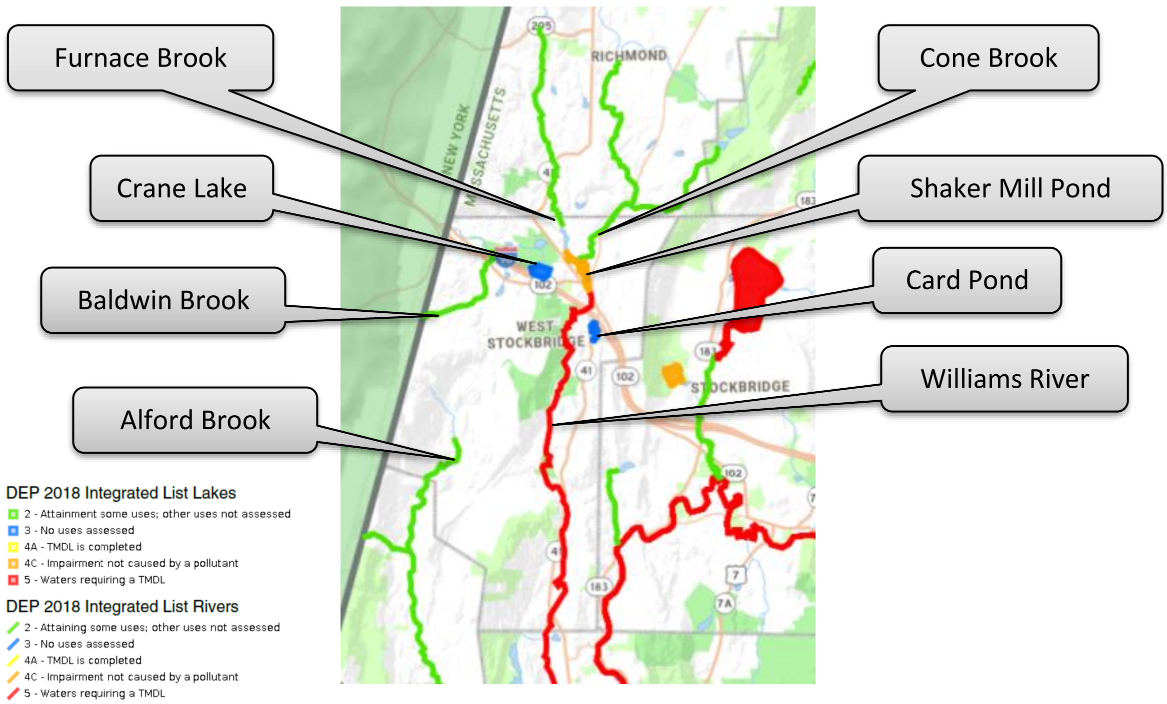

Figure 1: Water Quality in the Town of West Stockbridge[20]

As described on the Department of Public Health (DPH) website, "the Environmental Toxicology Program tests for waterborne health hazards at ocean and freshwater beaches across Massachusetts. To minimize illness and injury associated with swimming, and to notify the public about the quality of beach water, the DPH collects beach water quality data from local health departments and the Massachusetts Department of Conservation and Recreation (DCR). All public and semi-public bathing beaches in Massachusetts are monitored for fecal indicator bacteria, and on occasion, harmful algae. Monitoring occurs during the beach season, which begins when the school year finishes in mid-June and ends during the weekend of Labor Day."[21]

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[20] Map created using MassMapper and Final Integrated List of Waters Information as of December 2022 https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html

[21] https://www.mass.gov/lists/water-quality-at-massachusetts-swimming-beaches#2021-

The following two public beaches are sampled in the Town of West Stockbridge:

- Card Pond Beach
- Crane Lake Camp

Monitoring results are available on the DPH website.

During development and evaluation of nature-based solutions (grant Subtask 3.4), solutions located in the watershed of each of the waterbodies on which these beaches are located need to reflect bacteria and pathogen reduction approaches.

Groundwater

The Town operates and maintains both a primary and a back-up well located in a 12 acre town-owned Zone II protected zone behind the Gaston property, off of Swamp Road. Well #1 has a depth of 51' and pumps at a volume of 70 gpm. Well #2 is 48' deep and pumps at 50 gpm. Both wells pump chlorinated water directly up to the Lenox Mtn. Water Storage Tank which has a capacity of 150,000 gallons. In addition to equalizing pressure throughout the system, the tank provides a three-day emergency supply of safe drinking water in the event of an emergency. According to the Annual Drinking Water Quality Report (Consumer Confidence Report) for Calendar Year 2021[22], none of the contaminants tested for (nitrate, iron, manganese, nickel, sodium, Haloacedic* Acids HAA5, Trihalomethanes TTHM, Perchlorate) exceed regulatory benchmarks.

In addition, there are three non-community groundwater wells in West Stockbridge (one at the Pleasant Valley Motel, two at Camp Kingsmont).

All of these sources have a Wellhead Protection Areas in the form of a Zone I (the protective radius required around a public water supply well or wellfield which is depending on the type of well and approved yield and is no less than a radius of 100 feet) and either an Approved Wellhead Protection Area (Zone II[23]) or an Interim Wellhead Protection Area[24].

Note that a figure has not been included to protect the information related to drinking water well supply.

Locations of the Wellhead Protection Areas for these drinking water supplies will be considered during identification and development of solutions (grant Subtask 3.4) as, per the Massachusetts Stormwater Handbook and Stormwater Standards[25], " Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply…require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts

[22] https://www.weststockbridge-ma.gov/sites/g/files/vyhlif4031/f/pages/ccr_2021.pdf

[23] As stated in 310 CMR 22.02, a Zone II is: "That area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at safe yield, with no recharge from precipitation). It is bounded by the groundwater divides which result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone IIs shall extend up gradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock , or a recharge boundary)."

[24] In the absence of an approved Zone II, DEP has adopted the Interim Wellhead Protection Area (IWPA) as the primary, protected recharge area for PWS groundwater sources.

[25] https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards

Stormwater Handbook. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply."

Water Level Data

Water level data is necessary for H&H modeling (grant Subtask 3.3).

USGS Gages[26] are available to support water level data for modeling. The gage(s) that will be utilized for modeling (Subtask 3.3) will be further discussed in the deliverable for that work. No other local water level data was identified.

Agriculture/Farms/Forestry/Land Use

De and re forestation have potential to affect runoff rates and volumes entering the stream system and/or developed areas, thereby impacting culverts and roadways. Forests can help to minimize sediment runoff and recharge groundwater. Forest harvesting activity in the area occurs at the rate of approximately one property a year, according to the Department of Conservation and Recreation's Regional Forester.

At this rate, changes in land use are not significant enough to affect modeling parameters (grant Subtask 3.3). In addition, based on discussions with Town staff, runoff from agriculture, farms, and/or forestry practices do not appear to impact flooding in the community.

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[26] https://waterwatch.usgs.gov/?m=real&r=ma

FINDINGS ORGANIZED BY PROJECT SUBTASKS

The following references will be used to support field data collection (Subtask 3.2):

- Hazard Mitigation Planning
- Road-Stream Crossing Management Planning
- Drainage system extent, condition, and operations and maintenance efforts
- Known problem areas
- Comprehensive or Master Plans

The following references will be used to support Town-wide stormwater and watershed modeling (Subtask 3.3):

- Hazard Mitigation Planning
- Road-Stream Crossing Management Planning
- Drainage system extent and condition
- Known Problem Areas
- Water Level Data
- Richmond Pond Management Plan

The following references will be used to support development and evaluation of nature-based solutions (Subtask 3.4):

- Hazard Mitigation Planning
- Drainage system operation and maintenance efforts
- Known problem areas
- Capital plans
- Critical Roads for emergency response, evacuation, etc.
- Complete Streets Plan
- Comprehensive or Master Plans and Land Use Controls
- Open space planning / acquisitions plans
- Water quality data
- Water level data
- Agriculture / Farms
- Forestry
- Richmond Pond Management Plan

Solutions will consider all town-prioritized problems and goals outlined in each of the plans identified.

The following references will be used to support prioritization of those solutions and development of a plan (Subtask 3.5):

- Hazard Mitigation Planning: priority mitigation and adaptation actions
- Road-Stream Crossing Management Planning

- Drainage system extent, condition, and operation and maintenance efforts
- Known problem areas
- Capital plans
- Critical roads for emergency response, evacuation, etc.
- Transportation and Complete Streets plans
- Economic Development Plans
- Open Space Planning/ Acquisition Plans
- Richmond Pond Management Plan

Prioritization of solutions and the developed plan will consider all town-prioritized problems and goals outlined in each of the plans identified.

APPENDIX B

Field Investigation Memorandum

MEMORANDUM

TO: Town of Richmond & Town of West Stockbridge

FROM: Joanna Nadeau, AICP, Weston & Sampson Project Team Manager and Project Field Team

DATE: December 8, 2022

SUBJECT: A Climate Ready Culvert Design and Comprehensive Stormwater Plan

Task 3: Resilient Stormwater Action and Implementation Plan (RSAIP) for Richmond and West Stockbridge

Subtask 3.2 Deliverable: Field Data Collection Summary Memorandum

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In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson performed field investigations from October 10 to October 14, 2022 at locations where flooding has been reported to occur, roadways experience erosion, stream crossings were not previously inventoried or additional measurements were needed, and/or additional data would improve accuracy of assessment of drainage infrastructure. With the help of Town staff, the team mapped drainage infrastructure, took photographs, collected measurements, and noted observations at multiple stream crossings, dams, pre-determined problem areas, stream channels, and elements of structural drainage systems. In addition, during the field work, staff visited the West Stockbridge Town Hall to evaluate potential rain garden demonstration locations (Subtask 2.4). The goal of this field work was to support hydrologic and hydraulic (H&H) modeling of present and anticipated future climate conditions (Subtask 3.3) and understand existing conditions to support identification, evaluation, and prioritization of potential flood reduction and erosion solutions (Subtask 3.4).

This memorandum presents a summary of the field investigations related to the following:

- Dams
- Drainage Systems for Roadways
- “Problem Areas” (of Flooding, Erosion, and Stormwater Runoff)
- Road Stream Crossings
- Stream Channels
- West Stockbridge Town Hall Potential Rain Garden Demonstration Location(s)

Dams

The field investigations evaluated 21 dams total in Richmond and West Stockbridge. Dams are important hydraulic features to capture in a H&H model as they provide some temporary water storage by restricting flow downstream via spillways or other outlets. Data collected at man-made dams included:

- global positioning system (GPS) locations;
- dam type;
- construction material;
- spillway type;
- spillway and dam length, breadth, and crest dimensions; and
- measurements from stream bottom to spillway crest and dam crest on upstream and downstream sides.

Data collected for beaver dams included:

- dam length, breadth, and crest dimensions; and
- measurements from stream bottom to dam crest on upstream and downstream sides.

Figure 1. Examples of dams investigated in Richmond, including Richmond Pond Dam, Pittsfield (left), Furnace Road Dam (middle), and Dublin Road Dam (right).

Dams visited in the field included five (5) jurisdictional dams and 14 small non-jurisdictional and/or beaver dams. Jurisdictional dams are dams that have a large enough storage capacity to be regulated by the Massachusetts Department of Conservation and Recreation's Office of Dam Safety. Four of five jurisdictional dams have a high or significant hazard classification. Dam hazard classifications are based on the potential loss of life and property damage caused by a potential dam failure. The higher the classification level, the higher the likelihood of loss of life and/or property damage. The jurisdictional dams are listed in Table 1.

Table 1. Jurisdictional Dams Inventoried

Dam Name	Dam Location	Watershed	Hazard Classification
Upper Root Reservoir	Lenox	Williams River	High
Lower Root Reservoir	Lenox	Williams River	High
Richmond Pond	Pittsfield	West Branch Housatonic River	Significant
Shaker Mill Pond	West Stockbridge	Williams River	High
Card Pond	West Stockbridge	Williams River	Low

Of the 21 dams inventoried, two (2) are in the Richmond Pond drainage area (the West Branch Housatonic River Watershed), six (6) are in the Green River Watershed, and 13 are in the Williams River Watershed. Table 2 summarizes the dams inventoried in the field.

Information gathered about dam type, construction material, spillway type, spillway and dam length, breadth, and crest dimensions, and other measurements is included in the GIS data, incorporated into the H&H model, and will be utilized to support recommendations. It is important to note that most of the privately-owned dams are on private property and cannot be accessed from public right-of-ways.

Figure 2. Dam spillway on private property on West Alford Road in West Stockbridge.

Table 2: All Dams Inventoried

Community	Location	Watershed	Brief Description	Photo
Lenox	Southern end of Upper Root Reservoir	Williams River	Jurisdictional water supply dam, owned by Town of Lenox	
Lenox	Southern end of Lower Root Reservoir	Williams River	Jurisdictional water supply dam, owned by Town of Lenox	
Pittsfield	Northern end of Richmond Pond	West Branch Housatonic River	Jurisdictional recreation pond dam, privately owned	

Community	Location	Watershed	Brief Description	Photo
Richmond/Pittsfield	Near 98 Central Berkshire Boulevard, Pittsfield, MA	West Branch Housatonic River	Small, stone dam, privately owned	
Richmond	Behind 1018 Dublin Road	Williams River	Small dam with pedestrian bridge over spillway, privately owned	
Richmond	On driveway for 350 West Road	Williams River	Small concrete dam, privately owned	
Richmond	On pond behind 2040 State Road	Williams River	Small earthen embankment dam, privately owned	

Community	Location	Watershed	Brief Description	Photo
Richmond	At driveway for 2871 State Road	Williams River	Recreational dam with driveway over embankment, privately owned	
West Stockbridge	Behind 145 West Center Road	Green River	Beaver dam, on private property	
West Stockbridge	At 41 West Alford Road	Green River	Recreational dam, privately owned	
West Stockbridge	Across the street from 19 West Alford Road	Green River	Beaver Dam, on private property	

Community	Location	Watershed	Brief Description	Photo
West Stockbridge	In the woods, West of 176 West Center Road	Green River	Beaver dam, on private property	
West Stockbridge	0.09 miles southeast of the West Alford Road and Wilson Road Intersection	Green River	Recreational dam, privately owned	
West Stockbridge	Behind 8 Woodruff Road	Williams River	Small dam and pond in field, privately owned	
West Stockbridge	Between 5 Woodruff Road and Red Rock Road	Williams River	Rock Pile Dam, privately owned	

Community	Location	Watershed	Brief Description	Photo
West Stockbridge	In the Flat Brook Wildlife Management Area, behind 51 Albany Road	Williams River	Beaver dam, on private property	
West Stockbridge	At Shaker Mill on Shaker Mill Pond	Williams River	Jurisdictional, recreational dam, start of the Williams River, owned by the Town of West Stockbridge	
West Stockbridge	Behind 46 Main Street	Williams River	Small, stone block, run-of-river dam, privately owned	

Community	Location	Watershed	Brief Description	Photo
West Stockbridge	Northern end of Card Pond	Williams River	Jurisdictional, recreational dam leading to culvert crossing, owned by the Town of West Stockbridge	
West Stockbridge	Adjacent to 30 Great Barrington Road	Williams River	Small earthen embankment dam, privately owned	
West Stockbridge	Adjacent to 245 Great Barrington Road	Williams River	Concrete run-of-river dam, privately owned	

Drainage Systems for Roadways

A major focus of this study is the existing drainage systems for the Towns' roadways, which include conveyances designed for collecting or transporting stormwater (runoff from precipitation and snow melt). Drainage systems include catch basins/drop inlets, manholes, pipes, and outfalls as well as gutters, ditches, and man-made channels, as well as pipes that act as a culvert crossing a roadway where there is no stream (called "cross culverts"). During Weston & Sampson's field work, 159 cross culverts and 139 catch basins/drop inlets were field mapped (almost 300 structures total). We located structures through GPS in both a Trimble and an iPad, which provide no less than ± 30 feet each direction. In addition, the Trimble unit collects elevation data.

Town of Richmond

The Town of Richmond has very limited traditional drainage systems except on Deer Hill Road and East Slope Road, which are subdivisions. Field drainage mapping focused on cross culverts, inlets, and catch basins located in problem areas. In total, 112 cross culverts and 35 drop inlets and catch basins were mapped in the Town. Areas within the drainage system that are not operating effectively ("problem areas") are discussed in further detail in a later section.

Town of West Stockbridge

Field drainage mapping in West Stockbridge focused on cross culverts, inlets, and catch basins located in problem areas noted by Town staff as well as downtown. In total, 47 cross culverts and 104 drop inlets and catch basins were mapped in the Town. Problem areas are discussed in further detail in the next section.

In downtown West Stockbridge, a total of 42 drainage structures were mapped, including six concrete drop inlets and 36 catch basins. Those structures have been numbered SW-1 through SW-44 for the purpose of this study's mapping and notation. The interior of the concrete drop inlets was inaccessible without heavy machinery, and therefore flow directions were hypothesized according to visible piping. Outfalls were not mapped.

Most catch basins investigated were in good condition, other than SW-1 which was completely clogged by debris, and SW-2 through SW-5, which had sediment up to the pipe inverts on the date of the field observations. All outlets flow towards the Williams River. Data collected included depths of pipe inverts, depth of sump, number of pipe inverts, and direction of flow.

Problem Areas

Field investigations also included on-site evaluations of 40 "problem areas" that were identified by Town staff. Weston & Sampson staff visited each of the problem areas and collected information pertaining to existing conditions, including detailing the existing drainage systems, signs of roadside erosion, and flooding impacts. Town staff visited numerous problem areas with the field team and facilitated understanding of existing conditions. Each problem area was numbered for the purposes of mapping and notation, e.g., R.PA-1. Photos and measurements of dimensions of key features were also collected.

In addition, a rain event occurred on Thursday, October 13, 2022, overnight into Friday, October 14, 2022, with an estimated 1.8 inches of rainfall.[1] Precipitation began around 5:00 PM Thursday and continued until around 6:00 AM on Friday. This provided Weston & Sampson staff with the opportunity to visit selected problem areas before and after the rain event and gain an improved understanding of the drainage challenges in these areas.

Many of the problem areas have similar existing conditions, so to facilitate a rapid and wide-ranging assessment, we have grouped them by type of problem in the discussion presented here. The three generalized problem types include:

- Ineffective conveyance on steep slopes,
- Ineffective drainage and ponding,
- Storm drain networks,
- Stream crossing issues, and
- Dam-related issues (manmade or beaver).

Town of Richmond

A total of 22 problem areas in Richmond were visited and are documented in Table 3. Additional descriptions are provided in the narrative following this table. Attachment A includes a map of problem areas assessed for both communities.

Table 3. Problem Areas in Richmond

Problem Area ID	Road Name	Generalized Problem Type	Description of Existing Conditions
R.PA-1	Summit Road	Stream crossing	Undersized road stream crossing, leading to flooding in road. Major, heavy rainstorms clear debris from upstream forest and block the culvert. The typically dry stream rises fast.
R.PA-2	Dublin Road*	Ineffective drainage and ponding	Drainage from State Road (MA Rte. 41) and Perrys Peak Road cause flooding around homes and in road during every storm.
R.PA-3	Dublin Road*	Stream crossing / ineffective drainage and ponding	Intermittent stream floods road during major, heavy storms due to lack of swales and silting of swamp downstream of crossing, causing backwatering. Work here requires an individual NOI.
R.PA-4	Dublin Road	Ineffective drainage and ponding	During every storm, runoff from private property overloads existing swales and floods the road.

[1] Source: Community Collaborative Rain, Hail, & Snow Network. Daily Precipitation Reports by State. https://www.cocorahs.org/ViewData/StateDailyPrecipReports.aspx?state=MA

Problem Area ID	Road Name	Generalized Problem Type	Description of Existing Conditions
R.PA-5	Dublin Road*	Stream crossing	Beaver activity clogs culverts, road overtops during large events, most frequently in the fall.
R.PA-6	Town Beach Road	Ineffective drainage and ponding / stream crossing	Flooding issues at adjacent yards during heavy events, possibly caused by high water levels in Nordine Swamp with beaver activity at the crossing and backwatering from Shore Road.
R.PA-7	Swamp Road	Stream crossing	Former road embankment downstream of current road culvert is undersized, three culverts upstream discharge to one 18-inch culvert, road washed out three times in summer of 2021, larger rock and paved swales installed in response.
R.PA-8	Osceola Road	Ineffective drainage and ponding	Flat road with steep slopes upland, road has ledge on both sides, runoff ponds on road.
R.PA-9	Osceola Road	Ineffective conveyance on steep slopes	Driveways flood because they are downhill from the steep road surface.
R.PA-10	Osceola Notch Road	Ineffective conveyance on steep slopes	Road erosion caused by uncontrolled runoff down road, first happened in 2022.
R.PA-11	East Road*	Ineffective drainage and ponding	Flat road with nowhere for water to go with steep slopes upland, ponding occurs every time it rains and from snow melt.
R.PA-12	West Road	Ineffective conveyance on steep slopes	Runoff from rainstorms or snow melt from steep ledge banks along both sides of road, no way to get water off the off the road.
R.PA-13	West Road	Ineffective conveyance on steep slopes	Runoff from rainstorms or snow melt from steep ledge banks along both sides of road, no way to get water off the off the road.
R.PA-14	West Road	Ineffective conveyance on steep slopes	Ledge along one side of road and houses downhill on the other, nowhere for water to go.
R.PA-15	West Road	Stream crossing	Major, heavy or long duration rainstorms clear debris from upstream forest and block the culvert, causing flooding and road overtopping.
R.PA-16	West Road	Stream crossing	Major, heavy or long duration rainstorms clear debris from upstream forest and block the culvert, causing flooding and road overtopping.
R.PA-17	Rossiter Road*	Stream crossing	Minor roadside flooding likely caused by water backing up from downstream.

Problem Area ID	Road Name	Generalized Problem Type	Description of Existing Conditions
R.PA-18	Rossiter Road at Fire Pond	Stream crossing / Dam-related issues	Occasional roadway flooding caused by beaver activity clogging outlet.
R.PA-19	Rossiter Road	Dam-related issues	Historical roadway flooding caused by beaver activity (now resolved) clogging outlet.
R.PA-20	Sleepy Hollow Road	Stream crossing / dam-related issues	Roadway overtopping during heavy storm events, flooding exacerbated by beaver activity.
R.PA-21	Dean Hill Road	Ineffective conveyance on steep slopes	Drainage issues during every rain event caused by steep terrain and few opportunities to add swales.
R.PA-22	Swamp Road	Stream crossing	Road erosion between Cheever Road and Stevens Glen caused by culverts clogging during heavy events, no issues reported since hurricane in 2014.

Note: Problem areas denoted with an asterisk (*) were visited before and following rain event.

Town of West Stockbridge

A total of 18 problem areas in West Stockbridge were visited and are documented in Table 4. It should be noted that most of the problems occurring in West Stockbridge are related to heavy rain events, which are considered to be events with rainfall intensities greater than ½ to one inch per hour.

Table 4. Problem Areas in West Stockbridge

Problem Area ID	Road Name	Generalized Problem Type	Description of Existing Conditions
WS.PA-1	Cone Hill Road	Ineffective drainage and ponding	Road erosion and ponding at intersection with Iron Ore Road during heavy rain events or snowmelt, maintained minimum of three times per year.
WS.PA-2	Lenox Road	Ineffective conveyance on steep slopes	Current swales and drop inlets not catching all runoff from hillside because upland development has changed drainage patterns, maintained three to four times per year.
WS.PA-3	Smith Road	Stream crossing / dam-related issues	Beaver activity clogs culvert in spring and late fall, causing roadway overtopping up to 12 inches and erosion up to 24 inches, maintained weekly during spring and fall.
WS.PA-4	Smith Road	Ineffective conveyance on steep slopes	Road erosion caused by uncontrolled runoff from steep road in non-paved section, maintenance occurs after heavy rain events.
WS.PA-5	Red Rock Road	Ineffective conveyance on steep slopes	Road erosion caused by uncontrolled runoff from steep road, maintenance occurs after heavy rain events.
WS.PA-6	Austerlitz Road	Ineffective conveyance on steep slopes	Road erosion caused by uncontrolled runoff from steep road, maintenance occurs after heavy rain events.
WS.PA-7	West Center Road	Stream crossing / dam-related issues	Beaver activity clogs culvert in spring and late fall, causing roadway overtopping and erosion up to 24 inches, maintained weekly during spring and fall.
WS.PA-8	West Alford Road	Stream crossing / dam-related issues	Beaver activity clogs culvert in spring and late fall, causing roadway overtopping and erosion up to 24 inches, maintained weekly during spring and fall.
WS.PA-9	West Alford Road	Stream crossing / dam-related issues	Beaver activity clogs culvert in spring and late fall, causing roadway overtopping and erosion up to 24 inches, maintained weekly during spring and fall.

Problem Area ID	Road Name	Generalized Problem Type	Description of Existing Conditions
WS.PA-10	Wilson Road	Stream crossing / dam-related issues	Beaver activity clogs culvert, causing roadway overtopping up to 12 inches, wetlands fill with sediment reducing storage capacity, causing road shutdowns, maintained prior to storm events.
WS.PA-11	Maple Hill Road*	Ineffective conveyance on steep slopes	North area: former drainage issues solved with drop inlets and drains. South area: Steep gravel road with no swales and drop inlets, cause erosion up to three feet deep, which clog driveway culverts, maintained after heavy rain events.
WS.PA-12	Downtown	Storm drain networks	Flooding occurs two to three times a year in spring and fall, privately-owned culvert beneath 1 Stockbridge Road floods house and yard with water level reaching up to five feet, culvert is privately maintained.
WS.PA-13	Shaw Road	Stream crossing	Undersized culvert with collapsing headwall is downstream of small dam, culvert clogs during heavy rain events, causing road to overtop and wash out, maintained after heavy events.
WS.PA-14	Pixley Road*	Ineffective conveyance on steep slopes	Section of Pixley Road missing drainage swales and drop inlets, undersized swales in steep-graded areas, causing erosion of road during heavy events, ongoing maintenance and after heavy events.
WS.PA-15	Pixley Road*	Ineffective conveyance on steep slopes	Section of Pixley Road missing drainage swales and drop inlets, undersized swales in steep-graded areas, causing erosion of road during heavy events, ongoing maintenance and after heavy events.
WS.PA-16	Pixley Road*	Ineffective conveyance on steep slopes	Section of Pixley Road missing drainage swales and drop inlets, undersized swales in steep-graded areas, causing erosion of road during heavy events, ongoing maintenance and after heavy events.
WS.PA-17	Pixley Road*	Ineffective conveyance on steep slopes	Section of Pixley Road missing drainage swales and drop inlets, undersized swales in steep-graded areas, causing erosion of road during heavy events, ongoing maintenance and after heavy events.
WS.PA-18	Long Pond Road	Ineffective conveyance on steep slopes	Swales and drop inlets present, road erosion.

Note: Problem areas denoted with an asterisk (*) were visited both before and following rain.

THE FOLLOWING SUBSECTIONS BREAK UP THE PROBLEM AREAS INTO FIVE GENERAL PROBLEM TYPES AND PROVIDE DISCUSSION OF EXAMPLES OF EACH TYPE.

Weston & Sampson staff mapped the existing infrastructure and flow patterns by walking each road listed below (3.3 miles total). It should be noted that the list of investigated infrastructure below is not an extensive list of all drainage infrastructure present, but contains the infrastructure that we were able to map during out site visits.

Type of Issue #1: Ineffective Conveyance on Steep Slopes

West Stockbridge's Smith Road (WS.PA-4), Red Rock Road (WS.PA-5), Austerlitz Road (WS.PA-6), and Long Pond Road (WS.PA-18) and Richmond's Dean Hill Road (R.PA-21), the northern section of West Road (R.PA-12), and East Road (R.PA-11) all share a similar drainage issue: ineffective conveyance on steep slopes.

Driveway crossings were generally not mapped as they are privately-owned and not maintained by the towns. A few driveway culverts were mapped in a few locations to help understand connectivity.

Table 5. Drainage Infrastructure for Problem Areas with Type #1 Issues

Problem Area	Number of Cross Culverts Investigated	Number of Driveway Crossings Investigated	Number of Drop Inlets or Catch Basins Investigated
WS.PA-4 (Smith Road)	1	1	-
WS.PA-5 (Red Rock Road)	3	1	-
WS.PA-6 (Austerlitz Road)	1	-	-
WS.PA-18 (Long Pond Road)	2	-	7
R.PA-21 (Dean Hill Road)	3	-	2
R.PA-12 (West Road)	2	1	-
R.PA-11 (East Road)	2	-	-

The current infrastructure in place, including limited cross culverts, drop inlets, and driveway culverts, does not control stormwater flow effectively. During periods of heavy rainfall, channeling and erosion occur on the roads and pooling occurs in the woods. There are currently some berms limiting the outflow of stormwater on the sides of the steeper parts of the roads, creating a bottleneck effect and eroding the roads, however there are limited places for turnouts. Limited real estate for infrastructure makes it challenging to maintain and relieve high velocities flowing down the hill. Some private properties on Dean Hill Road are flooding due to lack of controlled flow.

Figure 3. Condition of the roads post-rain event on October 14, 2022. There is channeling on the north and south swales, looking downhill, of Red Rock Road (right and center). Accelerated flow down steep parts of Austerlitz Road bleed into the woods at the bottom of the hill, eroding the road (left).

West Road (R.PA-12 through R.PA-14) in Richmond rises and falls with the topography of the land, leading to ponding and driveways being washed out by heavy rain events. A small portion (0.1 mile) of West Road, between the intersections with Rossiter Road and State Road, is built on a ledge, as seen in Figure 4. One side of the road is lined with ledge while the other is lined with driveways sloping downhill to residences. Runoff flows off the ledge, across the road, and down driveways and into yards. A section of West Road that covers 0.35 miles, just north of Rossiter Road, is surrounded on both sides by ledge, preventing adequate stormwater flow to the surrounding woods.

Figure 4. Water flows off the ledge onto private property on West Road (left) and pavement loss on Osceola Notch Road (right).

The upper portion of Osceola Road (0.1 miles; R.PA-9) and Osceola Notch Road (0.12 miles; R.PA-10) also experience flooding during heavy rainfall events. Some private residents along Osceola Road have reported driveways flooding due to lack of drainage systems on the road or that the few existing drainage swales do not have the capacity necessary to handle the runoff coming down Osceola Mountain. Osceola Notch Road experiences pavement erosion due to a lack of stormwater runoff flowing down the roadway. The runoff finds the lowest point on the side of the road and flows over it, eroding the shoulder, and creating a non-stabilized channel adjacent to the road, causing erosion along a 10- to 15-foot-long section of the road.

The existing drainage system on the northern section of Maple Hill Road (WS.PA-11), including 11 drop inlets, diverts flow to the stormwater drainage under State Line Road through sub-terrain piping along the road. This drainage system does not span the entire road. Two Weston & Sampson staff documented erosion and drainage issues by walking 1.1 miles of the northern section of the road. Five cross culverts along the road divert flow to Fish and Game land on the east side of the road, and five driveways cross the road as well. Road erosion, bleeders, and channeling are evident from heavy rain events in these sections of the road.

Figure 5. Condition of the southern portion of Maple Hill Road where culverts have not yet been installed and there is significant flow into the woods, eroding the road.

The north section of Lenox Road (WS.PA-2) has eight cross culverts with drop inlets and two driveway crossings along the road that mitigate road flooding. Weston & Sampson staff documented erosion and drainage issues by walking 0.64 miles of the northern section of the road. Large developments have blocked natural routes for stormwater runoff, and new carvings can be seen in the hillside. Additional cross culverts have been put in place to prevent road flooding from runoffs, but swales along the east side of the road are inadequate to prevent road flooding in areas where cross culverts have not been installed.

Figure 6. Condition of the drop inlet (left) and outlet (right) of a cross culvert of a 1.5 ft circular PVC pipe. The pipe is partially deformed and blocked by debris.

Type of Issue #2: Ineffective Drainage and Ponding

The lower portion of Osceola Road (0.3 miles; R.PA-8) is a primarily flat gravel road with steep slopes upland, as shown in Figure 7. Runoff flows down Osceola Mountain and ponds in this section of the road because there are no drainage structures in place here to divert the runoff away from the road. The road is built on ledge and is surrounded by either private property or undeveloped land, with little room to detain water off the road.

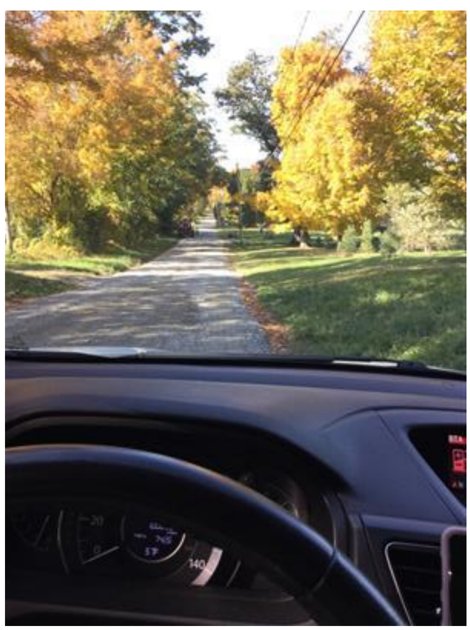


Figure 7. The gradient of the lower section of Osceola Road

A house on Dublin Road (R.PA-2) experiences flash flooding in their backyard during heavy rain events caused by increased runoff from Route 41 and a development along Perry Peak Road. Stormwater control is not sufficient on Perrys Peak Road and Route 41, causing flow across these roads to funnel down into the yard of 600 Dublin Road. Route 41 is a state-owned road and cannot be altered by the Town.

Type of Issue #3: Storm Drain Networks

A culvert crossing (WS.PA-12) in downtown West Stockbridge, on Main Street, goes under a house and two main roads before discharging to the Williams River. Upstream of the house, is another crossing under South Street and beyond that, there is ponding due to a large beaver dam. The culvert, as seen in Figure 8 below, under the house cannot support the amount of stormwater runoff from the surrounding hills during heavy rain events and floods the basement of the house and the yards adjacent. Flooding levels have been recorded as high as three (3) feet, as seen by water damage on a shed in the backyard. Flow patterns of water are etched in the backyard from past heavy storm events. The water does not follow the path of the stream into the culvert during storms.

Figure 8. The inlet to the culvert beneath a home in downtown West Stockbridge

Type of Issue #4: Stream Crossings

Several cross culverts and road-stream crossing culverts in both Towns have insufficient capacity to manage runoff (summarized in Table 6). The culvert capacity and height from water surface to road crown are a concern for these cross culverts and road-stream crossing culverts in Table 6, some of which have previously washed out. The culverts are too small to support the flow of water during heavy rain events leading to increased ponding at the inlet and eventual overflow onto the roads.

Table 6. Problem Areas for Type #4 Issues

Problem Area	Number of Culverts Investigated
R.PA-17 (Rossiter Road)	1
R.PA-19 (Rossiter Road)	1
R.PA-15 (West Road)	1
R.PA-16 (West Road)	1
R.PA-7 (Swamp Road)	1
R.PA-20 (Sleepy Hollow Road)	2
WS.PA-12 (Shaw Road)	1

Figure 9. Culvert crossing on Rossiter Road which experiences flooding during heavy rain events. The inlet (left) grating is partially covered by debris and the outlet (right) headwall may need further study.

In Richmond, a culvert on Swamp Road (R.PA-22), between Cheever Road and Stevens Glen Road, occasionally becomes blocked by debris during heavy rain events. According to the Town, this has not occurred since 2014. During the largest rain events, the stream flows at high velocities down the hill and bypasses the culvert to flow south along the edge of the Swamp Road, causing the road to erode. Town Beach Road (R.PA-6) in Richmond experiences a similar flooding issue. This culvert is immediately downstream of a large beaver dam that creates an impoundment in Nordine Swamp, which causes stormwater runoff to back up in the swamp and occasionally overtop the road. Reportedly, the downstream road, Shore Road, can have a backwatering effect that floods yards between Shore Road and Town Beach Road. Flooding is caused by backwatering from the pond or stream overflowing over the banks from beaver dam overtopping.

Figure 10. Two culverts on Sleepy Hollow Road experience flooding during heavy rain events.

Type of Issue #5: Dam-related Flooding

Dams are great at impounding water for extended periods of time. This is effective for flood storage but can also cause flooding upstream. Manmade dams generally have control systems to allow for drawdown when necessary, however beaver dams do not. Beaver dams can be a nuisance for causing flooding to adjacent property.

A road-stream crossing at Rossiter Road (R.PA-19) and at Sleepy Hollow Road (R.PA-20) in Richmond experiences flooding due to beaver activity. Beavers build dams at road-stream culverts causing impoundments to form where there would otherwise be free-flowing streams. During heavy rain events, the water levels in these impoundments rise and eventually overtop the roadway.

Several stream crossings in West Stockbridge, including along Smith Road (WS.PA-3) and two crossings along West Alford Road (WS.PA-8 and WS.PA-9) also experience flooding issues related to beaver activity. In the spring and fall, beavers clog the culvert at Smith Road. During heavy rain events or after snow melt, the clogged culvert backs up water levels in the wetland until the road is overtopped, sometimes by up to one foot of water. Erosion gullies up to two feet are also created as a result of the overtopping. Similar impacts have been observed at the two West Alford Road crossings. There is little freeboard between the culvert inverts on the upstream side and the road crown, making these crossings susceptible to roadway overtopping. There is a large beaver dam with a significant impoundment behind it just upstream of WS.PA-9. The water level in the impoundment is typically within a foot or two of the road crown.

Figure 10. Road-stream crossing culverts clogs by beavers along West Alford Road. WS.PA-8 (left) has an impoundment behind it. WS.PA-9 (right) has a small impoundment between it and a large beaver dam.

Existing Solutions: Success of Drop Inlets to Address Problem Areas

Pixley Hill Road (WS.PA-14 through WS.PA-17) in West Stockbridge was identified as a problem area and was investigated before and after the rain event. Weston & Sampson staff members documented erosion, drop inlets, driveway cross culverts, and other note-worthy findings along the two (2) mile road. This gravel road has steep slopes and abuts many residential properties.

The Town of West Stockbridge recently added drop inlets in portions of Pixley Hill Road to manage runoff. The 15 drop inlets located along the area of Pixley Hill Road just North of the Robin Road intersection appeared to be performing as intended after the rainfall event. An additional seven drop inlets were investigated after the rain event in the southern portion of Pixley Hill Road.

The condition of the road and the drop inlets largely remain the same before and after the rain event. One location where conditions differed was at the top of the hill in front of the first drop inlet. Water was ponded with a depth of 0.7 inches at the deepest point in the morning following the rain event. Figure 11 shows the pre- and post-rainfall conditions.

Figure 11. Pre-rainfall (left) and post-rainfall (right) show ponding in front of the first drop inlet in a series at a high point on Pixley Hill Road in West Stockbridge.

A small amount of flow was observed throughout the drop inlets going down the hill in the morning following the rain event (Figure 12). As shown in Figure 12, some inlets were dry prior to the rain event and contained leaves or other debris and sediment build up. The leaves in the drop inlet pictured appeared to have been flushed out during the rain event. Some drop inlets contained water prior to the rain event but the depth of water was typically less than that of the pipe invert so it could not flow out.

Figure 12. Photos taken inside of a drop inlet (#14) pre-rainfall event (left) and post-rainfall event (right) on Pixley Hill Road in West Stockbridge during field investigations on October 13-14, 2022.

There was minimal evidence that significant volumes of runoff were flowing across the road during the rain event. Figure 13 shows the difference before and after the rain event leading to a drop inlet as virtually undisturbed.

Figure 13. Photos taken looking uphill of drop inlet (#14) pre-rainfall event (left) and post-rainfall event (right) on Pixley Hill Road in West Stockbridge during field investigations on October 13-14, 2022.

Given the effective stormwater management performance observed by this existing drop inlet system, this strategy will be further considered for other problem areas and explored for potential coupling with nature-based solutions.

Road-Stream Crossings

The Road-Stream Crossing Management Plan[2] for each Town includes a comprehensive inventory of road-stream crossings; however, mapping and data collection of additional crossings was needed to fill gaps for improved accuracy of the planned H&H model. The existing inventory describes two crossings that have been replaced since the time of site visits completed for preparation of the Road-Stream Crossing Management Plan, so these were investigated.

During this field investigation, some other locations mapped during the Road-Stream Crossing Management Plan development were also visited to spot check that conditions had not changed. There were also a few crossings that HVA had not inventoried that were necessary for model development.

Field investigations included a total of 51 stream crossings within town, state, and private property, some of which were railroad crossings and abandoned road embankments. GPS location, shape,

[2] The Housatonic Valley Association. Town of Richmond Road-Stream Crossing Management Plan. 2022.
The Housatonic Valley Association. Town of West Stockbridge Road-Stream Crossing Management Plan. 2022.

number of barrels, dimensions (length and width, or diameter), and distances from invert to road crown were collected for each stream crossing. Additional information on habitat improvement potential, erosion, and condition was also noted. The information that was gathered is included in the GIS data, incorporated into the H&H model, and will be utilized to support recommendations.

Town of Richmond

Field investigations in Richmond included 33 stream crossings. Within the West Branch Housatonic River Watershed, 25 stream crossings were assessed. The remaining eight crossings are in the Upper Williams River Watershed. The sizes and types of crossings vary between one-foot diameter culverts and 38.5-foot span bridges.

Figure 14. Culvert near Lake Road (left), and culvert on Town Beach Road (right) in Richmond.

Town of West Stockbridge

Field investigations in the Town of West Stockbridge included 18 stream crossings. Seven crossings were visited in the Alford Brook (headwaters of the Green River) Watershed. The remaining 11 stream crossings in West Stockbridge are within the Williams River Watershed. The crossings ranged from two feet in diameter to 70-foot span bridges.

Figure 15. Flat Brook crossing with three barrels in West Stockbridge.

Stream Channels

The project scope included field investigations of stream channels, to help understand and document erosion issues and stream aggradation and capture measurements needed for the H&H modeling. Due to the topography, development patterns, and amount of open space, the streams do not have extensive erosion issues and generally have capacity to manage existing storm flows. The primary issues identified near streams are due to beaver activity or undersized culverts.

Every hydraulic model requires that a downstream boundary condition be defined for each watershed/stream. Typically, downstream boundary conditions are assigned constant water levels set to the peak water surface elevation predicted by the Federal Emergency Management Agency (FEMA) from their Flood Insurance Studies (FIS). In this case, no FEMA FIS are available, so Weston & Sampson staff collected downstream boundary conditions by completing a site visit and estimating slopes along the bottom of the stream channel in each of the following three locations:

1. At the West Stockbridge town line along Alford Brook (within the Green River Sub-basin);
2. At the West Stockbridge town line along the Williams River; and
3. Downstream of the Richmond Pond Dam along the West Branch Housatonic River.

Through conversations with municipal staff from both Richmond and West Stockbridge, it was determined that conducting comprehensive investigations of reported "problem areas", discussed earlier in this memorandum, instead of spending additional time evaluating stream channels, would provide the Towns with more valuable information. Thus, once model boundary conditions were established, additional stream channel investigations were not deemed necessary at this time.

West Stockbridge Town Hall Potential Demonstration Rain Garden Location(s)

Weston & Sampson visited the West Stockbridge Town Hall (21 State Line Road) to identify potential locations for installation of a demonstration rain garden (for Subtask 2.4). A rain garden can be described as "a depressed area in the landscape that collects rainwater from a roof, driveway, or street and allows it to soak into the ground." Planted with grasses and flowering perennials, rain gardens can be a cost effective and beautiful way to reduce runoff from a property. Rain gardens can also help filter out pollutants in runoff and provide food and shelter for butterflies, songbirds, and other wildlife.[3]

The installation of a demonstration rain garden is intended to help members of the community to see the benefit of and potential for employing small, site-scale stormwater management on their own properties. Residents and families will be invited to help with the planting, and a brochure will be developed to explain the benefits and include a how-to guide for landowners.

[3] https://www.epa.gov/soakuptherain/soak-rain-rain-gardens

Figure 16: West Stockbridge Town Hall Potential Rain Garden Location(s)
Image from MassMapper[4] using Property Tax Parcels[5] and 2021 Aerial Photography[6]

Based on the site visit, Weston & Sampson offers the following observations about potential locations for a demonstration rain garden:

- Area 1: Site Entrance – While there is a large lawn area between the building and State Line Road, the area is very flat, so there is limited flow from the access drive and other land areas to effectively capture and manage stormwater. It also does not appear to be a highly visited area. These two factors do not make this a favorable location for a demonstration rain garden.
- Area 2: Front of Town Hall – Downspouts from the building roof drain to this area. However, the front of the Town Hall is already nicely planted – installation of a rain garden would require removal of these plantings. There is also limited space between the building and the pavement – around 5 to 7 feet. These two factors do not make this a favorable location for a demonstration rain garden.
- Area 3: Parking / Courts / Skate Park – To the east of the Town Hall building lies a parking lot, courts, and skate park. The parking lot is relatively flat and currently has a low point in the paved area. There is no structural drainage system observable. Installation of a rain garden in this area would require re-grading the parking lot and potentially addition of structural drainage. The

[4] https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html
[5] https://www.mass.gov/info-details/massgis-data-property-tax-parcels
[6] https://www.mass.gov/info-details/massgis-data-2021-aerial-imagery

courts are also relatively flat as well and provide limited opportunity to create runoff entering a rain garden. These actors do not make this a favorable location for a demonstration rain garden.

- Area 4 and Area 5: Playing Fields – To the south of the Town Hall building are playing fields. These spaces are grassed and relatively flat and are also not close to impervious cover like parking, roofs, and roadways. While they are publicly-used locations, there is limited if any value in providing a rain garden in these areas.
- Area 6: Playground – There are safety concerns associated with installing a rain garden in the playground area. In addition, it is unclear from what area a rain garden would capture runoff. These two factors do not make this a favorable location for a demonstration rain garden.
- **Area 7: Walkway – There is a walkway that extends from this parking lot around the back of the building to the library and the playground. There is grassed space between the walkway and the building that would allow for capture of rainwater from the roof downspouts. This is an ideal demonstration location as it is highly visible, minimizes disturbance to structures and paved areas, and downspout piping can easily be modified to direct rainwater from the roof into the demonstration rain garden(s).**
- Area 8: East Side of Building – When facing the Town Hall, to the left side of the building is police access and parking. It appears this space is mostly utilized by municipal employees and few visitors would traverse this side of the building. These factors do not make this a favorable location for a demonstration rain garden.

The following images show the potential spaces for rain gardens in Area 7 along the walkway.

Figure 17. West Stockbridge Town Hall Potential Rain Garden Location #1
Looking east from parking lot towards Town Hall building

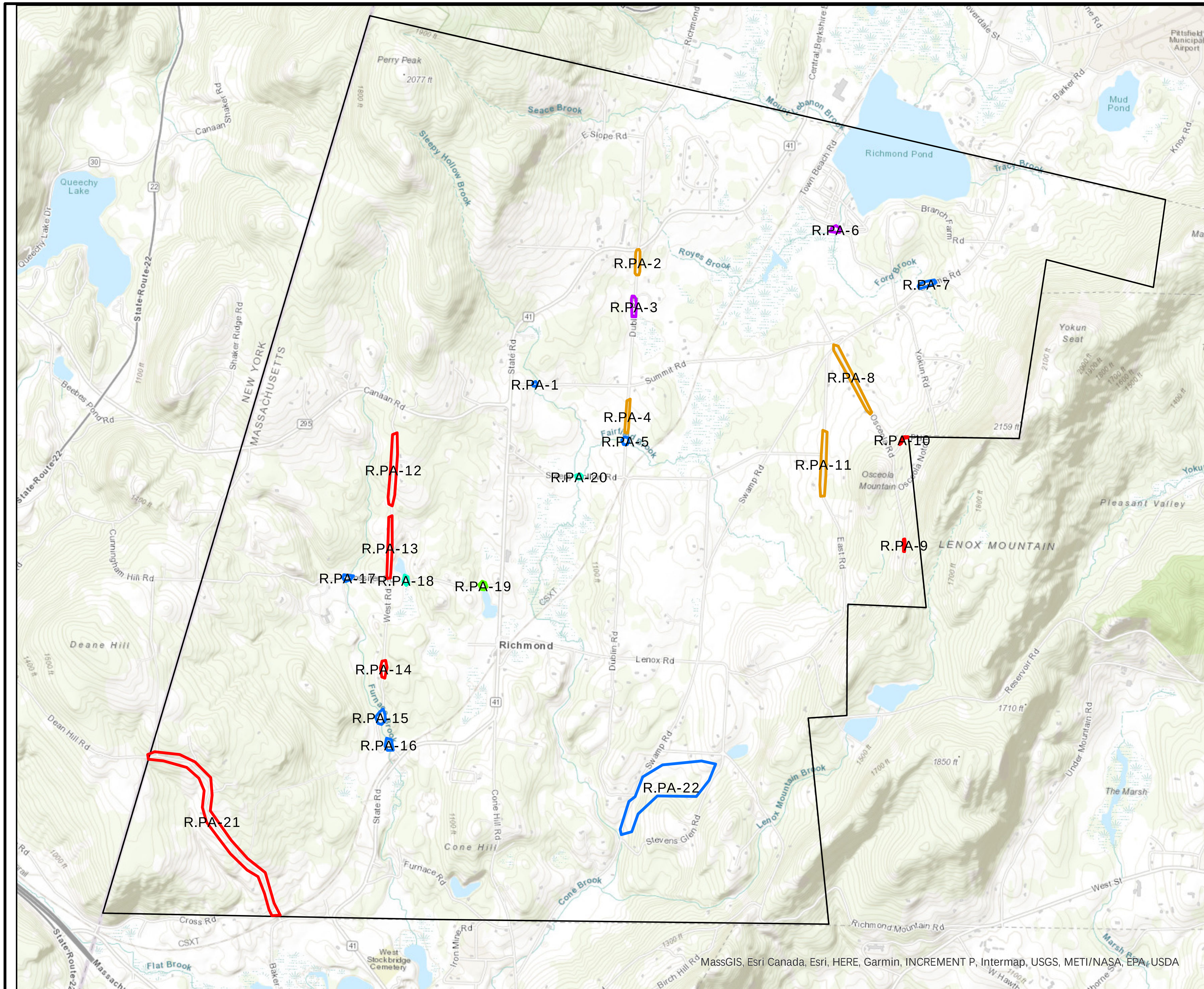
Weston & Sampson

Figure 18. West Stockbridge Town Hall Potential Rain Garden Location #1
Looking north-east from walkway towards Town Hall building

Figure 19. West Stockbridge Town Hall Potential Rain Garden Location #2
Looking east towards Town Hall building from walkway close to Library entrance

Attachment A

Problem Areas (Maps)



Problem Areas

Problem Type

- Dam-related issues
- Ineffective conveyance on steep slopes
- Ineffective drainage and ponding
- Stream crossing
- Stream crossing / dam-related issues
- Stream crossing / ineffective drainage and ponding
- Storm drain networks

N

0.07 0.03 0 0.07 0.13 0.2 0.26 Miles

FIGURE 1

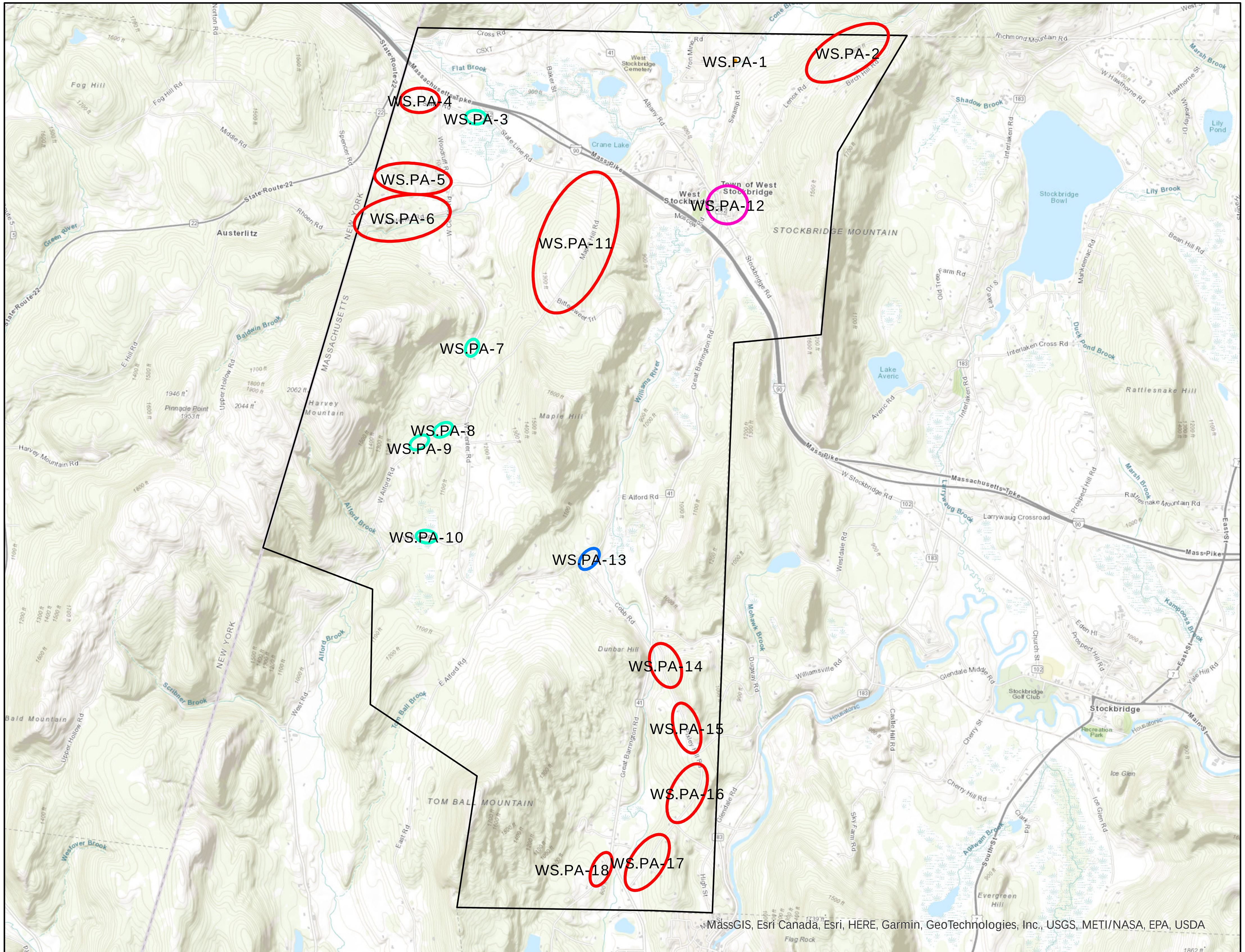
TOWN OF RICHMOND, MA
RICHMOND/WEST STOCKBRIDGE MVP FY23

RICHMOND PROBLEM AREAS

DECEMBER 2022 SCALE: NOTED

Weston & Sampson

Path: \\wse03.local\WSE\Projects\MA\Richmond MA\Richmond-W Stockbridge MVP Stormwater Plan\Task 3-RA\SP\3.3-Modeling\GIS\Maps\files\MVP_Stockbridge_and_Richmond\MVP_Stockbridge_and_Richmond_TM.aprx User: LambertD Saved: 1/6/2023 9:47 AM Opened: 1/6/2023 9:51 AM



Problem Areas

Problem Type

- Dam-related issues
- Ineffective conveyance on steep slopes
- Ineffective drainage and ponding
- Stream crossing
- Stream crossing / dam-related issues
- Stream crossing / ineffective drainage and ponding
- Storm drain networks

N

0.07 0.03 0 0.07 0.13 0.2 0.26 Miles

FIGURE 2

TOWN OF WEST STOCKBRIDGE, MA
RICHMOND/WEST STOCKBRIDGE MVP FY23

WEST STOCKBRIDGE PROBLEM AREAS

DECEMBER 2022 SCALE: NOTED

Weston & Sampson

APPENDIX C

Model Update, Integration, and Calibration

westonandsampson.com

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Reading, MA 01867
tel: 978.532.1900

REPORT

March 2023

TOWNS OF

Richmond and West Stockbridge

MASSACHUSETTS

Richmond and West Stockbridge Town-Wide Hydrologic and Hydraulic Assessment

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

P:\MA\Richmond MA\Richmond-W Stockbridge MVP Stormwater Plan\Task 3-RAISP\3.3-Modeling\Report\H&H Report DRAFT rev4.docx

EXECUTIVE SUMMARY

In support of developing the Resilient Stormwater Action and Implementation Plan for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson performed detailed hydrologic and hydraulic (H&H) analyses of the three watersheds within the towns' limits, those of the Williams River, Alford Brook, and Richmond Pond. Those analyses were conducted through the development of a stormwater model, employing the EPA's Storm Water Management Model.

As documented in Section 2, the stormwater model was developed through a combination of publicly available reports and GIS databases, existing information provided by the Towns, several studies and reports including a recent study by the Housatonic Valley Association, and through field measurements taken by Weston & Sampson. The model was subsequently calibrated against historical streamflow observations recorded by a USGS gage on the nearby Green River during Tropical Storm Irene and against anecdotal reports by town staff and residents of the location, magnitude, and frequency of known floodprone areas.

Despite limitations of the stormwater model, common to all such models and described in detail in Section 4.2, the model provides a reliable means to understand present and future flood risk in both Richmond and West Stockbridge and to test the efficacy of potential flood reduction solutions.

Evaluation of flooding impacts associated with baseline climate conditions and with a 2070 climate scenario are summarized in Section 3. Tables 4 and 5 as well as Figure 3 through 6 are particularly informative and focus on the number of impacted buildings and the number and severity of impacts to road-stream crossings from flooding events. The key findings of the stormwater model-based analyses are:

- Both communities experience flood risk and flood impacts in multiple watersheds, particularly during storm events with a recurrence interval of ten years or greater.
- The increased rainfall totals associated with a 2070 climate scenario appear not to have a significant effect on flooding impacts during the frequent 2-year design storms and have only a modest impact during 10-year design storms.
- During more extreme design storms, typified by the 100-year event, the simulated flood risk and anticipated impacts are dramatically greater under a 2070 climate scenario than they are under a baseline climate.

Under future deliverables, namely the Task 3.4 Development and Evaluation of Nature-Based Solutions Report, Weston & Sampson will summarize the effectiveness of a wide range of potential solutions for flood reduction, ranging from the construction of additional flood storage, nature-based solutions, including the use of green infrastructure, and more.

1.0 INTRODUCTION

In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson performed detailed hydrologic and hydraulic (H&H) analyses of the three watersheds within the towns' limits: the Williams River, Alford Brook, and Richmond Pond watersheds.

Detailed H&H analyses of those three watersheds were conducted through the development of a stormwater model, constructed to help answer three questions:

1. What are the frequency, magnitude, extents, depths, and impacts to homes and infrastructure under a baseline climate and existing watershed conditions?
2. How might the scale of flooding and the associated impacts change under future climate scenarios if no action is taken in the watersheds?
3. And how effective are various potential solutions at addressing flooding impacts under both the baseline climate and future climate scenarios?

The results of model solutions aimed at answering the first two questions are presented in Section 3. The effectiveness of various flood reduction projects and potential solutions will be summarized under separate cover in the Task 3.4 Development and Evaluation of Nature-Based Solutions Report.

The stormwater model employs the EPA's Storm Water Management Model (SWMM), v.5.1.015. SWMM combines hydrologic rainfall-routing methods with river reach and pipe flow routing hydraulic methodologies. The SWMM-based stormwater model was developed using PCSWMM, a state-of-the-art 3rd party software platform developed by Computational Hydraulics International (CHI). The core of PCSWMM's functionality is derived from its use of SWMM, but it also includes several suites of tools to streamline the preprocessing of input parameters and the postprocessing of model results as well as integration with Geospatial Information Systems (GIS). It also includes additional capabilities to represent 2D flowpaths and floodplain storage in a more dynamic manner than a basic SWMM model. A detailed discussion of the model development process is described in Section 2.

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2.0 MODEL DEVELOPMENT

2.1 Overview

The PCSWMM stormwater model consists of several different components, including subcatchments to reflect the land's response to rainfall; storage nodes to reflect significant flood storage in wetlands and ponds; conduits to represent stream channels, stormwater drains, culverts, ditches, dam spillways and crests, and other natural and manmade features that carry runoff; junctions to represent stream banks and catch basins; and a detailed 2D mesh to represent the flood storage and conveyance capacity of the floodplains associated with the three watersheds and their tributaries. Development of each of those components are described in detail in this section.

Development of the stormwater model relied upon data from a wide variety of sources, including federal and state agencies and GIS clearinghouses, town-provided data, and anecdotal reports of flooding and stormwater management concerns by town staff and citizenry. In addition, Weston & Sampson conducted numerous site investigations in both communities, often alongside town staff, between October 10th and October 14th, 2022, with the goal of filling any remaining data gaps not filled by existing datasets and to observe and understand the extents and potential causes and solutions of areas and infrastructure prone to flooding and erosion. For additional details on the field investigations, refer to our Field Data Collection Summary Memorandum, dated December 8, 2022.

Following initial development of the stormwater model's geometry, Weston & Sampson calibrated the model based on existing data and field investigations to ensure that it produces reliable output, which can be used to support watershed planning and decision making. A detailed description of the model calibration process is described near the end of this section.

2.2 Subcatchments

The entire study area is approximately 31,864 acres (49.8 square miles), with subcatchments ranging in size from 140 square feet to 4,338 acres. The land surface within the Williams River, Alford Brook, and Richmond Pond watersheds is represented by a series of 764 subcatchments. Refer to Figure 1 for a map of the modeled watersheds. The subcatchments were delineated based on watershed hydrology, the location of waterbodies, land use patterns, project goals, and potential future modeling needs. Subcatchments were delineated using LiDAR and a suite of tools in the Spatial Analyst toolkit in ArcGIS. The delineations were then hand-checked and modified to account for existing stormwater infrastructure that might redirect flows. The area of each subcatchment controls the volume of rainfall landing on its land surface while its location within the larger watershed affects the estimation of several other subcatchment characteristics.

SWMM-based models like this one generally calculate runoff from a subcatchment for impervious surfaces and pervious surfaces independently as they can have vastly different runoff patterns. Impervious surfaces were identified from a combination of the State of Massachusetts' impervious surface and building footprints GIS as well as through visual review of the latest aerial imagery of the study area. The entire study area consists of approximately 2.7% impervious surfaces, comprised primarily of rooftops, roadways, and parking lots, with individual subcatchment impervious cover percentages ranging from 0 to 100%.

The Green-Ampt method was used for estimating subcatchment infiltration rates and, therefore, what rainfall remained stored within the subcatchment as opposed to that which would run off from each subcatchment's pervious portion. Using this method, a hydraulic conductivity, suction head, and initial deficit were established for each subcatchment based on the soil classes present. Soil classes were obtained from the USDA's latest Soil Survey for the region.

Subcatchments were further defined by impervious and pervious storage coefficients, which represent depression storage within a subcatchment. Examples of impervious storage are roadway potholes, isolated low spots in parking lots, and rain barrels fed from rooftops. Examples of pervious storage are vernal pools, spaces between row crops, ditches alongside driveways, and the many small pockets of water that naturally occur in grasslands and woodlands during heavy rain events. The values assigned to these parameters were estimated from each subcatchment's land uses as defined from the latest National Land Cover Database for the region.

Rainfall not infiltrated or stored within a subcatchment is then simulated to run off, thereby leaving the subcatchment. The rate of runoff from each subcatchment is affected by a subcatchment's length and a surface roughness. These two parameters were estimated from LiDAR and from the National Land Cover Database.

2.3 Storage Nodes

Large ponds, reservoirs, wetlands, and other impoundments were incorporated into the stormwater model as storage nodes in order to reflect their outsized impact on runoff hydrographs. A total of 14 such storage nodes were incorporated, including one in Lenox, seven in Richmond, and six in West Stockbridge. Each reservoir is defined by a stage-storage curve, developed from LiDAR at 1-foot intervals above the normal waterline, and by an outlet or outlets, which were defined from our field measurements. Note that many other significant flood storage areas within the watershed are not incorporated as storage nodes but instead are incorporated into the 2D mesh described later in this section, given their close proximity to the modeled waterways and floodplains.

2.4 Conduits

SWMM-based stormwater models use "conduits" to represent a wide range of runoff conveyance structures and geometries, ranging from round storm drains to rectangular spillways to complex stream channel cross-sections. In total, 897 conduits were incorporated into the model. In general, this stormwater model represents four types of conduits: storm drains, culverts and bridges, manmade and naturally occurring channels, and dam spillways. Figure 2 presents a map of the tributaries to the Williams River, Alford Brook, and Richmond Pond watersheds that were incorporated into the model and the locations of model junctions, storage nodes, and conduits.

To represent both towns' existing stormwater infrastructure, Weston & Sampson first reviewed Town-provided maps on which each Town marked-up approximate locations of existing stormwater infrastructure, providing the layout, material, and dimensions for many storm drains, cross-culverts, and road-stream crossing culverts. Weston & Sampson also reviewed the Road-Stream Crossing Management Plans (RSCMP) for each town, produced by the Housatonic Valley Association (HVA). As part of these plans, HVA conducted culvert assessments in accordance with the North Atlantic Aquatic Connectivity Collaborative's (NAACC) protocol for non-tidal stream crossings, which contain road-stream crossing culvert dimensions and invert depths for Town-owned and maintained culverts. Weston

& Sampson was also able to obtain some road-stream crossing data from MassDOT's database of state-owned structures.

Dimensions of dams and their outlet structures were obtained, where possible, from the latest Phase I Dam Safety Inspection reports on file with the Office of Dam Safety and from the latest available LiDAR. The dimensions of stream channels were obtained and/or estimated from FEMA Flood Insurance Studies, if available, from the latest LiDAR, and from aerial imagery. As noted previously, where our understanding of the connectivity or the size and shape of natural waterways or existing road crossings, dams, or stormwater infrastructure was insufficient, those data gaps were filled through an extensive field investigation.

Typically, beaver dams are not incorporated into town-wide stormwater models; however, Weston & Sampson understands that beaver activity has historically had a significant impact on the frequency and severity of flooding at some road crossings and in some floodplains. Based on an extensive review of aerial imagery, anecdotal reports, and LiDAR, we have attempted to incorporate the largest and most durable beaver dams directly into the model. Smaller beaver dams or dams that historical aerial imagery suggests are prone to frequent failures and realignments were not included.

2.5 Junctions

SWMM-based stormwater models use "junctions" to represent manholes, catch basins, and other such structures. Junctions also represent the upstream and downstream faces of dams, road-stream crossings, or points where there are significant changes in the shape or slope of channels and infrastructure in the incorporated conduits. Primarily, junctions are used to define the vertical profile of channels and pipes and to represent the confluence of two streams or the outfall of a piped stormwater network into a surface waterbody. Junctions are defined through two inputs, a rim elevation, and an invert elevation.

Rim elevations were generally estimated from LiDAR and used to represent ground surfaces at manholes and catch basins, dam crest and roadway overtopping elevations, and the top of bank elevation for open channels and roadside drainage swales or ditches. Invert elevations were generally estimated by subtracting the vertical heights of various "conduits" from the corresponding rim elevation. For instance, in the case of a junction immediately upstream of a road-stream crossing, the roadway-overtopping elevation was estimated from LiDAR or other existing information. The vertical height was obtained from existing information like the HVA Study or from our field measurements. The invert elevation upstream of that crossing was estimated by subtracting the embankment height from the estimated roadway elevation. This technique and others like it were used to incorporate a total of 646 junctions into the model.

2.6 2D Model Development

Following completion of the 1D framework, consisting of subcatchments, storage nodes, conduits, and junctions, Weston & Sampson developed and overlaid a 2D mesh over those 1D components. The 2D mesh serves two purposes: first, to account for floodplain storage, and second, to reflect the conveyance capacity of the floodplains. The 2D mesh also increases the accuracy and usefulness of the model output with regard to flooding extents, depths, flow directions, and velocities within the river channels and floodplains. The extents of the 2D mesh used in the Williams River, Alford Brook, and Richmond Pond watersheds are shown in Figure 1. The 2D mesh was created with variable resolutions based on the level of development and the potential for impacts to structures and infrastructure within the represented area. For instance, more developed areas and areas with a history of flooding are modeled with finer resolutions to provide greater detail while large wetlands and open waterbodies have coarser resolutions to reduce model run times. In total, nearly 20,000 2D cells were incorporated into the model to represent flooding extents, depths, and conveyance capacity of floodprone areas.

2.7 Downstream Boundary Conditions

Like most hydraulic models, this SWMM-based stormwater model requires that a downstream boundary condition be defined for each watershed. The model includes four downstream boundary conditions: one at the West Stockbridge town boundary along the Williams River, one at the West Stockbridge town boundary along Alford Brook, one downstream of Richmond Pond Dam, and one downstream of the Interprint, Inc. driveway in Pittsfield where Mount Lebanon Brook bypasses Richmond Pond during high flow events. These four downstream limits were modeled with the "normal depth" boundary conditions, which assumes that the slope of the water surface matches the slope of the channel bottom. The channel slopes required for this boundary conditions were measured during Weston & Sampson's field investigations.

2.8 Model Calibration

To improve the accuracy and reliability of the stormwater model's results, Weston & Sampson calibrated the model, by iteratively modifying model input parameters to maximize agreement between simulation results and historical observations. The calibration event selected for this model was Tropical Storm Irene, which occurred in August 2011, when 4.6 inches of rain fell over an approximate 24-hour period. This storm was selected over two other events that produced high river discharge because its rainfall depth and intensity most closely matched the range of design conditions for which the stormwater model was intended to evaluate.

Calibration was completed using two datasets of historical conditions: observed streamflow at USGS Gage 01198000 in the nearby Green River watershed and anecdotal flooding information collected through Town staff and public surveys. Calibrating stormwater models to 15-minute USGS flow data can be useful in ensuring that the total volume, peak rate, and the timing of a watershed's simulated rainfall-runoff response matches historical measurements. Critically, this method assumes that the watershed upstream of the USGS gage is of a similar character (e.g., size, shape, geology, extents of ponds and wetlands) to the modeled watershed(s). Table 1 summarizes the characteristics of the Green River and several key subwatersheds within the model.

Table 1: Watershed Characteristics

Watershed	Drainage Area (mi.^{2})	% Wetlands*	% Forest*	Average Slope (%)*
Green River	51.1	3.0	78.2	14.6
Furnace Brook	5.5	6.4	69.7	10.1
Alford Brook	3.4	5.4	74.2	15.7
Richmond Pond	7.0	10.0	55.8	12.0

** These values were collected from the web based USGS StreamStats Tool.*

As shown in Table 1, the Green River watershed upstream of the USGS gage is significantly larger than any of the three watersheds focused on during the calibration process. These differences were accommodated in part by area-weighting the USGS streamflow data based on the ratio of its size compared to that of each of the Furnace Brook, Alford Brook, and Richmond Pond watersheds, respectively. The slopes of the three project watersheds and the Green River are relatively similar, all between 10 and 16%. The prevalence of wetlands and forests is also relatively similar among three of the watersheds, but not for the Richmond Pond watershed. Its notably smaller forested area and greater wetland presence are due to the size of the pond surface itself. This potential complicating factor was minimized by focusing calibration efforts at the upstream edge of the pond, rather than at the outlet to the pond.

Note that of the three watersheds incorporated into the Richmond-West Stockbridge stormwater model, the Williams River is not specifically called out in Table 1. Instead, that watershed was represented by one of its smaller headwaters, Furnace Brook, because the presence of significant wetland and near-stream storage in the middle and lower reaches of the Williams River give it a significantly different character than the Green River watershed, complicating the calibration process. Focusing on just the Furnace Brook subwatershed allowed for more reliable model calibration for the Williams River watershed.

Through an iterative process, subcatchment parameters were altered to maximize agreement between model results and observed conditions. Subcatchment parameters altered included:

- Hydraulic conductivity and related parameters that control how readily rainfall infiltrates into the soil;
- Storage coefficients that control to what extent runoff is temporarily caught and held by small depressions in the land surface;
- Roughness coefficients and subcatchment dimensions that control how long it takes runoff to travel downhill to surface waterbodies; and
- Percent impervious to reflect the fact that impervious surface runoff behaves differently if it runs off onto nearby pervious surfaces as opposed to into a surface waterbody or storm drain.

After each iteration, simulation results were compared to area-weighted USGS gage data at three locations: the downstream end of Alford Brook in West Stockbridge, the upstream border of Richmond Pond, and the Furnace Brook Road crossing in the Williams River watershed in Richmond. After dozens of iterations, model input parameters were adjusted sufficiently where the model is reproducing area-weighted peak streamflow observations to within ±20%, a typical threshold for considering a model calibrated. Table 2 summarizes calibration results.

Table 2: Calibration Results

Watershed	Simulated Peak Flow (cfs)	Area-Weighted USGS Peak Flow (cfs)	% Deviation
Green River	–	–	–
Furnace Brook	798	877	9.0
Alford Brook	430	490	12.2
Richmond Pond	772	945	18.3

In addition to calibrating against historical USGS streamflow data, the Tropical Storm Irene calibration event simulations results were also compared against anecdotal reports of flooding throughout the watershed. In contrast to the USGS streamflow data-based approach, calibrating against anecdotal information is generally helpful in ensuring that the frequency and magnitude of historical flooding impacts is reproduced by the model. This method of calibration tends to be less precise and can be obfuscated by temporary or sudden changes in conditions like debris buildup, beaver activity, and slope failure, but requires making no assumption about watershed characteristics. It is useful to employ both methods when calibrating an H&H model such as this one.

A road-by-road summary of the anecdotal, observations-based calibration effort follows:

Richmond

- Summit Road experiences approximately 3 inches of flooding, consistent with anecdotal depth information.
- The original Swamp Road embankment, which has been subject to frequent overtopping events, overtops by 0.5 feet in the model.
- The West Road crossings do not overtop but do have less than 1.0 feet of freeboard in the model. Both crossings have experienced significant clogging during past floods, which would be expected to result in modeled overtopping.
- The Rossiter Road crossings do not overtop in the model; however anecdotal reports suggest that historical flooding was likely caused by clogging, which is not modeled. Limited modeled freeboard suggests that clogging would likely cause flooding.
- Sleepy Hollow Road experiences 0.5 feet of flooding, consistent with anecdotal flooding reports.
- Dublin Road crossings do not overtop in the model. However, flooding at the northern crossings are likely caused by downstream swamp silting and backwatering while flooding at the southern crossing appears to be caused by intermittent beaver activity, transient hydraulic conditions not incorporated into the model.
- Town Beach Road does not overtop in the model. A known cause of historical flooding is not noted in anecdotal reports. Flooding may have been influenced by beaver activity.

West Stockbridge

- Both West Alford Road crossings flood, one by 2.0 feet and one by 0.2 feet, generally matching anecdotal reports.
- Smith Road is simulated to overtop by approximately 0.1 feet near the intersection with State line Road. Anecdotal reports noted about 1 foot overtopping during Irene. Much of the discrepancy is likely attributed to reports of significant clogging.
- Wilson Road does not overtop in the model; however anecdotal reports suggest that historical flooding (of 1.0+ feet) was likely caused by clogging, which is not modeled. Limited modeled freeboard suggest that clogging would likely cause flooding.
- Shaw Road does not overtop in the model; however anecdotal reports suggest that historical flooding was likely caused by clogging, which is not modeled. Limited modeled freeboard suggest that clogging would likely cause flooding.

As noted above, in many cases, observed flooding of roadways in both communities is caused by or exacerbated by debris or sediment blocking or limiting the hydraulic capacity of the culverts conveying runoff beneath those roadways. Those transient conditions were not incorporated into the model geometry so that simulation results can be used to understand the true potential capacity of the channels and road crossings within these two communities and how those capacities might change under future climate scenarios.

Backwatering from beaver activity is also to blame in some cases. We made an effort to incorporate beaver and debris dams into the model geometry where such dams are relatively large and have consistently been in a similar position for years or even decades. In some cases, smaller or more transient beaver dams were not incorporated, affecting the model's ability to reproduce anecdotal flooding observations, such as at Dublin Road in Richmond.

However, in general, based on both calibration efforts, using USGS streamflow observations during Tropical Storm Irene and using anecdotal reports of flooding magnitudes and frequencies, this stormwater model is considered calibrated and represents a powerful tool with which to evaluate existing conditions as well as the impact of future climate scenarios and potential solutions on flooding.

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3.0 MODEL RESULTS

3.1 Design Storm Events

Design storm events are defined as hypothetical storm events of a depth of rainfall that would occur for the stated return frequency (i.e. once every 2 years or 10 years), duration (i.e 24-hours) and timing of distribution (i.e. NOAA 14 temporal distribution). These are based on the historical rainfall records for the area and can be used to calculate the water volume and peak flow rates that can occur in a system.

Given the scope of the project, the 2-, 10-, and 100-year storms were selected as appropriate design events. Given the size of the watershed, those design events were assumed to take place over 24 hours. Weston & Sampson modeled design events under both baseline climate conditions and a 2070 climate scenario. Design rainfall depths and their distribution over the course of a 24-hour event under baseline climate conditions were derived from NOAA's Atlas 14: Precipitation-Frequency Atlas of the United States for Stormwater Management (NOAA 14). NOAA 14 values represent the industry-standard design rainfall depths for events under a late-1900s/early 2000s (baseline) climate condition.

To determine future design storm depths, Weston & Sampson utilized used the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA's) Climate Resilience Design Standards Tool, which employs a methodology developed for the State of Massachusetts as part of their ResilientMA initiative, specifically "Climate Resilience Design Standards & Guidance by EEA, July 2022." As detailed in that guidance document, a detailed analysis of design storm projections using three different methodologies was conducted for nine locations across Massachusetts, using an ensemble of climate models of the RCP 8.5 emission scenario (the greenhouse gas emission scenario that EEA has selected to use). Based on this analysis, EEA selected the Cornell University-derived methodology as the basis for projections included in the Climate Resilience Design Standards Tool. The calculated rainfall depths for the 2070 climate scenario and their baseline climate counterparts are presented in Table 3.

Table 3: Design Rainfall Depths

24-hour Design Event	Design Rainfall Depth (in) by Climate Scenario	
	Baseline	Estimated 2070
2-year	2.95	4.0
10-year	4.76	6.5
100-year	7.65	10.5

3.2 Model Outputs

Using the stormwater model and design storm events described in Section 2 to simulate the six design storm events identified above, Weston & Sampson evaluated anticipated flooding impacts in the Williams River, Alford Brook, and Richmond Pond watersheds in an effort to answer the first two questions identified in Section 1, namely:

1. What are the frequency, magnitude, extents, depths, and impacts to homes and infrastructure under a baseline climate and existing watershed conditions?
2. How might the scale of flooding and the associated impacts change under future climate scenarios, if no action is taken in the watersheds?

PCSWMM-based stormwater models produce a wide array of model outputs, including flooding extents, depths of flooding, duration of flooding, flow rates, velocities, and more. To assess how flooding impacts vary between design storms and between climate scenarios, Weston & Sampson used the simulated flooding extents to estimate the number of impacted buildings and the simulated flood depths to understand potential impacts to road-stream crossings in both communities.

3.3 Buildings Impacted by Flooding

The number of buildings impacted by a design storm event is a useful metric for summarizing Town- or watershed-wide stormwater modeling results and flood risks as it provides a representation of the scale of flooding and the potential danger for loss of life that is meaningful to a wide range of audiences. Buildings were considered to be impacted by floodwaters generated during a given design storm event if they were located within 2D cells that simulations show would become inundated.

Note that PCSWMM assumes a 2D cell will become inundated if more than half of the terrain within the cell is below the water surface elevation simulated in that cell. We have purposefully developed the model's 2D mesh to have particularly small and detailed cells in developed areas and to generate the 2D cell boundaries in a way that minimizes the likelihood of sudden grade changes within a single cell. This is to address the potential within this methodology to overestimate the number of impacted or threatened buildings located in areas with particularly steep slopes or abrupt changes in ground elevation, if buildings are located at higher elevations at the edge of a 2D cell while the majority of the cell overlays relatively low-lying floodplain. Despite these precautions, the output provided by PCSWMM and the method used to interpret that output can overestimate the number of buildings impacted. Given the goals of the study, this modest level of conservatism is appropriate.

Using this approach, the number of buildings likely to be impacted for each of the six design storm events is summarized in Table 4, below. The locations of the buildings are also shown in Figures 3 through 6, representing the Richmond Pond watershed, the Williams River watershed in Richmond, the Williams River watershed in West Stockbridge, and the Alford Brook watershed, respectively.

Table 4: Buildings Impacted by Design Storm and Climate Scenario

Town	Watershed	Event	# Buildings Impacted		Change in # by 2070 (% Increase)
			Baseline	2070	
Richmond	Richmond Pond	2-year	13	13	0%
		10-year	13	13	0%
		100-year	14	16	14%
	Williams River	2-year	6	6	0%
		10-year	6	8	33%
		100-year	9	16	78%
West Stockbridge	Alford Brook	2-year	0	0	---
		10-year	0	0	---
		100-year	0	0	---
	Williams River	2-year	23	25	9%
		10-year	25	31	24%

		100-year	31	53	71%

In the Richmond Pond watershed, the number of impacted buildings changes very little as the design storm recurrence interval increases or as the design rainfall depth increases under a future climate scenario. Most of the buildings impacted in this watershed are located along the shore of Richmond Pond itself rather than one of its tributaries or a smaller upland pond or wetland. It appears that the large storage volume offered by Richmond Pond may buffer additional homes from becoming impacted. If the dam is modified in the future to comply with the State's dam safety regulations (as design storms increase), it may be beneficial to re-evaluate the potential impacts to structures around the pond.

In contrast, model simulations indicate that the number of impacted buildings in the Williams River watershed is in fact influenced by the size of the design storm and the climate condition, particularly at the 10-year and 100-year recurrence intervals, to a greater degree than the Richmond Pond watershed. For instance, at the 10-year recurrence interval, comparing a baseline climate to a future climate scenario with greater rainfall, the number of impacted buildings is expected to increase by 33% in Richmond and by 24% in West Stockbridge. Those increases are even greater during extreme floods like the 100-year event, in which the number of impacted buildings is expected to nearly double.

3.4 Roadway Impacts from Flooding

In addition to the potential risk to buildings, it is also useful to evaluate the flood risk posed by various design storms and climate scenarios by comparing the impacts to road-stream crossings. Particularly in more rural communities like Richmond and West Stockbridge, road-stream crossings being destroyed or unavailable for extended periods of time can have an outsized impact on emergency response times and planning and on residents' ability to safely travel to and from their homes. Impacts to road-stream crossings were estimated for each of the six design events by comparing simulated flood elevations to estimated roadway elevations as estimated during Weston & Sampson's field investigations or as reported in the HVA Study.

As discussed at the end of the Model Calibration discussion in Section 2.8, in developing this stormwater model, Weston & Sampson took care to incorporate the presence of many of the large and durable beaver dams that can be found without the study area because of their proven impact on flood levels and stream crossings. However, it was not feasible to model some of the smaller beaver dams or the various temporary debris dams, sediment erosion and deposition features, and other transient conditions that have historically reduced culvert capacity and affected the severity of flooding. As a result, simulated flood impacts to road-stream crossings may be fewer and less severe than has historically occurred.

In light of that limitation of the model and given the goal of this report and this study as a whole – to understand flood risk in both communities and how that risk may change over time, we have classified any road- or rail-stream crossing that overtops or has less than one foot of freeboard, the distance from the roadway down to the water surface, as "more floodprone." Other crossings were classified as "less floodprone." Figures 3 through 6 identify all modeled stream crossings and whether they were classified as more or less floodprone in the Richmond Pond, Williams River (Richmond), Williams River (West Stockbridge), and Alford Brook watersheds, respectively.

Table 5 below provides greater detail on the frequency and magnitude of potential impacts to stream crossings. While more than 100 stream crossings, including public and private roadways as well as active and abandoned railbeds, are incorporated in the stormwater model, not all were simulated to experience overtopping or significantly reduced freeboard. For readability, Table 5 includes only those structures classified as "more floodprone." Note that the impacts to each floodprone roadway are classified by their severity, as determined from their simulated flood depths/freeboards. The legend immediately below the table defines each of the five unique impacts classifications. Note also that the Model ID for each of the more floodprone crossings in Table 5 is also used to label those structures in Figures 3 through 6.

Table 5: Stream Crossing Impacts by Design Storm and Climate Scenario

Town	Watershed	Model ID	Location Name	* Impacts by Design Storm / Climate Scenario					
				2-year		10-year		100-year	
				Baseline	2070	Baseline	2070	Baseline	2070
Richmond	Richmond Pond	510	Former Swamp Road	1	1	1	3	3	3
		506	Swamp Road (near Cemetery Road)	1	1	1	1	1	2
		349	Swamp Road (near East Road intersection)	1	1	1	1	1	3
		523	Dublin Road (near Pittsfield town line)	1	1	1	1	1	2
	Williams River	246	Sleepy Hollow Road	1	1	1	3	3	4
		417	Rossiter Road (near State Road intersection)	1	1	1	3	4	5
		410	Private Driveway #1	1	1	1	2	3	3
		408	Rossiter Road (2000 ft west of West Road)	1	1	1	2	3	3
		250	Swamp Road (near East Road intersection)	1	1	1	1	2	3
		364	Summit Road (1,500 feet east of Dublin Road)	1	1	1	1	1	2
		391	Private Driveway #2	1	1	1	1	1	2
		244	Lenox Road	1	1	1	1	1	3
		285	West Road (south)	1	1	1	1	1	2
		513	Canaan Road	1	1	1	1	1	2
		370	State Road (near Summit Road intersection)	1	1	1	1	1	5
		289	State Road (near Richmond Library)	1	1	1	1	1	3
		252	Summit Road (near State Road intersection)	1	1	1	1	1	2
West Stockbridge	Alford Brook	496	West Alford Road (west)	1	1	1	1	2	3
		551	Easland Road	1	1	1	1	1	3
		491	West Alford Road (east)	1	1	1	1	1	4
	Williams River	298	Former RR #2	3	3	3	3	3	4
		297	Former RR #1	1	2	2	3	3	4
		450	South Street	1	2	3	3	4	5
		309	Baker Street	1	1	1	2	2	4
		314	Private Driveway #3	1	1	1	2	3	5
		443	West Center Road	1	1	1	1	2	3
		296	State Line Road	1	1	1	1	1	2
		295	I-90 Access Road	1	1	1	1	1	4
		320	Albany Road	1	1	1	1	1	2
		425	Van Schaack Road	1	1	1	1	1	5
		469	Quarry Road	1	1	1	1	1	3

**Stream crossing impact definitions:*

1 = Greater than 1 foot of freeboard; impacts unlikely
2 = Less than 1 foot of freeboard; temporary capacity restrictions may affect roadway impacts/usage
3 = Overtopping of less than 0.5 feet; emergency vehicle access potentially maintained
4 = Overtopping of between 0.5 and 1 feet; no emergency vehicle access likely
5 = Overtopping of more than 1 foot; embankment failure or permanent roadway damage likely

As shown in Table 5, impacts to stream crossings during the 2-year design storms are few, with only one impacted structure – an overtopped former railroad embankment – in the Williams River watershed in West Stockbridge showing flooding under the baseline climate condition. Under a 2070 climate scenario, the number of floodprone crossings during a 2-year design storm climbs to three, with two additional crossings, also in the Williams River watershed in West Stockbridge, expected to have less than 1.0 feet of freeboard.

The 10-year design storm under baseline climate conditions produces similar crossing impacts to the 2070 climate 2-year event, with the same three crossings impacted, albeit with South Street now expected to overtop. Impacts to stream crossings increase notably for the 10-year design storm when the greater rainfall depths associated with the 2070 climate scenario are considered. During that event, a total of nine crossings may be impacted in the Williams River watershed, four in Richmond and five in West Stockbridge, although all flood depths are simulated to remain below a depth of six inches, suggesting that emergency vehicles may be able to traverse the crossing if the embankment and roadway remain intact. In addition, the Former Swamp Road crossing in the Richmond Pond watershed is also expected to overtop during a 10-year design storm in the 2070 climate scenario.

Flooding impacts to stream crossings are expected to increase significantly from the 10-year to the 100-year recurrence interval. Under a baseline climate condition, the 100-year design storm is expected to impact a total of 11 crossings in the Williams River watershed: five in Richmond and six in West Stockbridge. Rossiter Road in Richmond and South Street in West Stockbridge are expected to experience flood depths in excess of six inches, suggesting that even emergency vehicles are unlikely to be able to safely cross at those locations. In addition, one floodprone crossing is indicated in each of the Richmond Pond and Alford Brook watersheds during the baseline climate 100-year event.

Stream crossing impacts during the 100-year design storm are expected to increase dramatically from the baseline climate condition to the 2070 climate scenario, with a total of 24 impacted crossings in the Williams River watershed. Of those crossings, 13 are in Richmond, with three expected to overtop by more than 6 inches and five others expected to overtop to a lesser degree. In West Stockbridge, 11 crossings are expected to be impacted with 7 overtopping by more than 6 inches.

Significantly more stream crossing impacts are simulated in the other two watersheds as well. Four crossings in the Richmond Pond watershed are expected to be impacted with two of them overtopping, and three crossings may be impacted in the Alford Brook watershed, all of which are expected to overtop.

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4.0 CONCLUSIONS

4.1 Findings

The stormwater model results presented in Section 3 paint a clear picture: both communities, Richmond and West Stockbridge, experience flood risk and flood impacts that impact buildings and roadways at various locations across three studied watersheds, particularly during storm events with a recurrence interval of ten years or greater. Naturally, there is a significant increase in flooding impacts associated with the baseline climate 100-year design storm when compared to the corresponding 10-year design storm.

Increased rainfall totals associated with the 2070 climate scenario appear not to have a significant effect on the flooding impacts to buildings or stream crossings during the frequent, 2-year design storms. Even during 10-year design storms, the increase in impacts associated with the future climate scenario is relatively modest. However, during more extreme design storms, typified by the 100-year event, the anticipated impacts to homes and businesses and to roadways and railbeds is dramatic. Those impacts are shown as the near doubling of impacted buildings and crossings and in the severity of those predicted impacts.

4.2 Limitations

Weston & Sampson has taken care to develop this stormwater model in a manner that reproduces real-life flooding experiences to the greatest extent possible, given the scope of the project as well as available modeling software. Extensive field investigations were performed, and comprehensive data compilation was used to gather the data necessary to fill significant data gaps, and the rigorous model calibration effort supports informative results.

We have made an effort to identify the limitations of the model throughout this report as they are relevant. As described in more detail in Sections 2.4 and 2.8, the most notable limitation of the model is its unfeasibility of incorporating small beaver or debris dams, sediment deposition, or other transient features that have and may continue to impede stream crossing conveyance capacities, resulting in higher flood levels. Given this limitation, estimates of flooding can be considered conservative in nature for some locations.

We also note that the methodology used to represent the land surface across nearly 40 square miles of watershed while also providing a high level of detail in developed areas is likely to result in an overrepresentation of the number of buildings impacted during simulated design storms.

Regardless of these limitations, the stormwater model developed in support of this project provides a reliable means to understand present and future flood risk in both Richmond and West Stockbridge and to test the efficacy of potential solutions.

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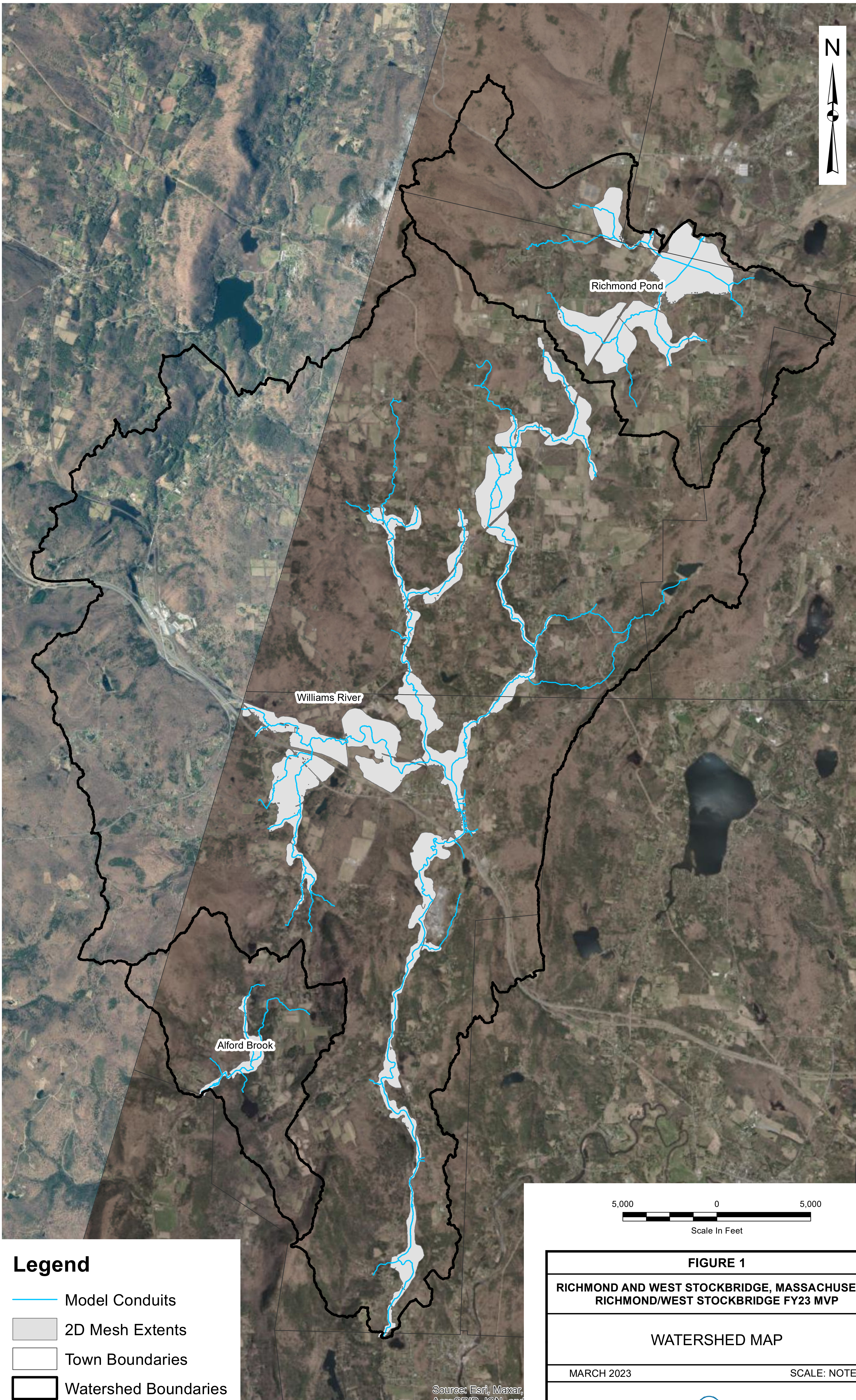
FIGURES



Legend

- Model Conduits
- 2D Mesh Extents
- Town Boundaries
- Watershed Boundaries

FIGURE 1

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

WATERSHED MAP

MARCH 2023 SCALE: NOTED

Weston & Sampson

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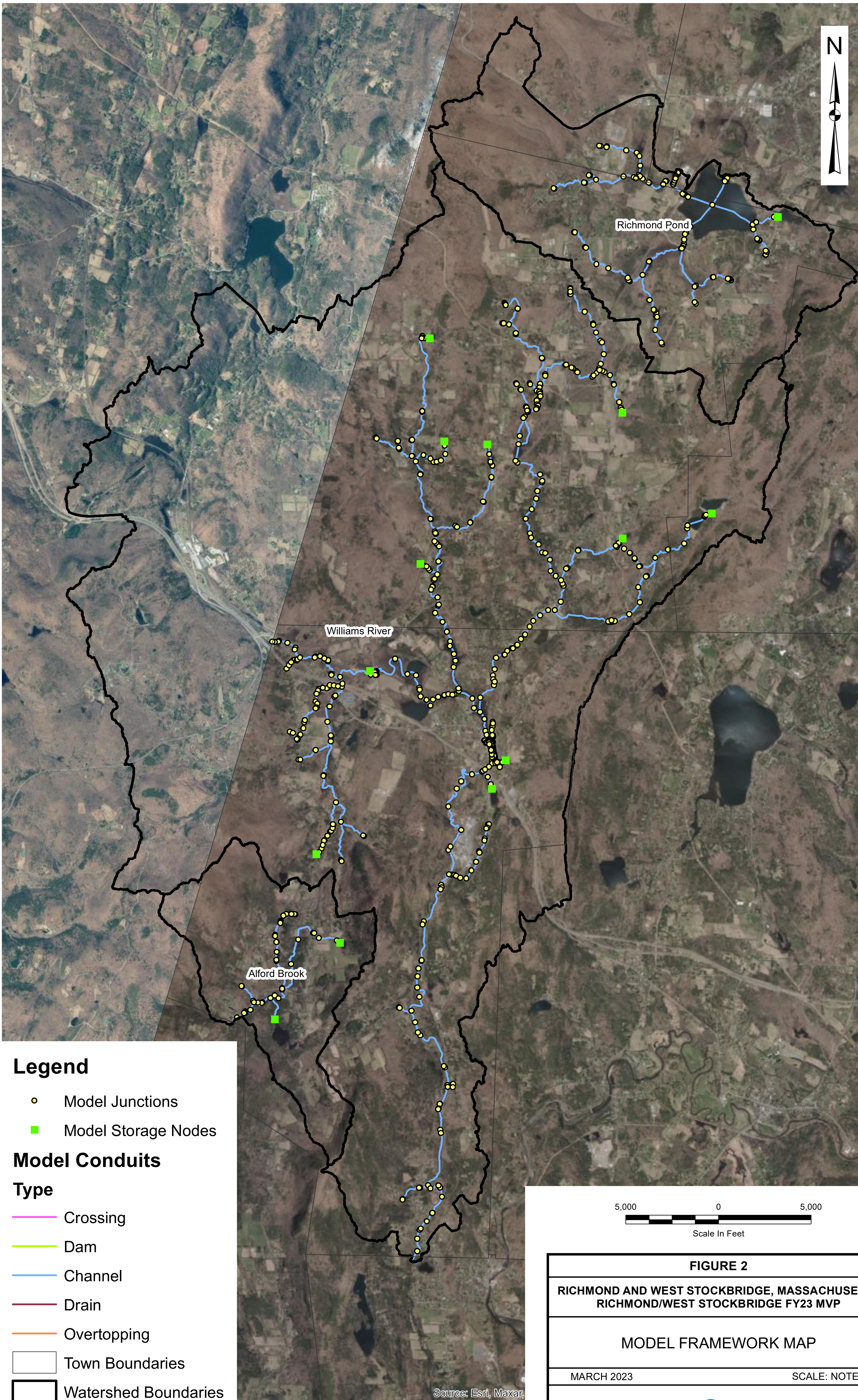


Legend

- Model Junctions
- Model Storage Nodes

Model Conduits

Type

- Crossing
- Dam
- Channel
- Drain
- Overtopping
- Town Boundaries
- Watershed Boundaries

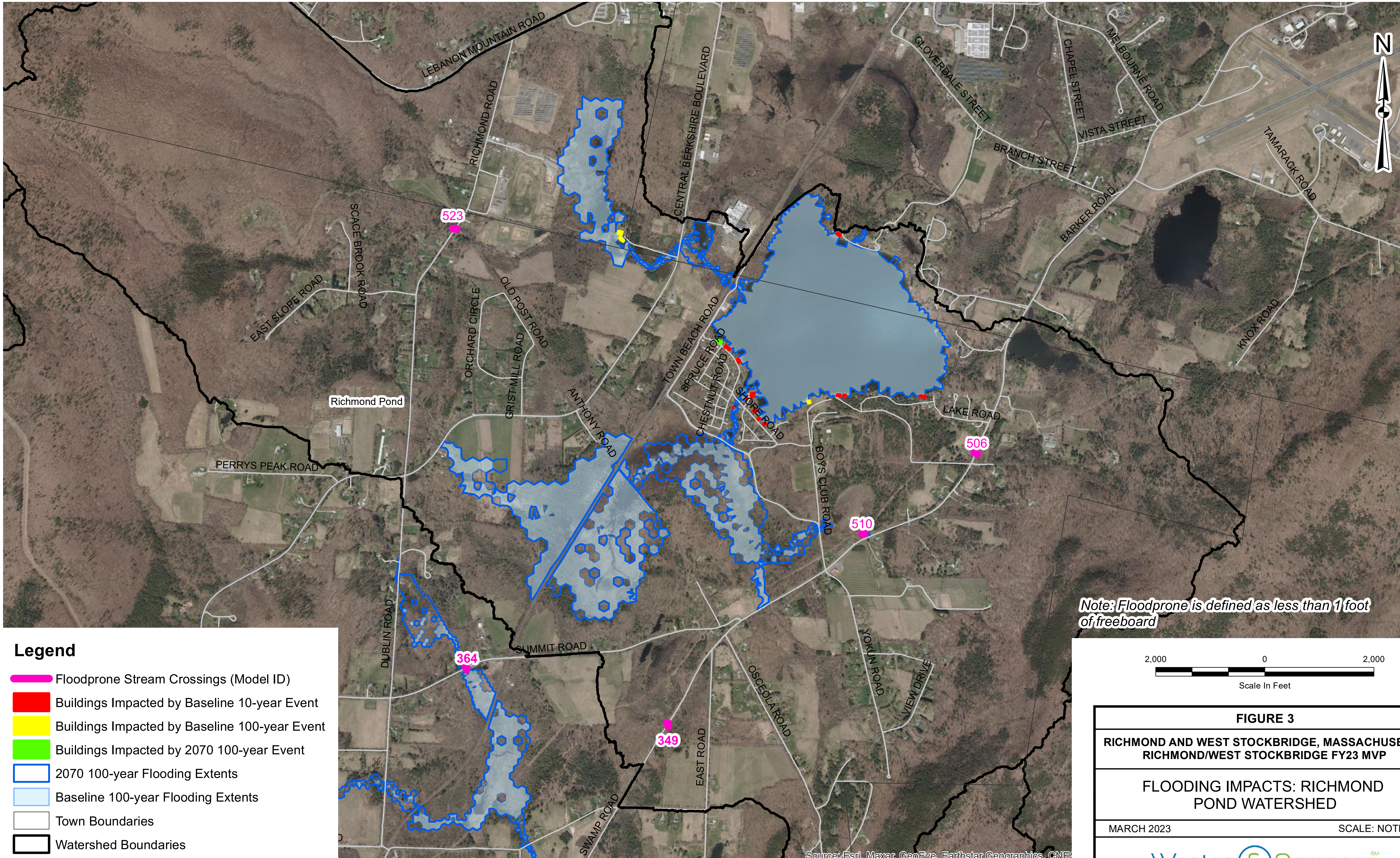
FIGURE 2

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

MODEL FRAMEWORK MAP

MARCH 2023 SCALE: NOTED

Weston & Sampson



Legend

- Floodprone Stream Crossings (Model ID)
- Buildings Impacted by Baseline 10-year Event
- Buildings Impacted by Baseline 100-year Event
- Buildings Impacted by 2070 100-year Event
- 2070 100-year Flooding Extents
- Baseline 100-year Flooding Extents
- Town Boundaries
- Watershed Boundaries

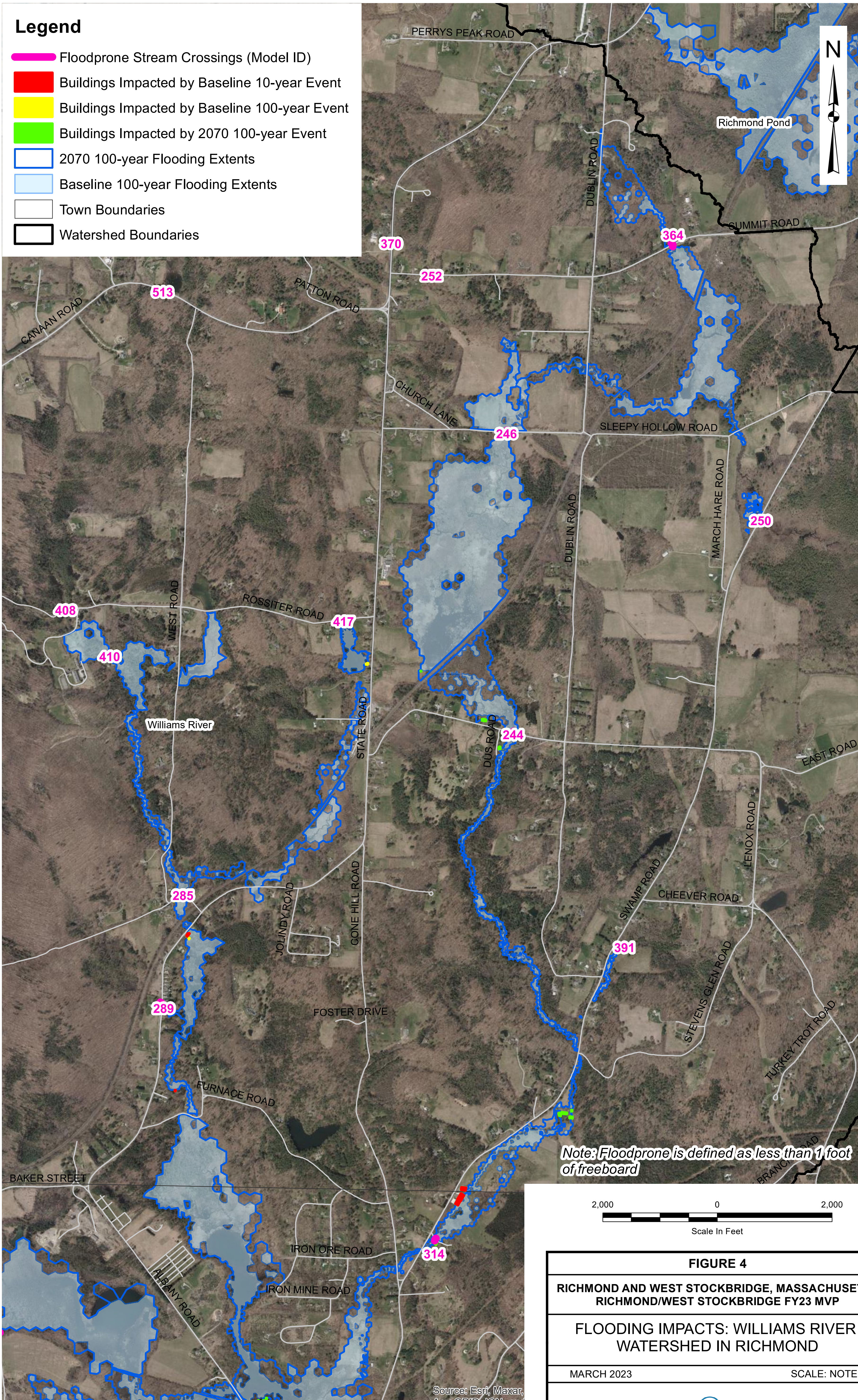
FIGURE 3

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

FLOODING IMPACTS: RICHMOND POND WATERSHED

MARCH 2023 | SCALE: NOTED

Weston & Sampson



2,000 0 2,000

Scale In Feet

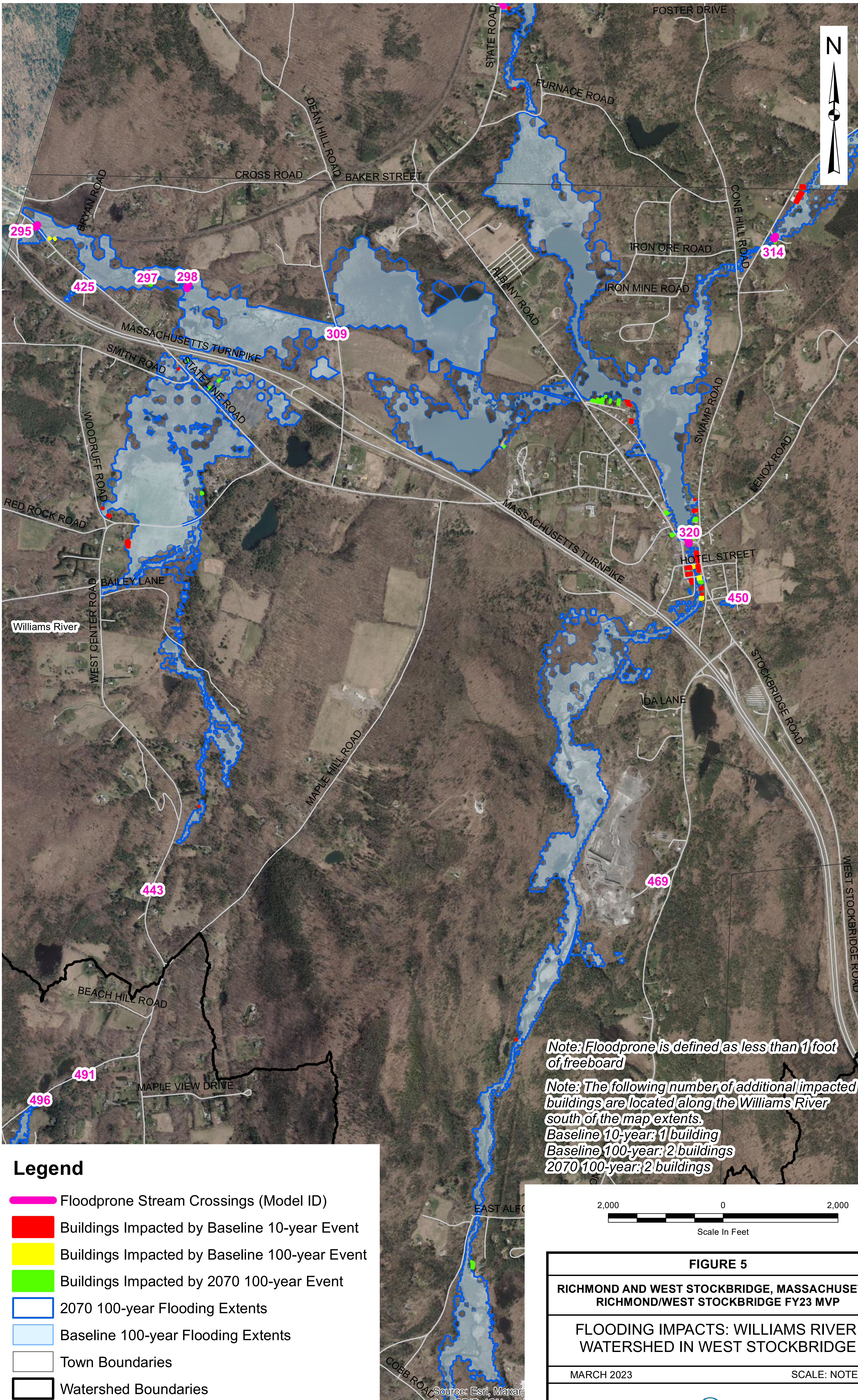
FIGURE 4

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

FLOODING IMPACTS: WILLIAMS RIVER WATERSHED IN RICHMOND

MARCH 2023 SCALE: NOTED

Weston & Sampson



2,000 0 2,000

Scale In Feet

FIGURE 5

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

FLOODING IMPACTS: WILLIAMS RIVER WATERSHED IN WEST STOCKBRIDGE

MARCH 2023 SCALE: NOTED

Weston & Sampson

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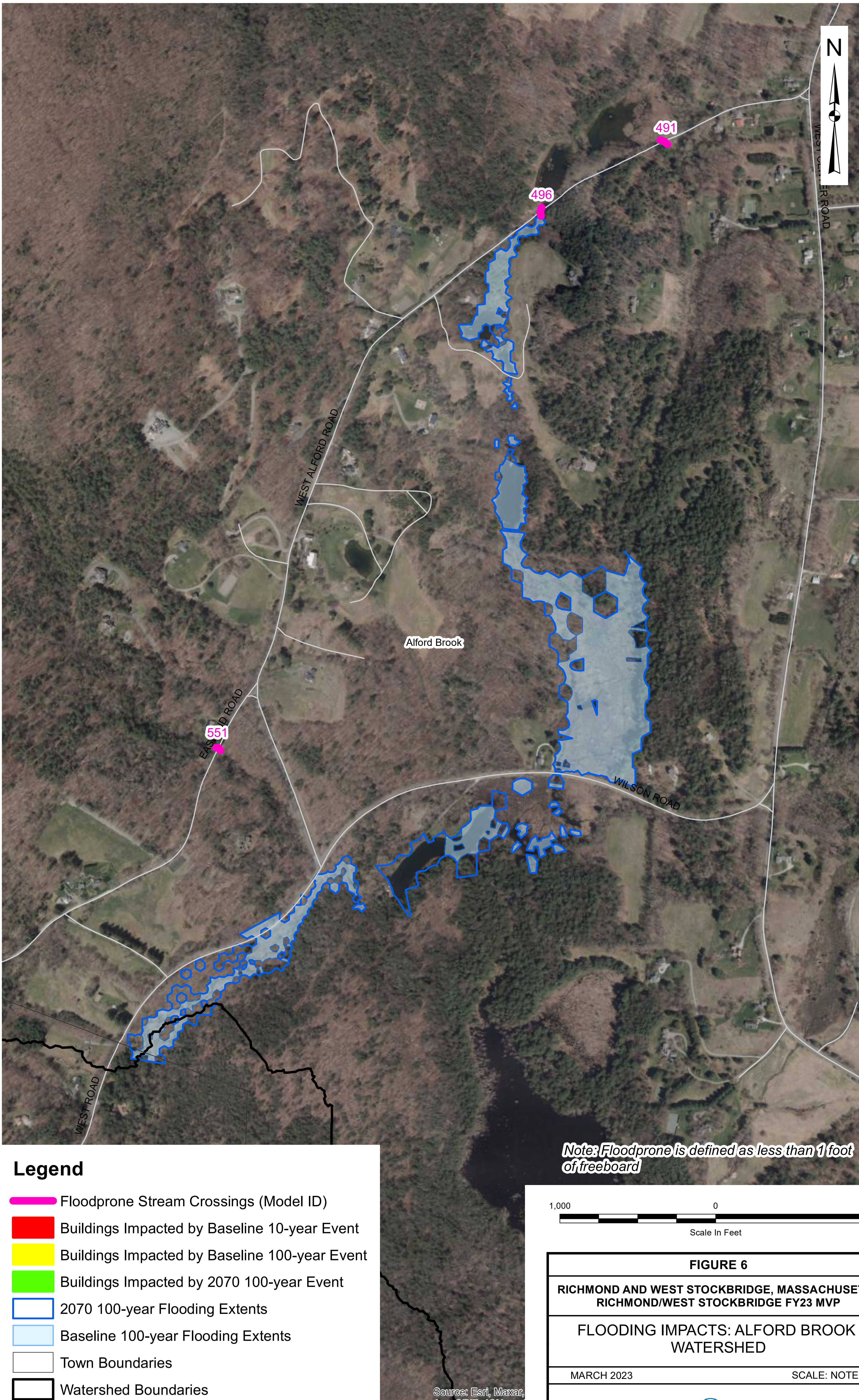

1,000 0 1,000

Scale In Feet

FIGURE 6

RICHMOND AND WEST STOCKBRIDGE, MASSACHUSETTS
RICHMOND/WEST STOCKBRIDGE FY23 MVP

FLOODING IMPACTS: ALFORD BROOK WATERSHED

MARCH 2023 SCALE: NOTED

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APPENDIX D

Nature Based Solutions Opportunities

M E M O R A N D U M

TO:	Town of Richmond & Town of West Stockbridge
FROM:	Weston & Sampson Project Team
DATE:	May 26, 2023
SUBJECT:	A Climate Ready Culvert Design and Comprehensive Stormwater Plan Task 3: Resilient Stormwater Action and Implementation Plan (RSAIP) for Richmond and West Stockbridge Sub-task 3.4 Deliverable: Development and Evaluation of Nature-Based Solutions

1.0 Introduction

In support of developing the Resilient Stormwater Action and Implementation Plan (RSAIP) for the Towns of Richmond and West Stockbridge, Massachusetts, Weston & Sampson completed a desktop analysis using ArcGIS Pro to identify potential opportunities to reduce the extent of flooding, combining data layers from MassGIS and qualitative data collected during Sub-task 3.2 field investigations. Additional description of the modeling analysis was provided in the report for Sub-task 3.3. The identified opportunities are detailed in this memo and include:

- Increasing flood storage at locations upstream or upslope to attenuate peak flow at known problem flooding areas;
- Modifying the outlet control structures of existing waterbodies (operational or physical modification) to provide additional storage prior to a rain event;
- Infrastructure upgrades such as upsizing conveyance conduits (e.g. road-stream crossings) if the flooding is caused due to conveyance capacity constraints;
- Implementation of nature-based flood reduction solutions including but not limited to green infrastructure, on both publicly owned and privately owned land; and
- Regional solutions for gravel roads and drainage.

2.0 Analysis Methodology

Weston & Sampson completed a desktop analysis in ArcGIS to identify climate resilient stormwater project opportunities throughout Richmond and West Stockbridge. The team combined spatial data layers of parcels, roads, buildings, waterways, elevation, regulatory and ecologically sensitive areas from MassGIS with infrastructure data and known problem flooding areas collected from the Towns and during field investigations. The team also utilized the Hydrology Toolkit in ArcGIS Pro to develop additional map layers, to illustrate informal or surface drainage pathways and anticipated problem areas throughout the watershed, based on slope, flow direction, and flow accumulation raster datasets from digital elevation models (DEM) and hydrology data from MassGIS. All these layers were overlaid to form a base map of existing conditions.

Problem areas were also identified through conversations with stakeholders, and solutions were identified focused on opportunities to improve upstream and downstream conditions as well as mitigate localized flooding. Town-owned open spaces, as well as rights-of-way (ROW) adjacent to surface waters or intercepting flow accumulation, were first investigated as potential areas for stormwater management concepts. The team also investigated privately-owned parcels if they represented a significant opportunity for increasing flood storage. Heavily regulated lands including protected lands and Massachusetts Department of Transportation (DOT) / State-owned roads were excluded from this preliminary identification process because of the limited feasibility of making changes at these sites.

Preliminary projects were identified and were iteratively refined with the Towns' input. Most of the final potential projects were incorporated into a hydraulic model and run for the same 10-year 24-hour storms under the projected 2030 (baseline) and 2070 (future) climate conditions to evaluate the near- and long-term benefits of solutions. The following sections of this memorandum outline the proposed projects, project descriptions, and their modeled performance in addressing flooding issues where available. Conceptual-level costs of proposed solutions were also developed where possible. The gravel roads solutions described in the next section were not modeled to estimate their flood reduction benefits, because their benefits would be localized and the scale of the model does not meaningfully show improvement in the watershed.

3.0 Gravel Road Solutions

It is well documented that gravel roads are particularly susceptible to damage from water. Water erodes a gravel road's surface and roadsides, transports dirt and sediment into drainage infrastructure including roadside swales and drainage piping, increases the disintegration of the road structure, and even can lead to road failure.

The Towns of Richmond and West Stockbridge are familiar with the challenges associated with designing and installing gravel roads and the rigorous maintenance needs and are employing progressive retrofit solutions to combat wear and tear. Gravel roads comprise approximately 50% of the roadways in Richmond and just over 35% of the roadways in West Stockbridge.

3.1 Reported Issues

The Towns have reported many common issues associated with gravel roads widely experienced by communities throughout New England along with some issues particular to the topography and geology of the area:

- Roadside swales and cross-culverts become clogged with solids and sediment that has washed out of the road. Roadway crews are then required to clean out swales and structures manually, which is time consuming and labor intensive.
- Many roads occur in areas with steep grades, which increases the velocity of runoff leading to increased erosion of the road and roadsides.
- Narrow rights-of-way limit alternatives for swales, green solutions, and drainage infrastructure.
- Shallow bedrock and rock outcroppings affect overland flow of stormwater and make installation of drainage solutions cost-prohibitive.
- Gravel roadways that are close in elevation to flooding water bodies or wetlands easily flood or become saturated with water when water tables rise due to rainfall. This can lead to repeated roadway degradation or drainage structure damage, which requires continued maintenance and labor to repair.
- Gravel roadways have low points that are prone to ponding. When standing water pools on top of roads, it can cause potholes, erosion, rutting, and can move sediment to clog drainage culvert or ditches.

These problem areas are detailed extensively and mapped in the Field Data Collection Summary Memorandum (Subtask 3.2 report), and that characterization of road-related problem areas led to several nature-based solutions later in this report, such as the West at Rossiter Road project (#6) and the Osceola and Swamp Road project (#7). This section describes general best practices and regional opportunities to improve and address gravel roads issues described above.

3.2 Best Practices for Gravel Road Drainage and Maintenance

To counteract the common issues when dealing with gravel roads, various solutions and conveyance upgrades are available. Richmond and West Stockbridge staff have utilized well-accepted guidance resources and best practices vetted throughout New England. The Towns currently use references including the Massachusetts Unpaved Roads BMP Manual (Berkshire Regional Planning Commission) prepared in 2001 and the Vermont Better Roads Manual (Vtrans) prepared in January 2019. In addition, the Towns are aware of and have received training through the UMass Amherst Baystate Roads program on gravel roads. A few examples of best practices the Towns have employed include: adding magnesium and/or calcium to road mixes to achieve better binding for grading-based maintenance; utilizing alternative materials such as crushed aggregate to achieve a more compacted roadway surface; incorporating new geotextiles as retrofits that provide stabilization; and adding curtain drains. Overall, Town staff are well informed about best practices for gravel roads but are limited by local budgets for maintenance and capital investments. Each season, Town Highway staff strategically determines where to retrofit gravel roads and use new materials, where to address the extensive ongoing operation and maintenance needs, and which areas are less urgent and must be put off for the future. As changing climate patterns introduce more extreme storms, precipitation, and drought, the Towns recognize the need for a more comprehensive and dedicated approach to addressing gravel road problems caused by stormwater going forward.

3.3 Solutions for Gravel Roads

The guidance manuals listed above provide information on **designing new or re-construction, recommended retrofits, and maintenance techniques** for gravel roads. A selection of best practices most relevant to the Towns' problem areas is described in Appendix A. Determining the right application for these solutions will depend on slope, road condition, staff capabilities, available equipment, and budget. Guidance for specific types of problem areas is described below, as key practices that can be applied to other similar road segments around the Towns. Additional information about implementation can be found in the guidance manuals for each solution.

3.3.1 Solutions for Gravel Roads: Problems with Slopes

Both Towns report slopes being a significant factor in gravel road maintenance and degradation. Table 1 shows the slope and length of gravel roads in each community. Figure 1 and Figure 2 show the locations of these slopes in Richmond and West Stockbridge, respectively. Locations on gravel roads where steeper slopes (>5%) occur adjacent to low lying areas or road-stream crossings are likely to be the worst sites of problem flooding and erosion and require more than the usual amount of maintenance, and possibly retrofit or redesigns.

Table 1. Miles of Gravel Roads by Slope and Community

Slope	Richmond Gravel Roads (Miles)	West Stockbridge Gravel Roads (Miles)
<3%	5.8	5.1
3-5%	7.0	4.5
5-10%	12.5	7.3
10-15%	5.1	3.4
15-20%	1.3	1.1
20-25%	0.5	0.4
25-35%	0.4	0.4
>35%	0.3	0.4

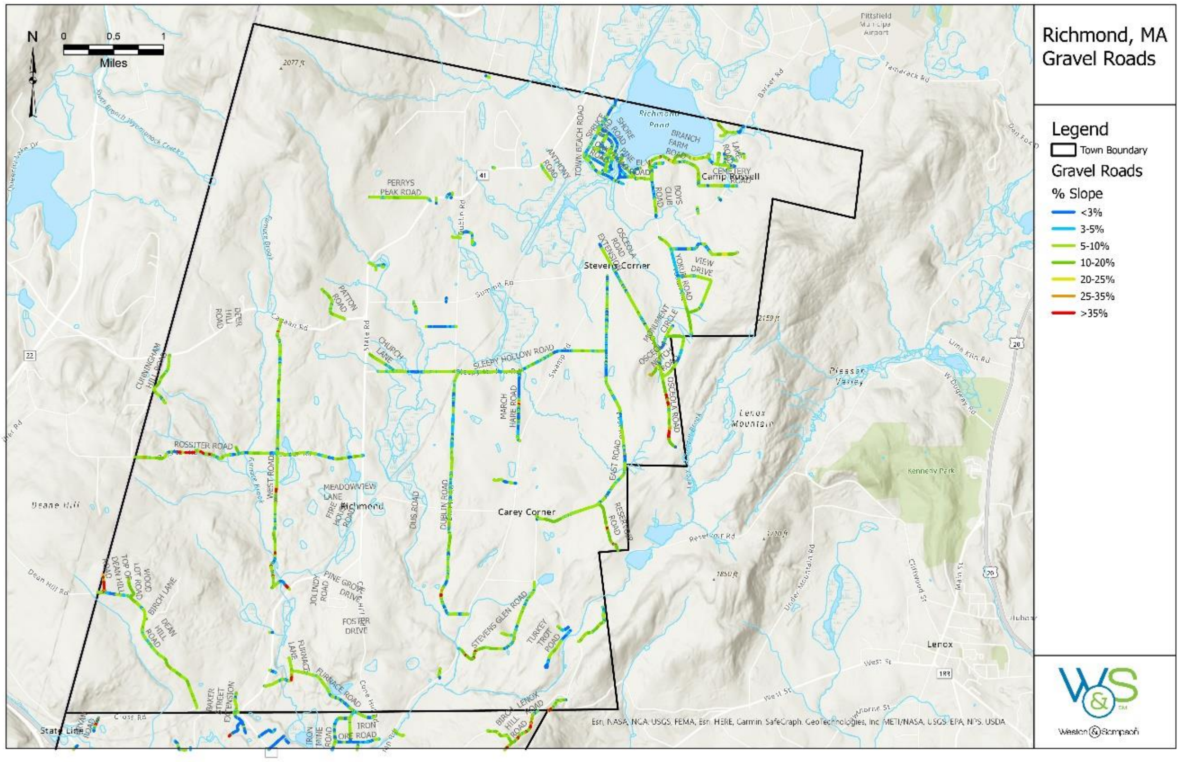


Figure 1. Slope of Gravel Roads in Richmond

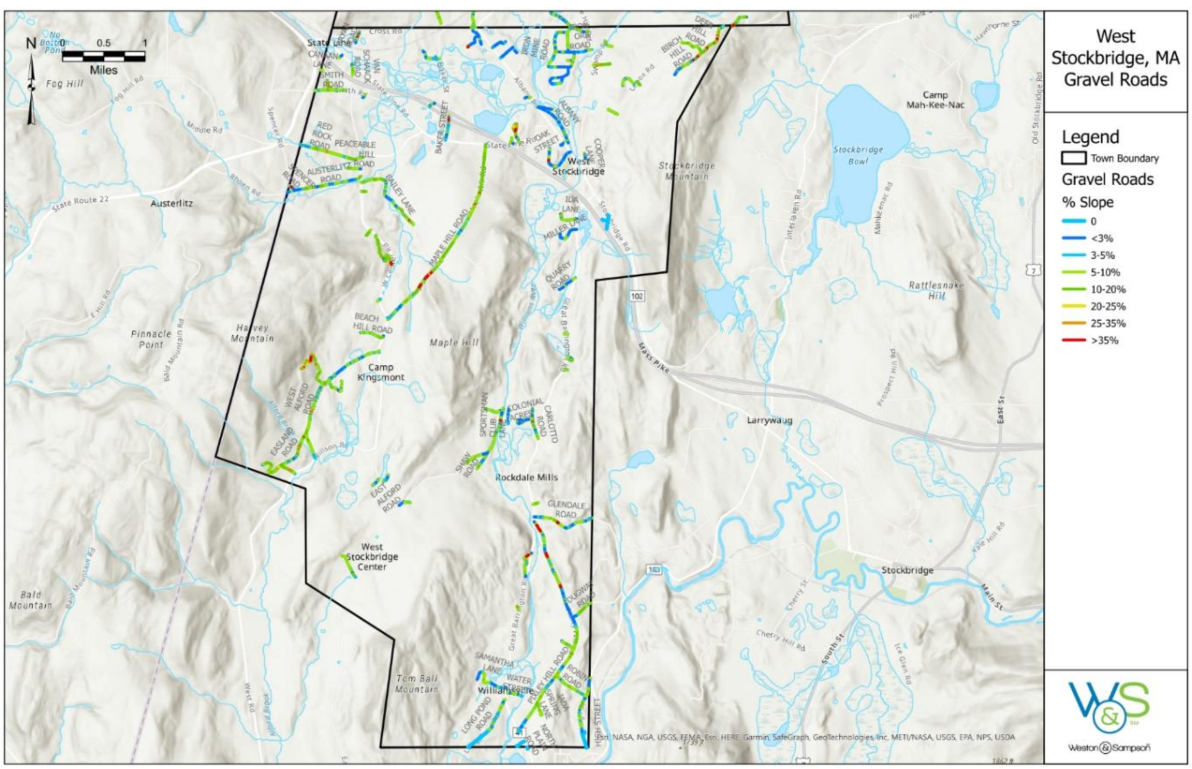


Figure 2. Slope of Gravel Roads in West Stockbridge

Gravel road problems related to steepness can be demonstrated in the following examples that follow a typology of approach. Recommendations for these examples can be applied to other locations with similar steepness conditions. General recommendations include:

- Evaluate and improve crown lines. Road crowns should be ~0.5-0.75in per LF of width, or 4% to 6%. Crown from outside edge towards centerline. See Appendix A for additional information.
- Complete traffic counts to evaluate redesign: Could road be narrowed, or could road be one way?
- Confirm that surface and sub-surface materials and treatment are correct.

Type 1: Flat areas (East Road)

A known flooding area on East Road (R.PA-11) occurs where a section of road with profile slope of <3-5% occurs. See Figure 3 for the map of the flooding area and road slopes. Water comes from the east side of the site. Ponding occurs every time it rains and from snow melt.

Generally, solutions for these road types include:

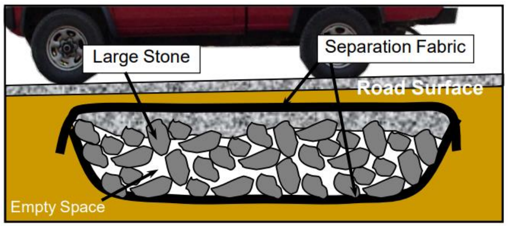
- Elevate the road in the flooded area. This work includes adding fill and likely adding cross culverts and potentially even a stream-road crossing. Any fill must consider requirements related to compensatory storage for existing flood zones. Access to private property must be maintained.
- Add piped drainage systems including inlets and outlets to help move the water to an abutting area. This is feasible in scenarios with abutting property that has space for and permission to receive the water.
- Add swales that incorporate storage if space is available. This includes a wide bottom swale with 4:1 side slopes, 20 feet wide. This is feasible where there is right-of-way area available for construction.
- Consider waterbars on mild slopes with very low traffic. See Appendix A for more information. Waterbars require frequent observation to confirm functionality.
- Where space is limited but conveyance across the road is desired, consider a French mattress. See Appendix A for more information.

A resource the Towns can consult is the 2021 Rural Dirt Road Assessment & Recommendation Report, prepared for the Towns of Sandisfield Sheffield, and New Marlborough, Massachusetts. French mattresses[1] were recommended[2] and employed at sites where subsurface infiltration could reduce off-road drainage onto roadsides with limited area for water infiltration or distribution. Examples of French mattress design are shown below.

---

[1] *Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads*, prepared by USDA Forest Service in collaboration with Penn State Center for Dirt and Gravel Road Studies, 2012.

[2] Penn State Center for Dirt and Gravel Road Studies Technical Bulletin for French Mattress - https://www.dirtandgravel.psu.edu/sites/default/files/General%20Resources/Technical%20Bulletins/TB_French_Mattress.pdf



For East Road itself, due to the narrow nature of the road and abutting private properties, solutions that are feasible without easements or taking of private property are limited to in-road options, such as French mattress, elevating the road, and the general solutions such as evaluating and improving crown lines, considering making the road one-way, and rebuilding portions of the road if needed. The opportunity to utilize nature-based solutions is limited for this roadway.

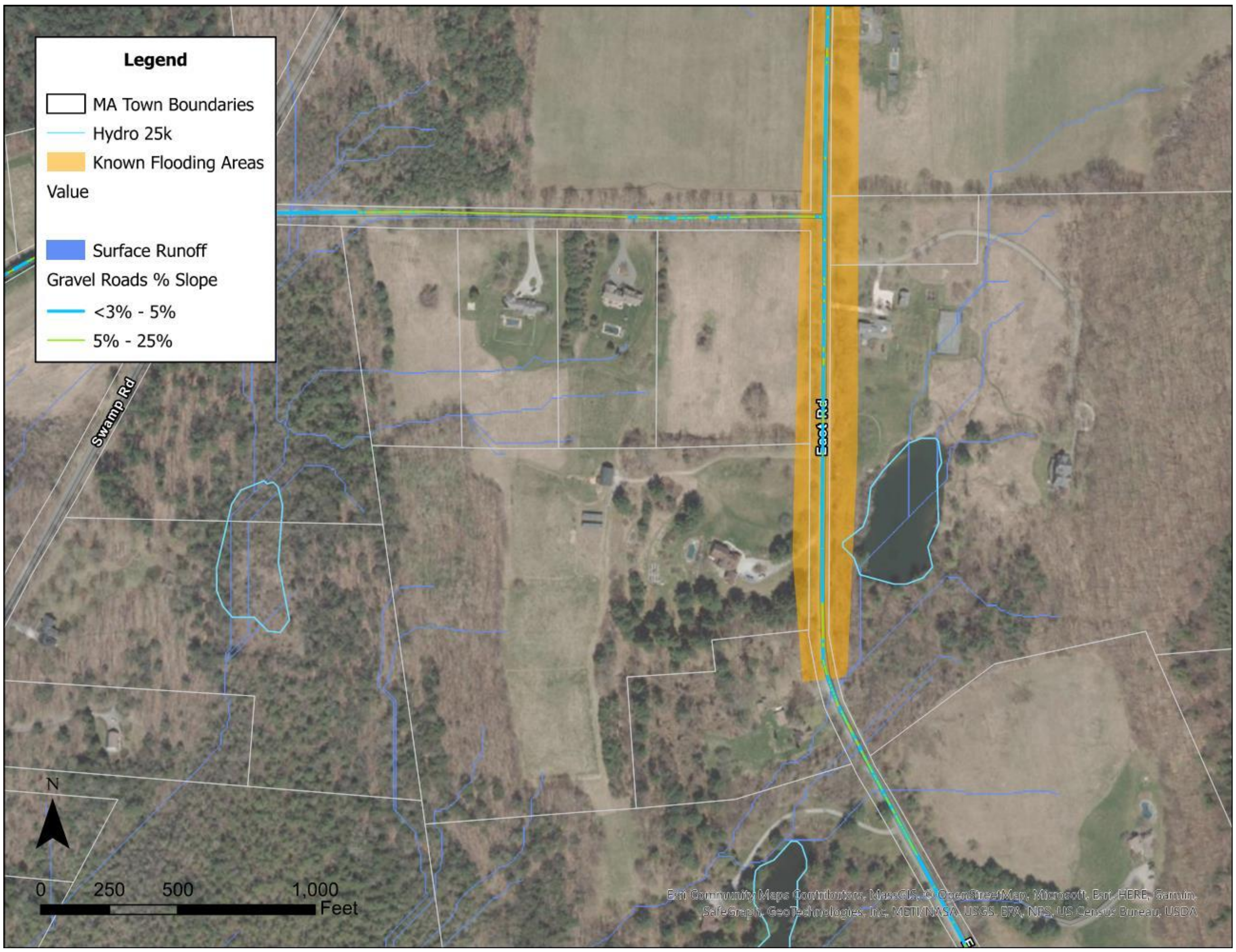


Figure 3. East Road in Richmond

Type 2: Steep areas (Upper Osceola Road)

A known flooding area on Upper Osceola Road (R.PA-8, 9, 10) occurs where a section of road has continuously sloped extremely steep (>25%) and steep sections (5-25%). See Figure 4 for the flooding area extent and road slope. Water comes from Osceola Mountain and runoff flowing down the roadway and causes erosion and ponding during heavy rainfall events.

Generally, solutions for these road types include:

- Improve conveyance to move water off the road corridor as fast as possible. This may include adding piped drainage systems including inlets and outlets, adding cross-culverts, and/or adding pavement/concrete swales that would move water to these piped systems. A storage location would be needed to capture water at the low point. Dissipation of velocity may be needed at certain points in the slope. This is feasible in scenarios with abutting property that has space for and permission to receive the water.
- Add subsurface storage such as French mattresses.
- Consider Velocity Controls and Energy Dissipaters (Check Dams). These may consist of Hay Bale Dikes, Stonedikes, Silt fence dikes. These practices require frequent observation to confirm functionality and frequent maintenance with advanced equipment. If installed incorrectly, can also detrimentally impact roads. See Appendix A for more information.
- Plant and seed roadside swales. This low-cost alternative allows natural vegetation to manage flows. Can be combined with a geogrid solution. This can be used for the lower end of moderate slopes (5 to 10%), not extremely steep slopes.

For Upper Osceola Road itself, due to the narrow nature of the road and abutting private properties, solutions that are feasible without easements or taking of private property are limited to in-road options such as French mattress and concrete swales, and the general solutions including evaluating and improving crown lines, considering making the road one-way, and rebuilding portions of the road if needed. The opportunity to utilize nature-based solutions is limited for this roadway.

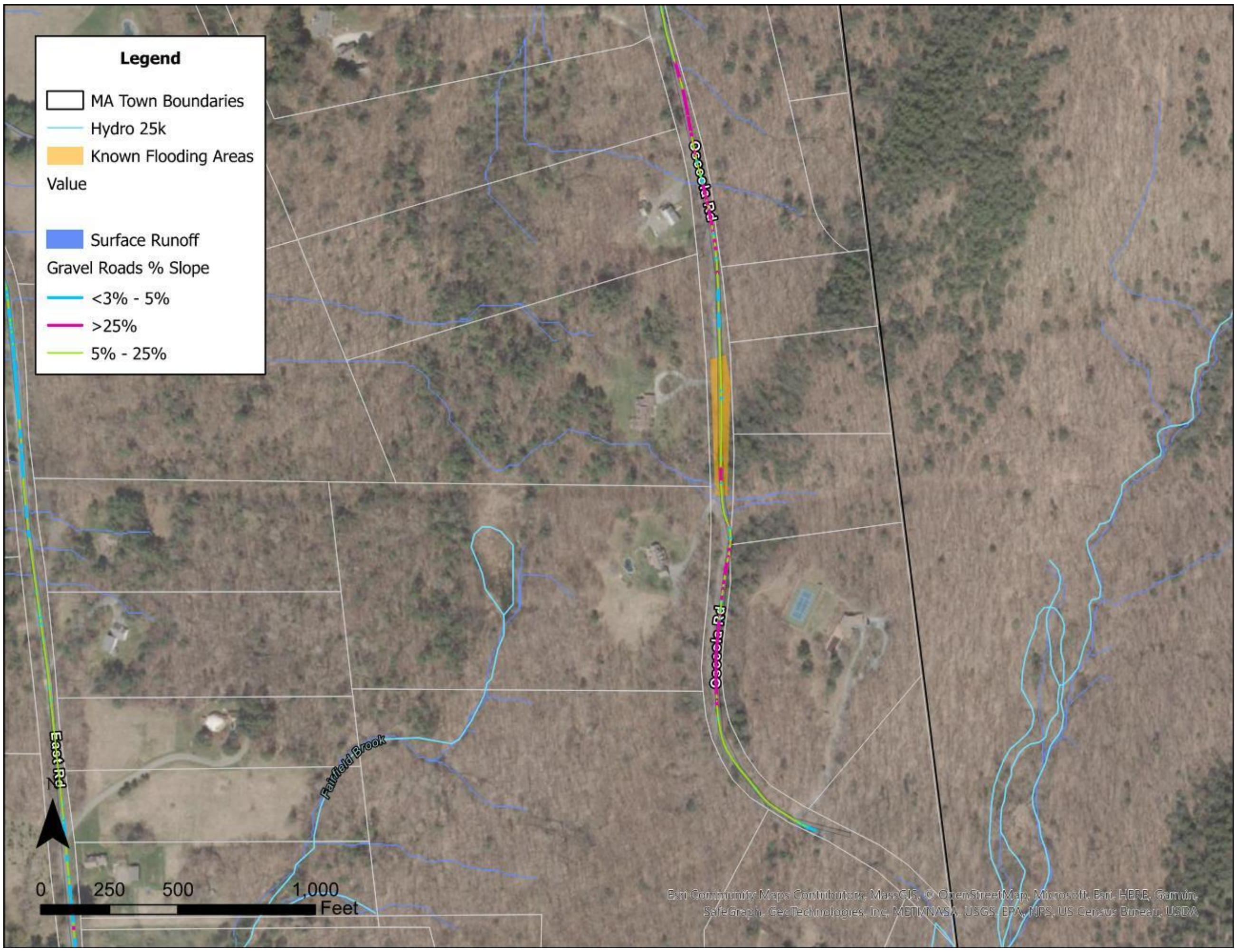


Figure 4. Upper Osceola Road in Richmond

Type 3: Steep section and flat section (Dean Hill Road)

A known flooding area on Dean Hill Road (R.PA-21) occurs where a section of road with slope of 3-5% and a slightly steeper section (5-25%) occurs adjacent to a steep side street (>25%) and surface flows. See Figure 5 for the flooding area extent and road slope. Water comes from the steeper and northern/eastern portions of the road. Ponding occurs every time it rains and from snow melt.

Generally, solutions for these roads include all of the solutions mentioned above, as well as:

- Adding bioretention in the intersection, with a forebay to capture sediment and an earthen bottom.
- Widen the swales in the flat sections.
- Harden the sections that are steep with concrete, asphalt, or turf reinforced mats (non-erosive). The mats could be vegetated to have a “green” component, but this will trap sediment, so check dams will be needed to pick up sediment behind them.

For Dean Hill Road itself, there may be green infrastructure options at intersections, but otherwise, due to the narrow nature of the road and abutting private properties, solutions that are feasible without easements or taking of private property are limited to in-road options. The opportunity to utilize nature-based solutions is limited for this roadway.

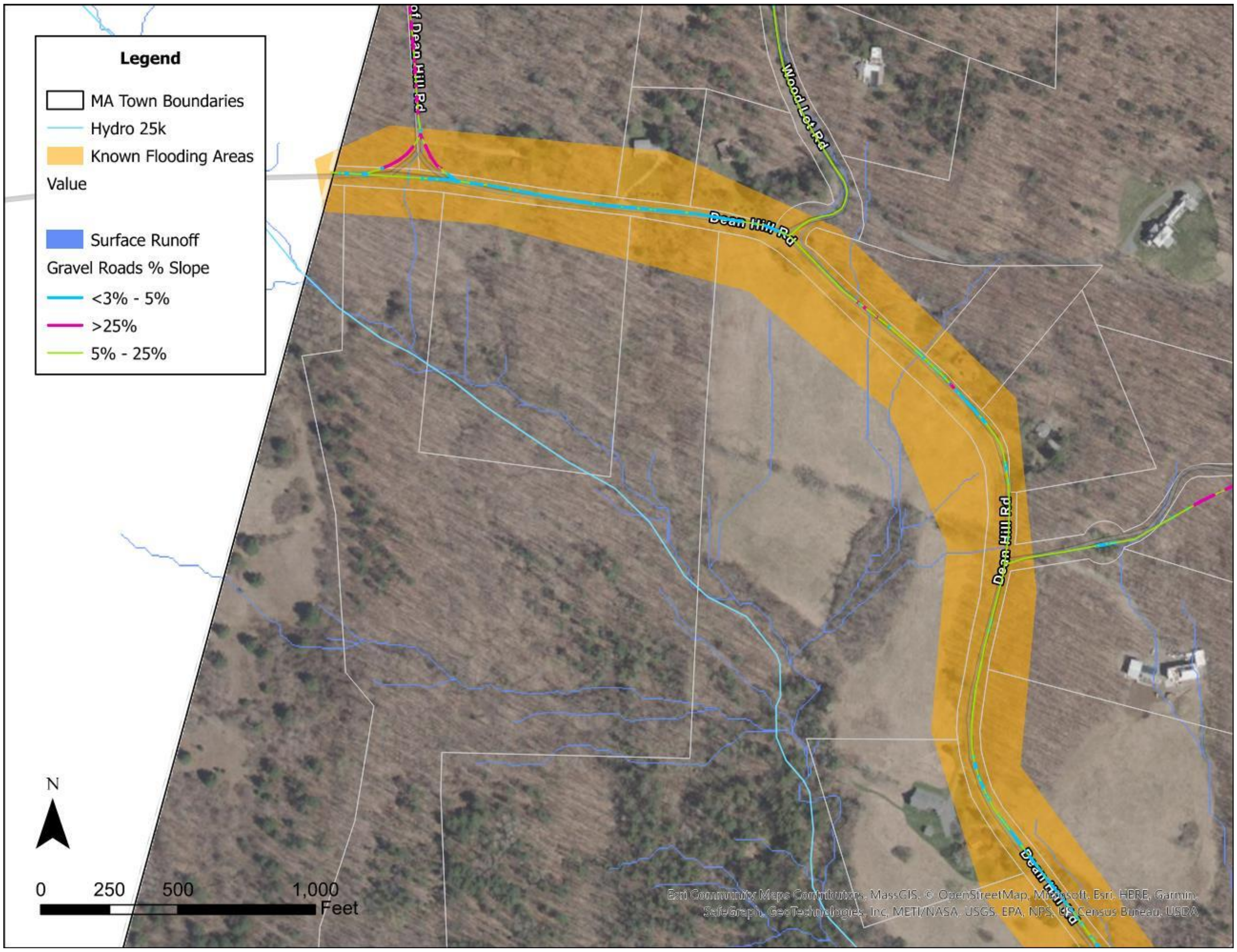


Figure 5. Dean Hill Road in Richmond

3.3.2 Costs of Proposed Projects

Conceptual-level costs of gravel road improvements were developed for several example projects identified above. The proposed project costs were grouped based on the estimated cost; the cost groupings are shown in Table 2.

Table 2: Opinion of Cost Groupings

Opinion of Cost	Description
$	<$100,000

$$	between $100,000 and $400,000
$$$	between $400,000 and $700,000
$$$$	between $700,000 and $1,000,000
$$$$$	>$1,000,000

Please note that all values presented herein are considered an engineer's estimate. Weston & Sampson has no control over the cost of availability of labor, equipment or materials, or over market conditions or a Contractor's method of pricing. Costs do not account for sub-surface conditions such as dewatering or contamination. These estimates been developed based on Weston & Sampson's professional judgement and experience. Weston & Sampson makes no guarantee that bids or negotiated cost of any work will not vary from this estimate. Costs presented are considered concept/screening level and therefore have an estimated accuracy range of -30% to +50%. Costs are presented in May 2023 dollars.

Table 3: Generalized Opinion of Cost

Project Type	Location	Best Practice and Opinion of Cost
Type 1	Slopes less than 5%	Elevate roadway: $$$$$ Add piped drainage systems including inlets and outlets to help move the water to an abutting area. $$ to $$$$ Add swales that incorporates storage if space is available. $$ to $$$ Install french mattress $$ to $$$
Type 2	Slopes greater than 5%	Improve conveyance and add storage: $$ to $$$$ In-road storage: $$ to $$$ Consider Velocity Controls and Energy Dissipaters (Check Dams). $
Type 3	Slopes less than 5% adjacent to steep slopes	Adding bioretention in the intersection, with a forebay to capture sediment and an earthen bottom. $$ Widen the swales in the flat sections. $$ to $$$ Harden the sections that are steep with concrete, asphalt, or turf reinforced mats (non-erosive). $$$

3.3.3 Solutions for Gravel Roads: Swales

For roadside swales to provide effective stormwater collection and conveyance, design and maintenance recommendations include:

- Increasing the size and dimensions of existing swales
- Changing the shape of the bottom of swales to be flatter
- Stabilizing and improving the gravel roadway to prevent erosive cycle

Above: Vegetated bioswales, *Weston & Sampson*
Left: Stone-lined bioswale, *Sustainable Technologies LID Guide*
Right: V-ditch concrete channel, *City of San Rafael*

Shown on the previous page are a range of design types for swales to accommodate different site objectives. Vegetated swales are shown at top and are described further in Appendix A. Alternative approaches include rock-lined swales and concrete or hard-lined swales. Turf reinforced mats and Geoweb are sustainable vegetated channels that can be used for slope protection and conveyance, but they will not easily erode and can capture sediment before it leaves the area. In particular, the

Geoweb technology makes maintenance easier because it is not easily punctured by maintenance equipment.

Example locations for swale redesigns are shown in Figure 6 at potential sites to improve swales: Dublin Road, Dean Hill Road, and Dublin and State Roads in Richmond.

Improving and changing the design of swales will be most effectively implemented along with gravel road improvements. These recommendations must be tailored to the constraints of each roadway site, as some locations will be limited in available options because of reduced roadside space or underground proximity to bedrock.

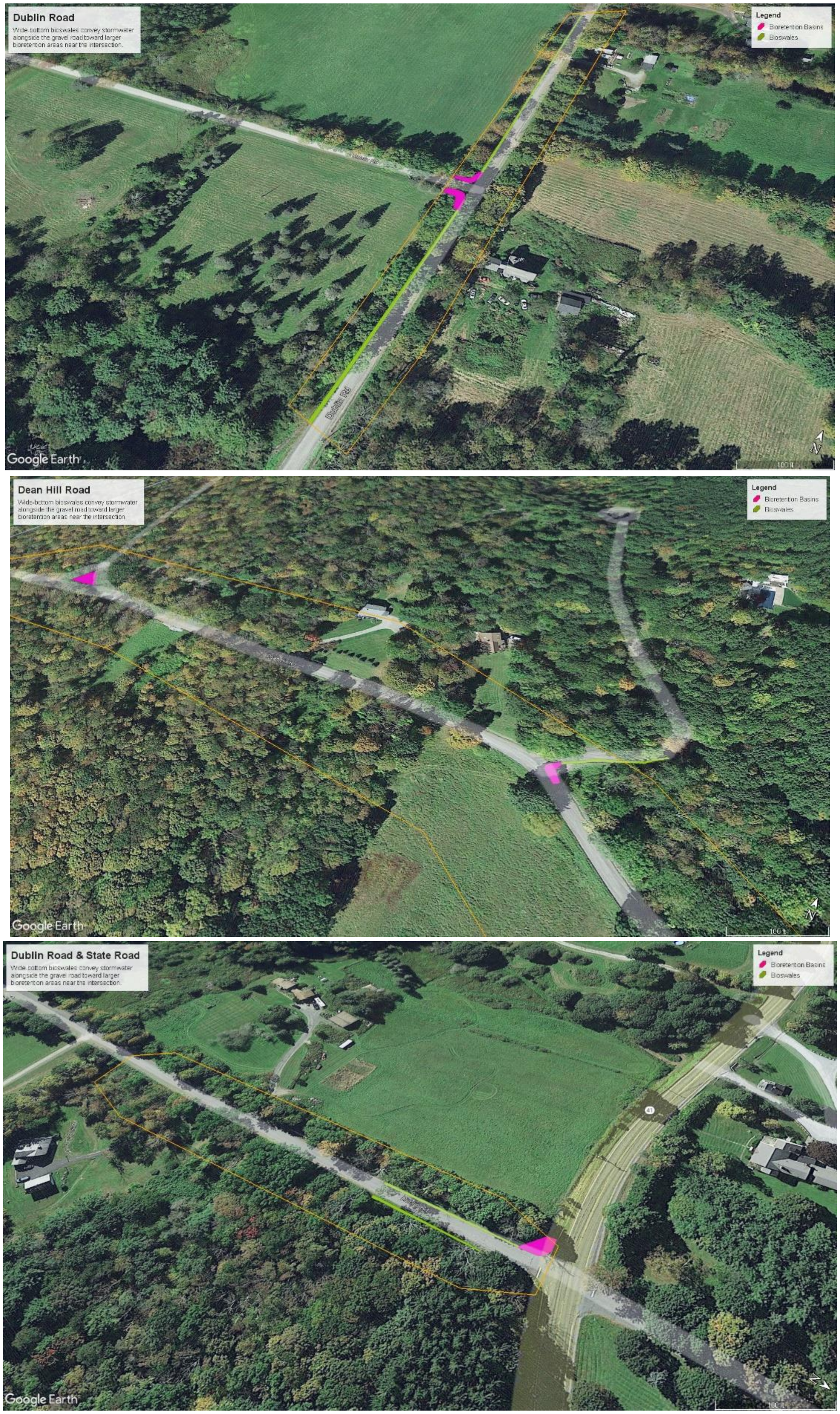


Figure 6. Example bioswale and bioretention opportunities in Richmond

Nature-Based Solutions and Flood Reduction Opportunities

Nature-Based Solutions (NBS) are climate adaptation measures "focused on the Protection, Restoration, and/or Management of ecological systems to safeguard public health, provide clean air and water, increase natural hazard resilience, and sequester carbon."[3] As our communities continue to experience increasingly frequent, extreme storm events, drought, and heat, NBS provide more resiliency in response to these variable conditions than traditional stormwater infrastructure.

Opportunities for both large scale and smaller scale flood storage through nature-based solutions were identified. All opportunities were chosen for their potential to intercept flows upstream or upslope of problem areas, such that stormwater can be stored during storm events and infiltrated or released after the peak of the storm has passed, reducing downstream flood impacts. Both public and private lands were assessed through this analysis. Opportunities identified through this analysis have been separated into larger-scale storage area projects and smaller, localized flooding / water quality improvement projects by town. Future study and design of these projects may alter these solutions from the features proposed herein, as they are still in the very early stages of design.

It is important to note that both Richmond and West Stockbridge currently employ numerous stormwater and drainage practices to mitigate flooding, to varying degrees of success. Both Towns have indicated sediment and erosion as key issues impacting the capacity of their existing swales / roadside drainage. Their ability to maintain these existing stormwater features is limited by budget, staff availability, the sheer size of both towns, miles of gravel roads to cover, and in many cases a lack of adequate space within the right of way. Although this process develops high level concepts, the projects and guidelines are meant to work in concert with the towns' existing drainage features, either by expanding them or mitigating the impacts to them, to address both current issues and future flooding that is likely to be worsened by climate change.

Large-Scale Storage Opportunities

The large-scale storage opportunity portion of the analysis focused specifically on reconnecting and expanding existing flood pathways to increase storage volumes and reduce downstream flooding. The team looked primarily at engineered solutions such as stream restoration, constructed retention ponds/wetlands, and subsurface infiltration chambers. Characteristics of a desirable site include:

- Open space upstream or downstream of flood problem areas
- Open space on slopes to intercept flows and encourage infiltration
- Open space adjacent to water bodies, wetlands, or undersized road crossings
- Open space surrounding choke points in the flood pathways

Once a space was identified, the team looked at existing conditions, land use, ownership, and site topography to recommend a nature-based solution type for implementation. Weston & Sampson

[3] Nature-Based Solutions. MVP Toolkit. 2021.
https://resilientma.mass.gov/mvp/content.html?toolkit=nature_based

identified fifteen large scale, nature-based solution alternatives between Richmond and West Stockbridge.

These projects were entered into a hydrologic and hydraulic model to understand the flood reduction benefits they provide in their respective sub-watershed, using a 10-year storm event projected for both 2030 and 2070. Each site was provided with a Significant, Moderate, or Minimal flood reduction ranking based on the results. Rankings of "Significant, Moderate, or Minimal" considered both the 2030 and 2070 magnitude of reductions in the peak and total runoff volumes as well as the subbasin (size, contribution) within which the project falls. There are exceptions primarily caused by the subbasins/locations of the projects, i.e., a project with a lower total volume reduction may still be considered significant when the subbasin is very large and has a high % impervious area. Any results listing hydrologic benefits as minimal do not reflect the potential co-benefits of a project, which collectively may result in the project being prioritized for implementation on other grounds.

Also, modeling results indicate the likely change to hydrologic and hydraulic conditions more accurately than they represent total volumes of flow that are driven by other, site-specific factors. Because of this, projects indicating a reduction in flows may have greater or smaller benefits in reality, because real world flood problems may not be fully represented by a model.

Nature-Based Solutions Alternatives in Richmond

The five (5) large-scale opportunities for nature-based solutions within the Town of Richmond that could mitigate impacts of current and future precipitation due to climate change are summarized in Table 4 and Figure 7. Note that projects are not numbered or listed here in order of ranking or priority. Prioritization of projects will be provided in the RSAIP (Sub-task 3.5).

Table 4: Richmond, MA Nature-Based Solutions Alternatives

Project #	Location	Land Ownership	NBS Type
4	West Rd near State Rd @ Furnace Brook crossing	Private	Stream restoration
5	Swamp Rd near Dublin Rd	Private	Floodplain restoration
6	West St at Rossiter Rd	Private	Bioswale
7	Osceola Rd at Swamp Rd	ROW	Bioretention
8	Town Beach Rd / Richmond Fen Wildlife Management Area	State / Private	Floodplain restoration

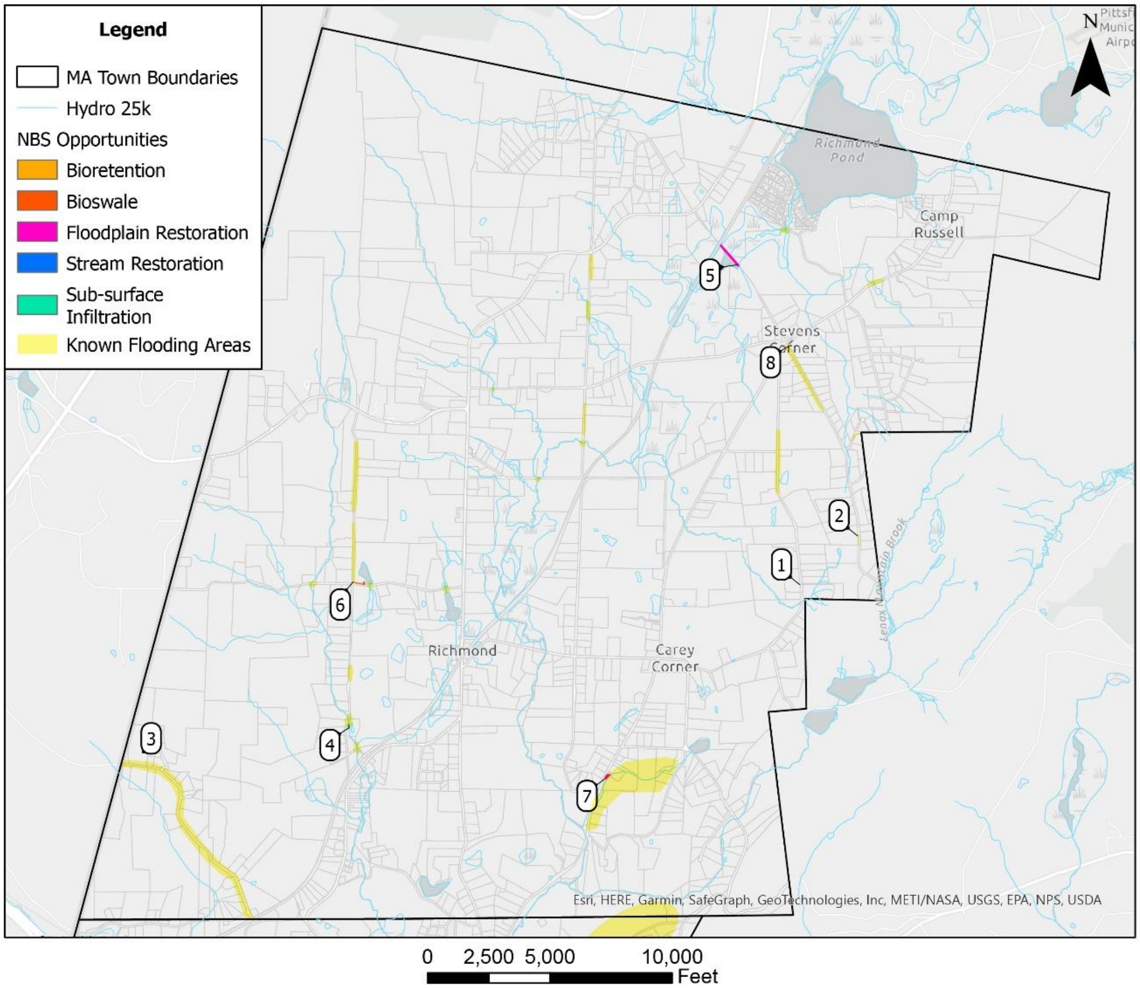


Figure 7. Richmond Gravel Roads and NBS Alternatives

Each scenario for proposed nature-based solutions is summarized in the sections below.

4. West Road near State Road @ Furnace Brook crossing

The Furnace Brook crossing at West Road, near the intersection of State Road, has reports of repeat flooding at the culvert. Culvert improvements are planned for this stream crossing, including increasing the culvert size and raising the road over it. An opportunity to integrate NBS with this culvert upgrade project is to restore the stream downstream of this pinch point. This concept proposes widening the existing stream channel to allow a wider cross section for flood storage as well as more stable slopes. Regrading around the bank edge would be required if the culvert project is implemented. There is an additional potential here to work with the private landowner by diverting excess flow from Furnace Brook into the pond on their property. A diversion structure just south of West Rd could use the pond as overflow during larger rain events.

Stream restoration projects are modeled by adjusting the dimensions of the conduit in the model. For this alternative, the stream top-of-bank (TOB) width is proposed to increase by 2’ on both sides. This project is upstream of the road stream crossing on West Road (south), which is expected to see increasing impacts of flooding by 2070.

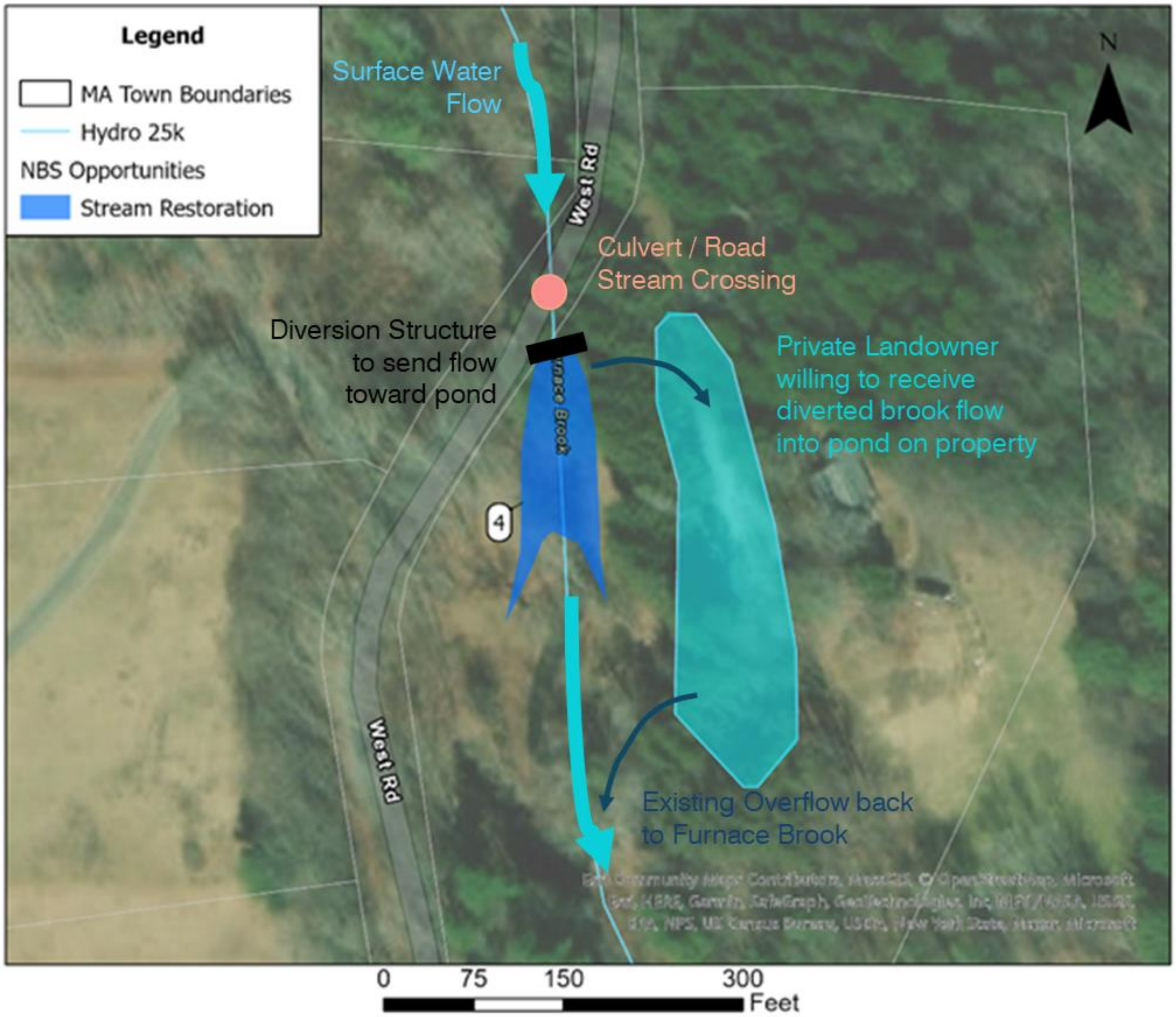


Figure 8. NBS Alternative 4

Summary of Modeling Results

- No peak or volume reductions expected under baseline.
- A stream restoration would reduce runoff volume by 0.1 MG during the 2070 10-year event.
- A stream restoration would reduce peak runoff by 0.2 cfs during the 2070 10-year event.

			10-year Reduction in Subbasin Runoff Volume (MG)		
Scenario	Project Number	NBS Type	2030	2070	Flood Reduction Benefits
West Road @ Furnace Brook	4	Stream Restoration	NA	0.1	Moderate

5. Swamp Road near Dublin Road

The Town identified a problem flooding area where the stream flows between Swamp Road and Stevens Glen Road. There is a pond on private property just along Swamp Road that could be retrofitted to expand flood storage capacity. Surface flow from Swamp Road is currently directed toward the pond. Elevations between the stream bed, the pond water surface, and the surrounding land indicate that if the land around the pond was strategically excavated, flood storage could be increased. This would not impact the day-to-day operations of the pond or the stream, but the project would create a flood storage for the stream to flow into the pond during storm events. Additionally, a diversion structure could be implemented to send more flow through the pond.

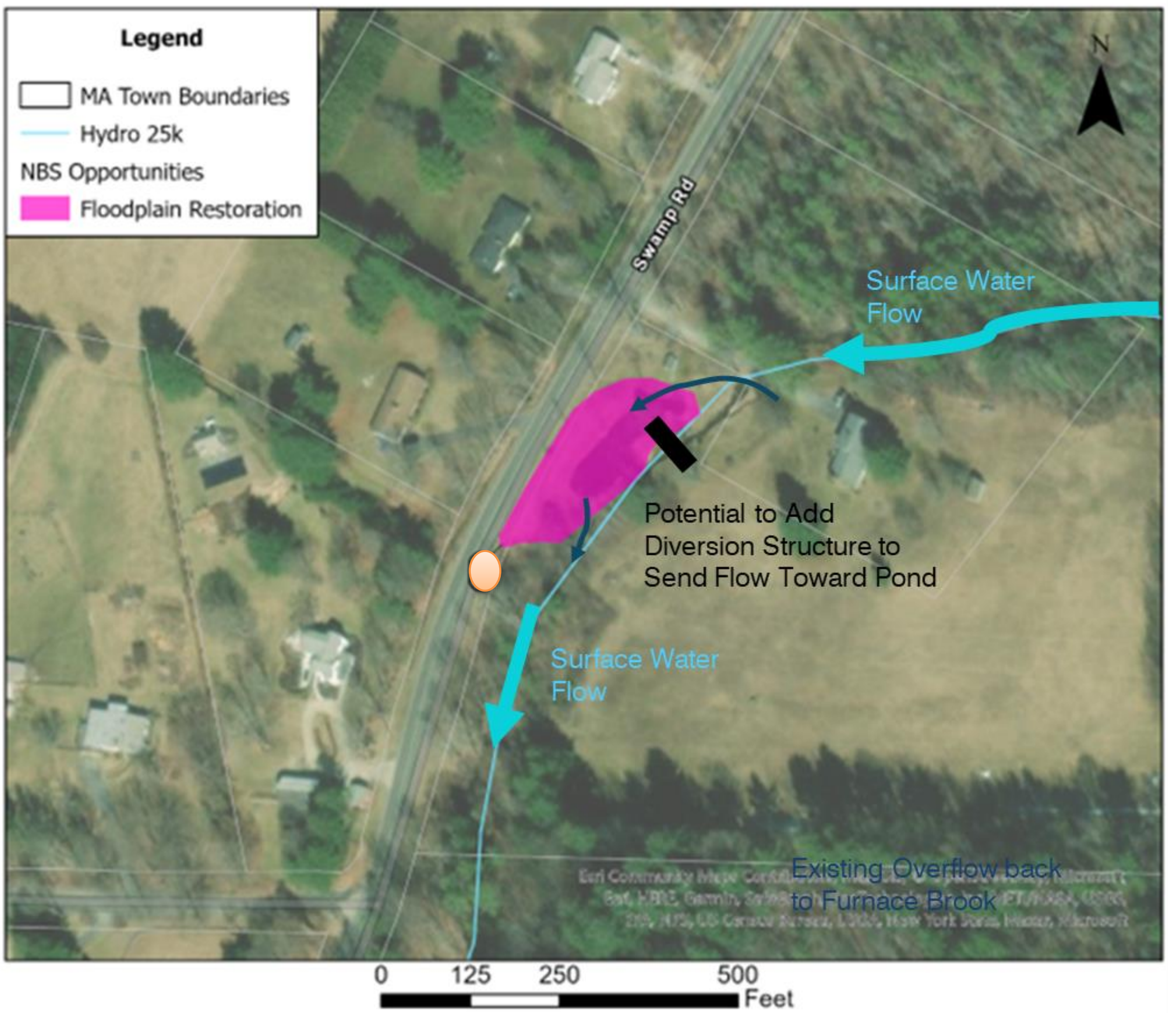


Figure 9. NBS Alternative 5

Summary of Modeling Results

- No significant flood mitigation benefits are expected in baseline or future scenarios.

				10-year Reduction in Subbasin Runoff Volume (MG)		
Scenario	Project Number	NBS Type	Area (SF)	2030	2070	Flood Reduction Benefits
Swamp Road	5	Floodplain Restoration	17,470	NA	NA	Minimal

6. West Road at Rossiter Road

The stream crossing that is just south of the pond shown in Figure 10 experiences frequent flooding, in part due to beaver activity. West Road also experiences drainage issues, as it has minimal ditches along the roads to direct runoff. This project recommends retrofitting an existing trench along Rossiter Rd., making it wider, flat-bottomed, and with check dams to mitigate impacts of sediment and erosion. The goal of this swale is to capture runoff coming east from the intersection of West and Rossiter Roads and store it prior to flowing into the pond. At the downstream end of the bioswale, the feature widens and can incorporate a level spreader for overflow into the pond. This will serve to minimize the additional roadway runoff collecting at the low point of the road stream crossing and avoid adding to existing flood issues at the crossing.

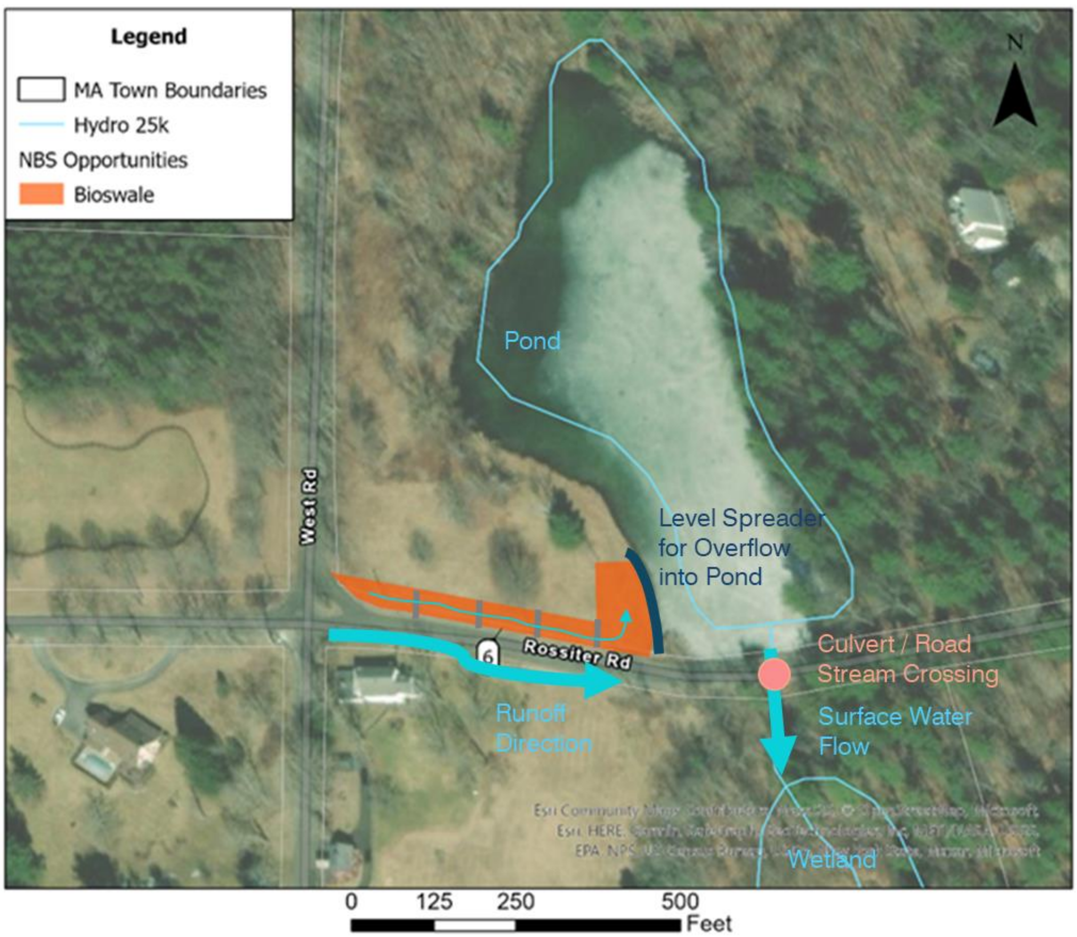


Figure 10. NBS Alternative 6

Summary of Modeling Results

- A bioswale would reduce runoff volume by 0.04 and 0.1 MG during the baseline and 2070 10-year events, respectively.
- A bioswale would reduce peak runoff by 0.3 and 0.7 cfs during the baseline and 2070 10-year events, respectively.

				10-year Reduction in Subbasin Runoff Volume (MG)		
Scenario	Project Number	NBS Type	Area (SF)	2030	2070	Flood Reduction Benefits
West Rd @ Rossiter Rd	6	Bioswale	13,850	.04	.1	Significant

7. Osceola Road at Swamp Road

The intersection of Osceola Rd. and Swamp Rd. was identified by the Town as a problem flooding area. There is an existing detention area at this location, which the Town installed and maintains twice per year. This proposed project is a retrofit of the existing detention area that will extend the basin along the right-of-way and increase storage. In conversation with the Town, this area receives significant sedimentation build up from the gravel road. Further design considerations for this feature and areas like this should include forebays at the inlet that can be easier to clean out periodically. This project would also benefit from the implementation of gravel road retrofits, described later in this memo.

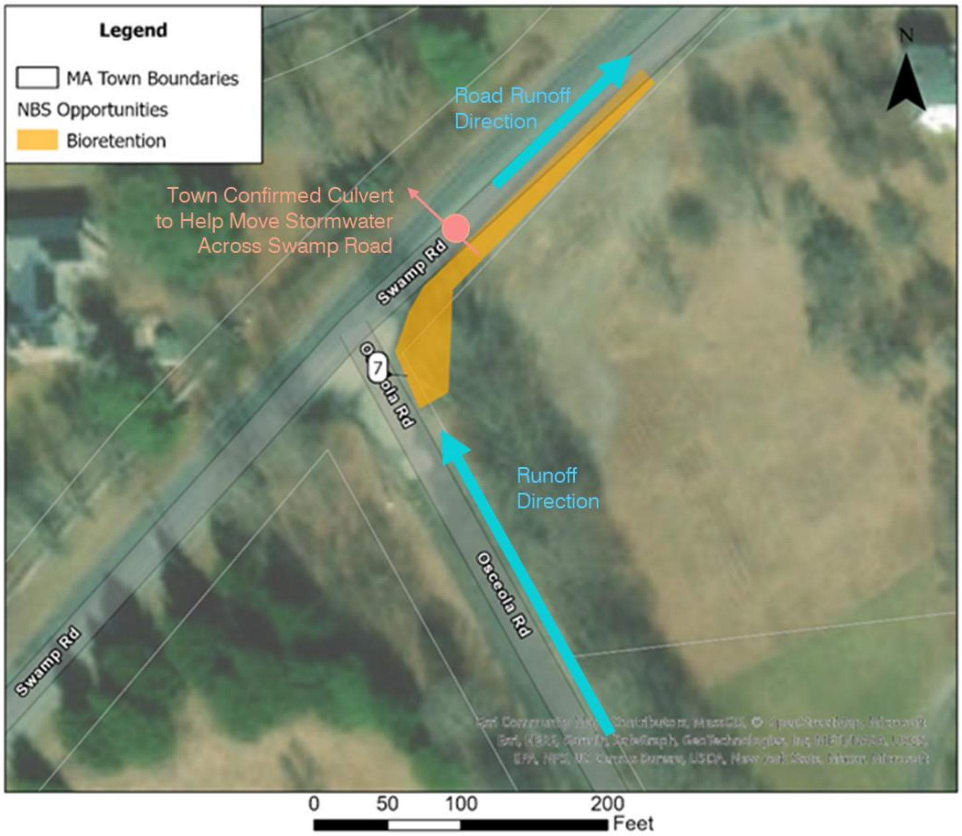


Figure 11. NBS Alternative 7

Summary of Modeling Results

- No peak or volume reductions expected under baseline.
- A bioretention cell would reduce runoff volume by 0.1 MG during the 2070 10-year event.
- A bioretention cell would reduce peak runoff by 0.8 cfs during the 2070 10-year event.

				10-year Reduction in Subbasin Runoff Volume (MG)		
Scenario	Project Number	NBS Type	Area (SF)	2030	2070	Flood Reduction Benefits
Osceola Road @ Swamp Road	7	Bioswale	4,790	NA	0.1	Significant

8. Town Beach Road / Richmond Fen Wildlife Management Area

The Royes Brook crossing at Town Beach Road, located northeast and downstream of this location, was noted by the Town as a problem flooding area due to beaver activity and backwatering from Shore Road downstream. This proposed project lies across the intersection of private and State land. There is a manmade berm that extends the length of this wetland that we propose removing or altering to re-establish the natural floodplain. Historic maps show that this was once a roadway, Lebanon Road, dating back to the 19th century, but appeared abandoned in the early 20th century.

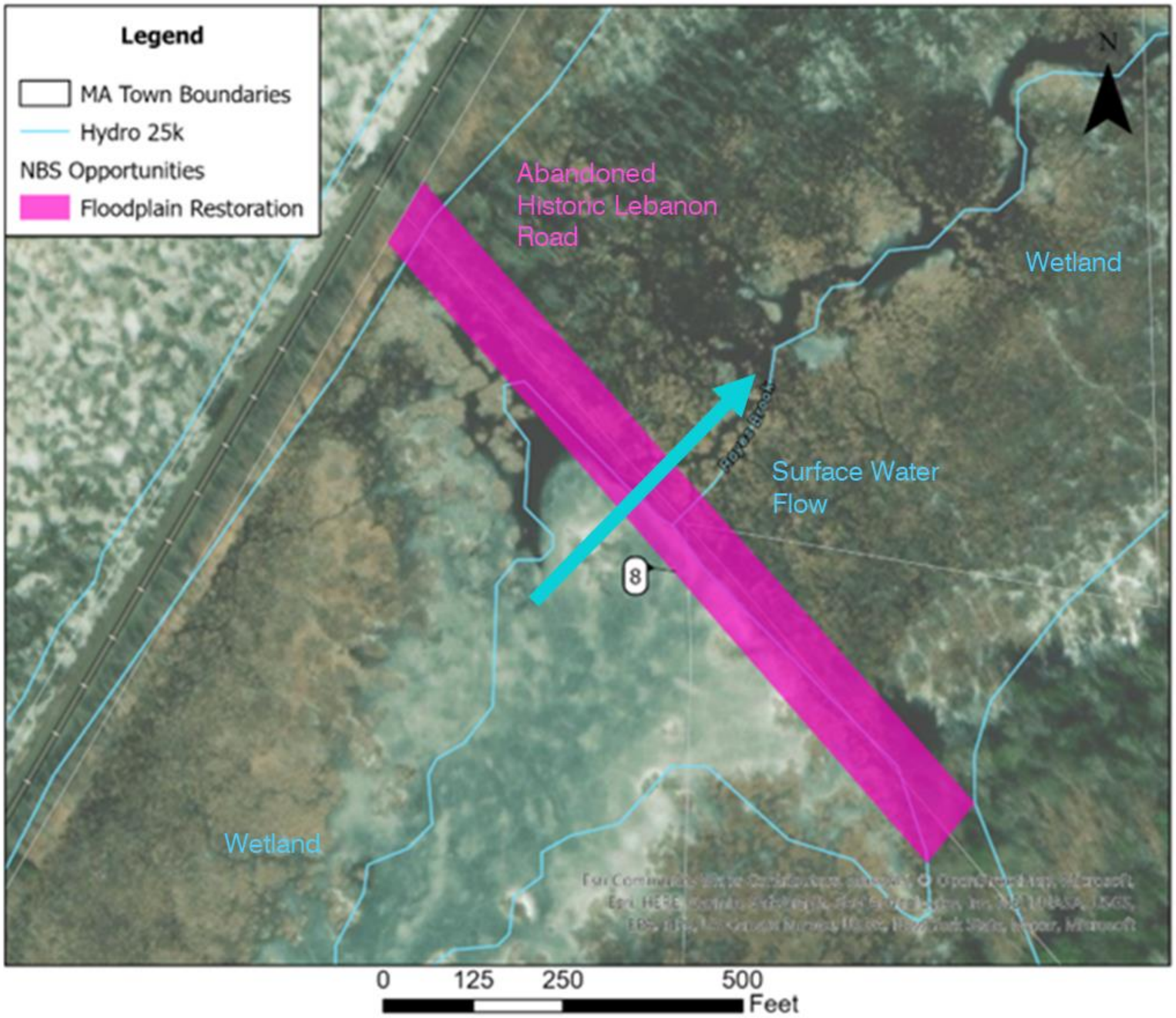


Figure 12. NBS Alternative 8

Summary of Modeling Results

- This project is straddling two subcatchments: J234 and J235.
- Both subcatchments would experience runoff volume reductions up to 0.3 MG and peak runoff reductions up to 0.7 cfs during baseline climate.
- Both subcatchments would experience runoff volume reductions up to 0.3 MG and peak runoff reductions up to 0.1 cfs during 2070 climate.

				10-year Reduction in Subbasin Runoff Volume (MG)		
Scenario	Project Number	NBS Type	Area (SF)	2030	2070	Flood Reduction Benefits
Town Beach Road	8	Floodplain Restoration	25,660	0.3	0.3	Significant

West Stockbridge NBS and Flood Reduction Opportunities

The 10 opportunities for the Town of West Stockbridge are summarized in Table 5. One additional project has been included, based on Town input, but was not incorporated into the modeling exercise.

Table 5: West Stockbridge, MA Opportunities

Project #	Location	Land Ownership	NBS Type
9	Woodruff @ Red Rock Rd	Town	Bioretention
10	Pixley Hill Rd	Town	Bioretention
11	State Line Rd @ Smith Rd	Town	Constructed Wetland
12	Red Rock Rd	Private	Bioswale
13	Austerlitz Rd	Private	Bioswale
14	South St	Private	Bioswale
15	South St	Public - ROW	Stream Restoration
16	Great Barrington Rd @ Card Pond	State / Private	Bioretention
17	Great Barrington Rd @ Card Pond	ROW / Private	Pervious Pavement
18	West Center Rd	Public - ROW	Stream Restoration

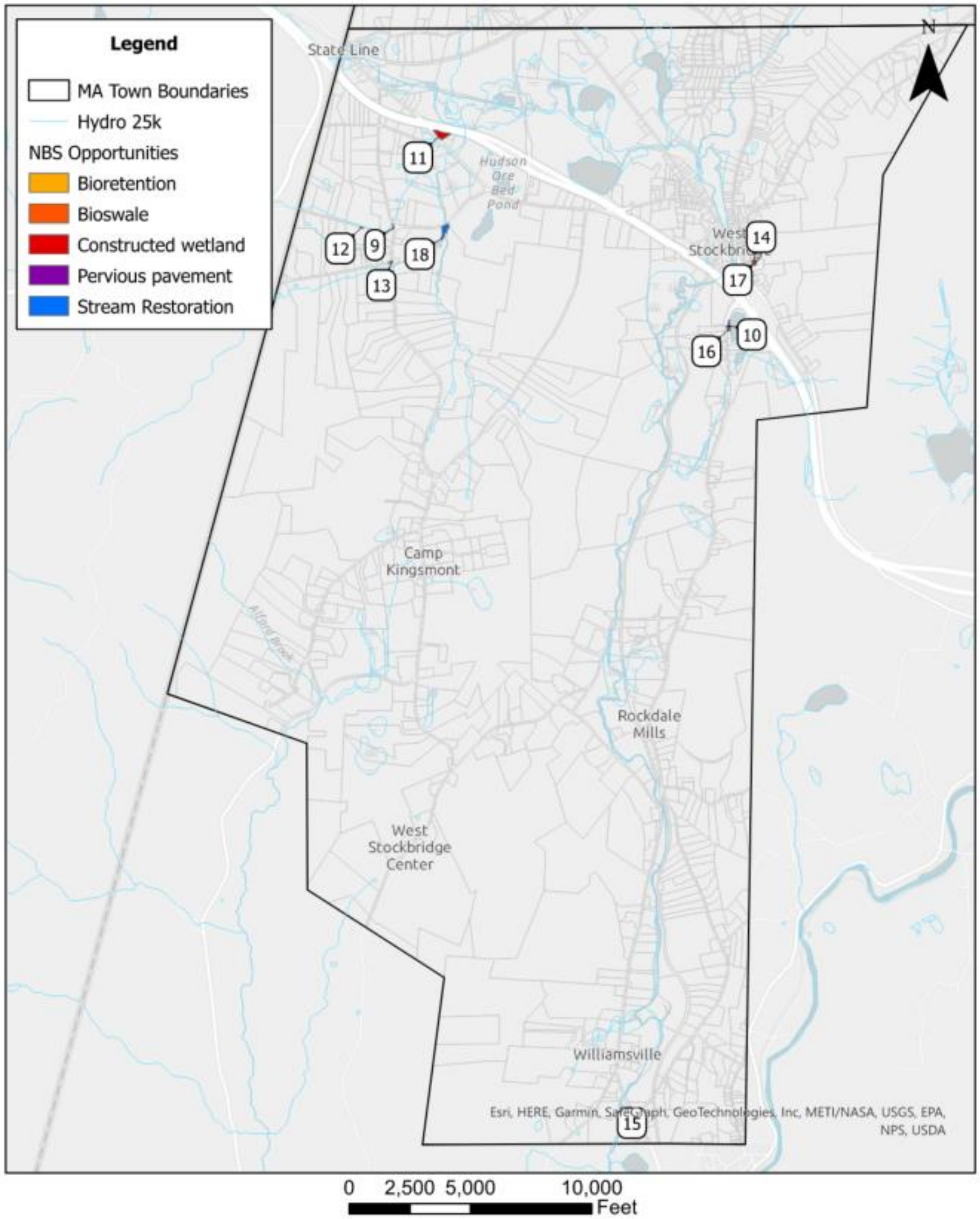


Figure 13. West Stockbridge NBS Alternatives

Each of the scenarios for proposed nature-based solutions is summarized in the sections below.

9. Woodruff @ Red Rock Rd

Town staff identified this area to be a problem flooding area due to ineffective conveyance along steep slopes. There is an existing gravel swale at this location that flows into a drop inlet catch basin. This alternative proposes retrofitting the gravel swale into an engineered, stepped bioretention basin that has an increased storage volume and promotes infiltration.

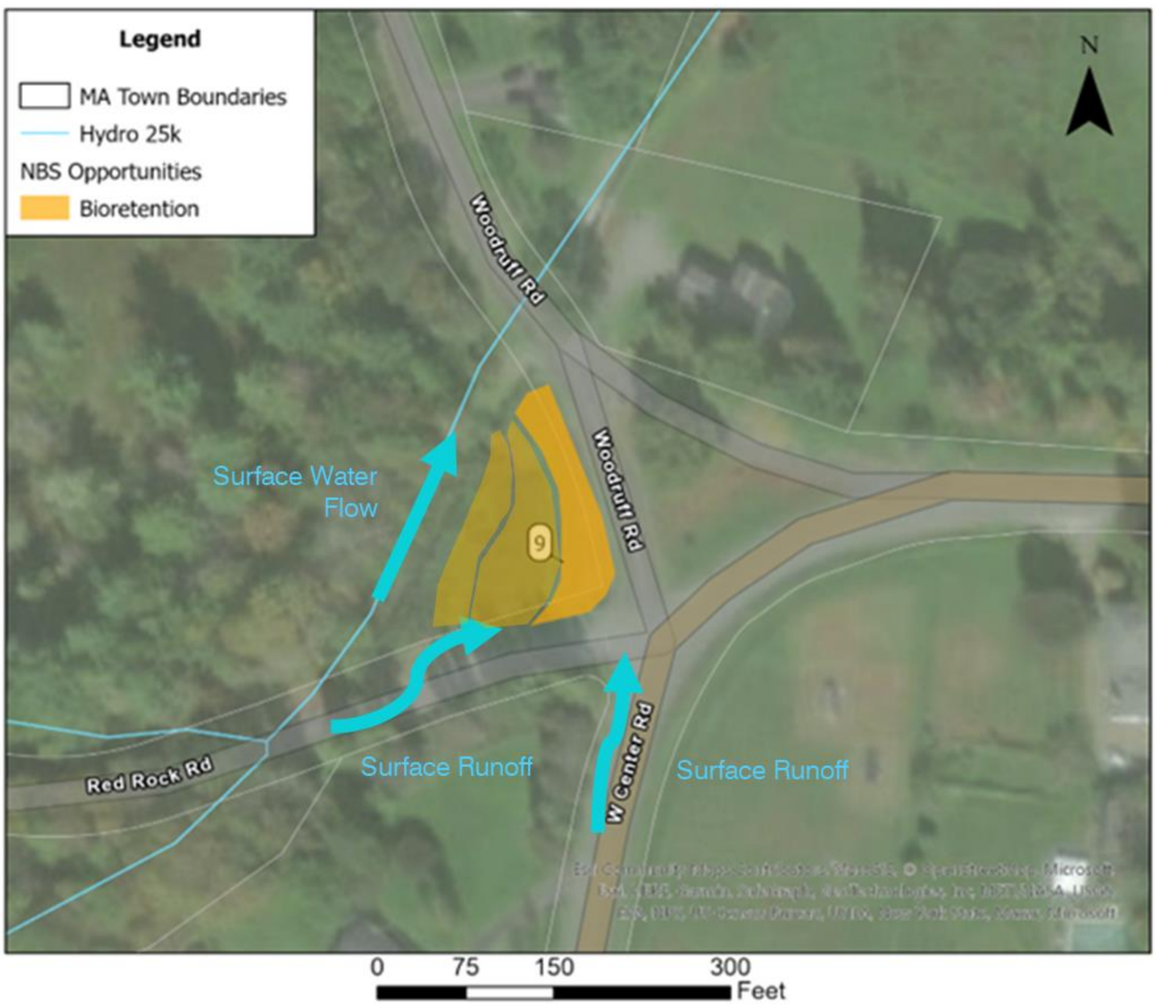


Figure 14. NBS Alternative 9

Modeling Summary

- No significant flood reduction benefits are expected in baseline or future scenarios.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subbasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
Woodruff @ Red Rock Rd	9	Bioretention	12,270	NA	NA	Minimal

10. Pixley Hill Road

The intersection of Pixley Hill Road and Great Barrington Road is a large area with a grassy traffic island. The Town noted that this location experiences high runoff volumes, and field investigations showed evidence of erosion and ponding. This alternative includes a retrofit of the grassy area to develop a bioretention basin that would intercept flows from Pixley Hill Road.

Figure 15. NBS Alternative 10

Modeling Summary

- No peak or volume reductions expected under baseline.
- A bioretention cell would reduce runoff volume by 0.02 MG during the 2070 10-year event.
- A bioretention cell would reduce peak runoff by 0.03 cfs during the 2070 10-year event.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subbasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
Pixley Hill Rd	10	Bioretention	980	NA	.02	Minimal

11. State Line Road at Smith Road

This concept proposed reconstructing and expanding a wetland area adjacent to a channelized stream flow. The stream runs through the eastern parcel. This alternative proposes to expand floodplain storage through excavating the existing grade and creating a lower area that could accept overflow from the stream during storm events. This alternative stretches across private parcels and would require the Town to purchase the northwestern parcel, which currently has a partially collapsed, dilapidated structure with an overgrown landscape. This project would also require coordination with MassDOT given their jurisdiction of Mass Pike and State Line Road. Modeling results show buildings in this area are impacted by the baseline 10-year storm event. This project aims to mitigate the impacts of those storms by providing space for flooding early during a storm event.

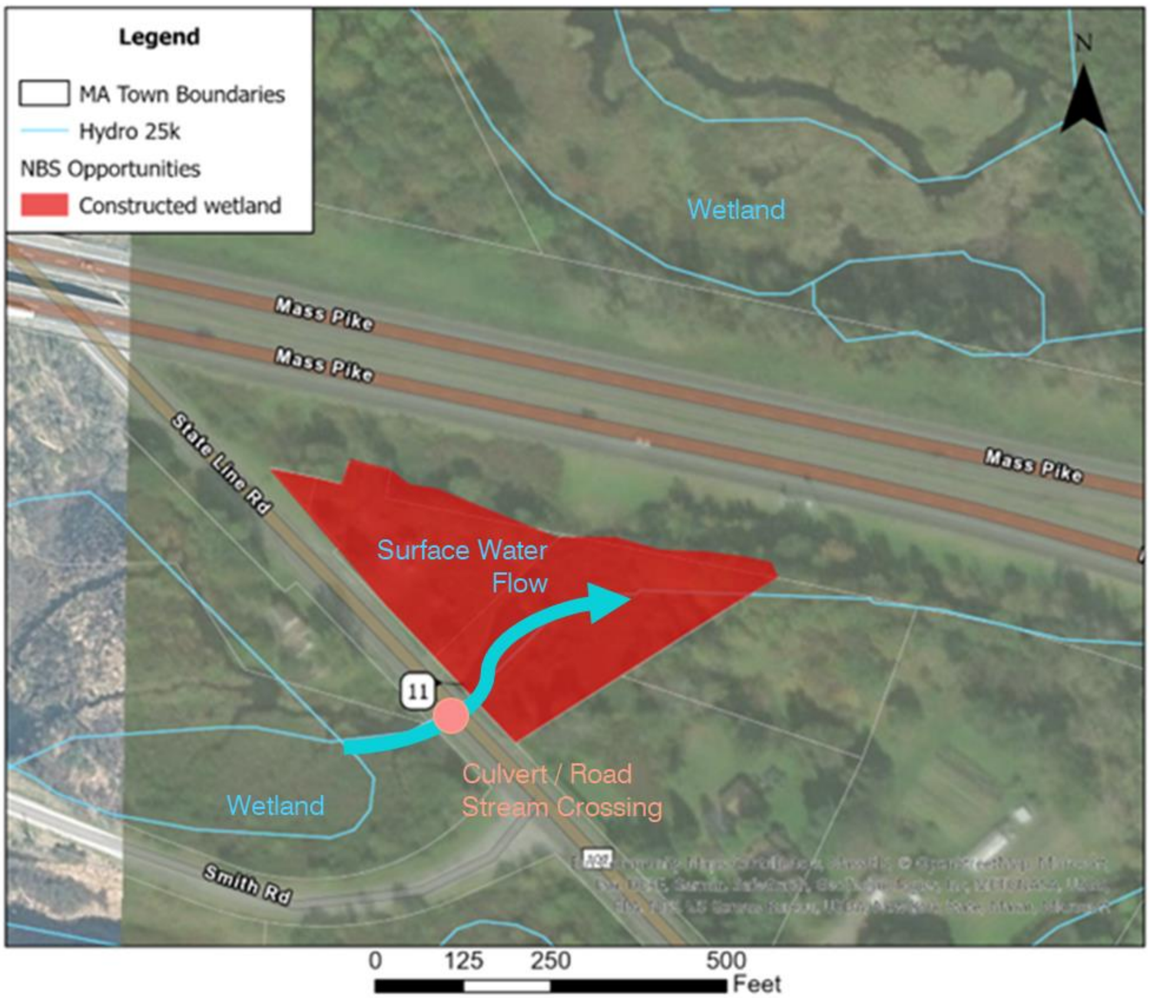


Figure 16. NBS Alternative 11

Modeling Summary

- This project is straddling four subcatchments: J489, J495, J19, and J496.

- No reductions in peak or volume reductions expected under baseline climate in subcatchment J489. The other subcatchments saw runoff volume reductions up to 0.04 MG and peak runoff reductions up to 0.2 cfs.
- All subcatchments would experience total volume reductions up to 0.1 MG and peak runoff reductions of up to 0.4 cfs during 2070 climate.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subbasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
State Line Rd	11	Constructed Wetland	67,430	.04	0.1	Moderate

12. Red Rock Road

Red Rock Road has been noted as a problem flooding area due to ineffective conveyance and steep slopes by the Town. The right-of-way along this road is mostly forested, however, at this location there is a grassy strip opening into a large agricultural field. This alternative recommends installing a bioswale in the existing grass area to intercept runoff coming down the upper portion of Red Rock Road and to decrease the volume of runoff flowing toward the Woodruff and Red Center Road intersection.

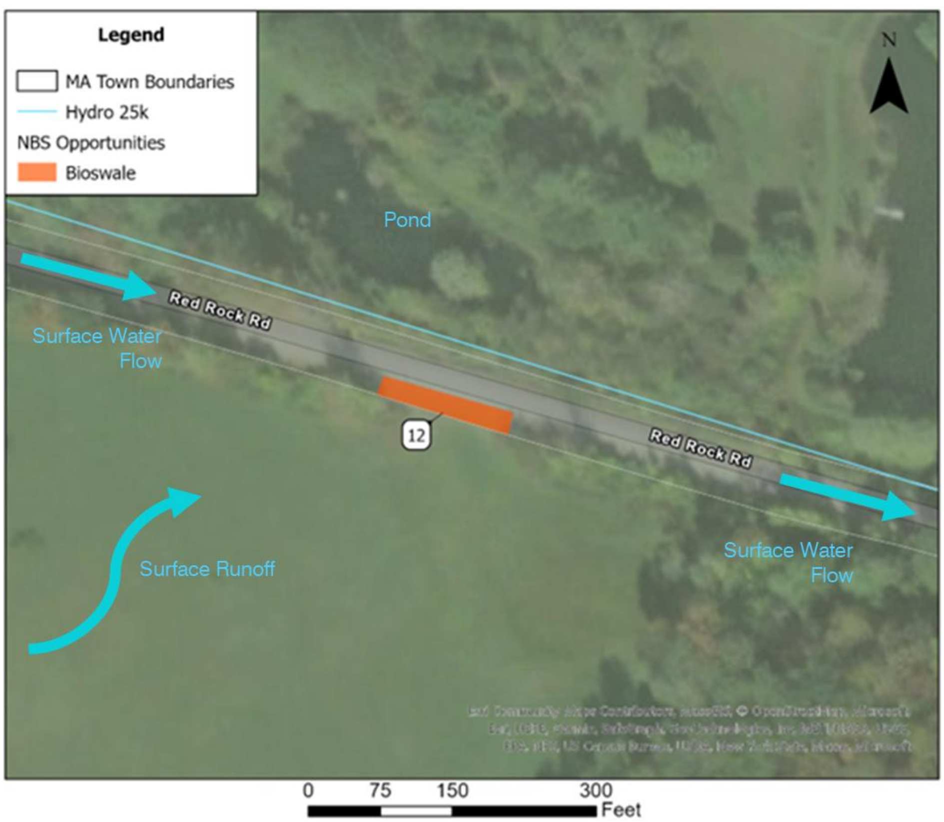


Figure 17. NBS Alternative 12

Modeling Summary

- No peak or volume reductions expected under baseline.
- A bioswale would reduce runoff volume by 0.02 MG during the 2070 10-year event.
- A bioswale would reduce peak runoff by 0.2 cfs during the 2070 10-year event.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
Red Rock Rd	13	Bioswale	1,725	NA	.02	Moderate

13. Austerlitz Road

The intersection of Austerlitz Road and West Center Road experiences high runoff volumes, and field investigations showed evidence of erosion and ponding along the road edges. This alternative would include installing a bioswale in the right-of-way that wraps around the corner to intercept runoff from Austerlitz Road and West Center Road and reduce flooding at this location. The Town has indicated that a conveyance pipe had been previously installed to help runoff move across the road and empty into the open space area across from Austerlitz Rd. This project can work in conjunction with that existing drainpipe and utilize it as a potential overflow.

Figure 18. NBS Alternative 13

Modeling Summary

- No peak or volume reductions expected under baseline.
- A bioswale would reduce runoff volume by 0.01 MG during the 2070 10-year event.
- A bioswale would reduce peak runoff by 0.2 cfs during the 2070 10-year event.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
Austerlitz Rd	13	Bioswale	1,720	NA	.01	Moderate

14-15. South Street

Residents at 1 Stockbridge Road have reported intense flooding on their property during storm events due to the culvert that runs underneath their house. This alternative would combine two strategies to reduce the runoff traveling cross country and into the back yards of several properties along Stockbridge Road. Stream restoration to the northwest of South Road would increase storage volume in this conduit. Additionally, expanding the flood plain for the stream to the south of South Road through a tiered bioswale could slow runoff and promote infiltration in place. Both projects would require coordination with private property owners.

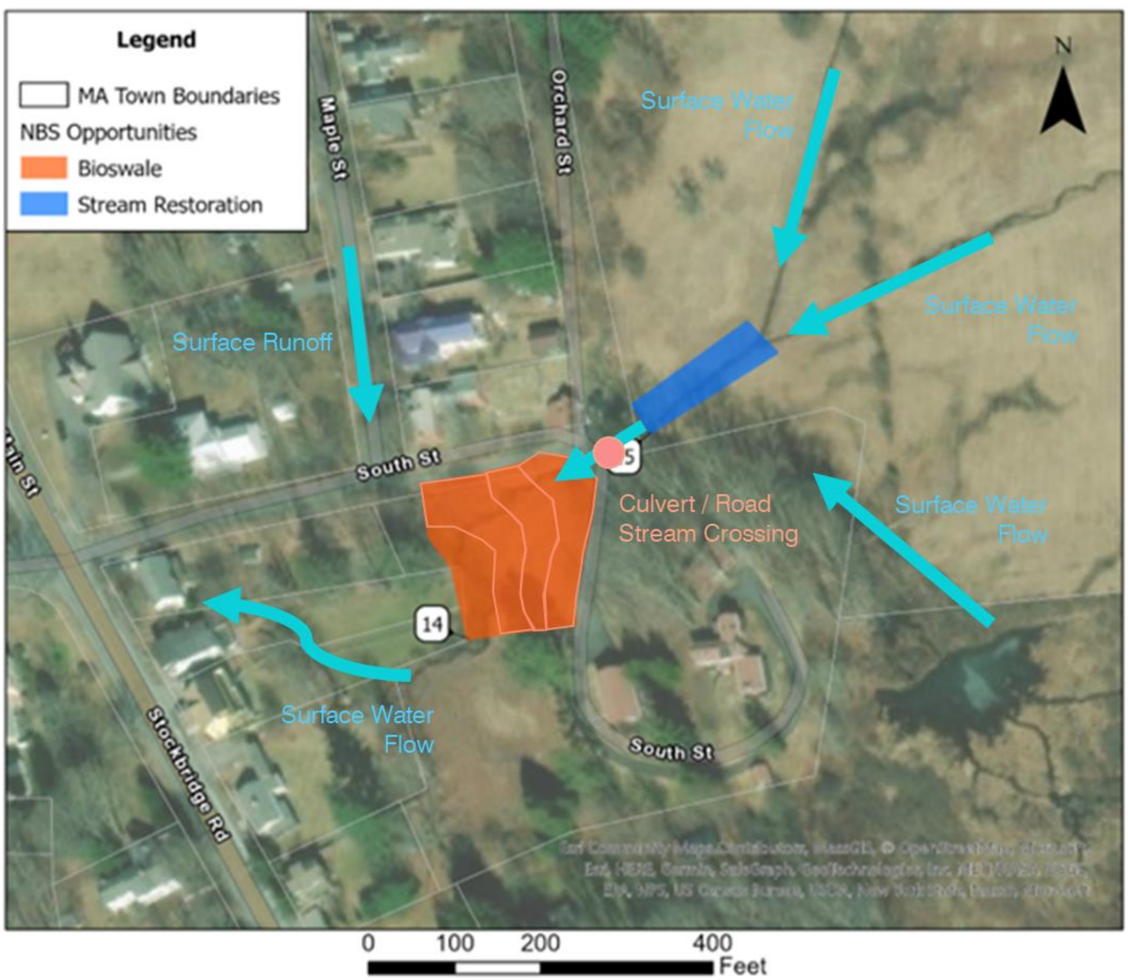


Figure 19. NBS Alternatives 14 and 15

Modeling Summary

South Street bioretention

- Model shows no significant benefits are expected in baseline or future scenarios.

South Street stream restoration

- Model shows no significant benefits are expected in baseline or future scenarios.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subbasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
South Street	14	Bioswale	17,775	NA	NA	Minimal
South Street	15	Stream Restoration	7,450	NA	NA	Minimal

16-17. Great Barrington Road

This parcel is municipally owned and includes a parking area and a large field surrounding Card Pond. The parking area has a steep slope up to Great Barrington Road and frequently washes out from runoff. This alternative proposes to raise the existing parking area and replace the gravel surface with a pervious surface. It also proposes to install a bioretention area adjacent to the lot in the grassy area to accept surface runoff and prevent runoff from running directly into Card Pond.

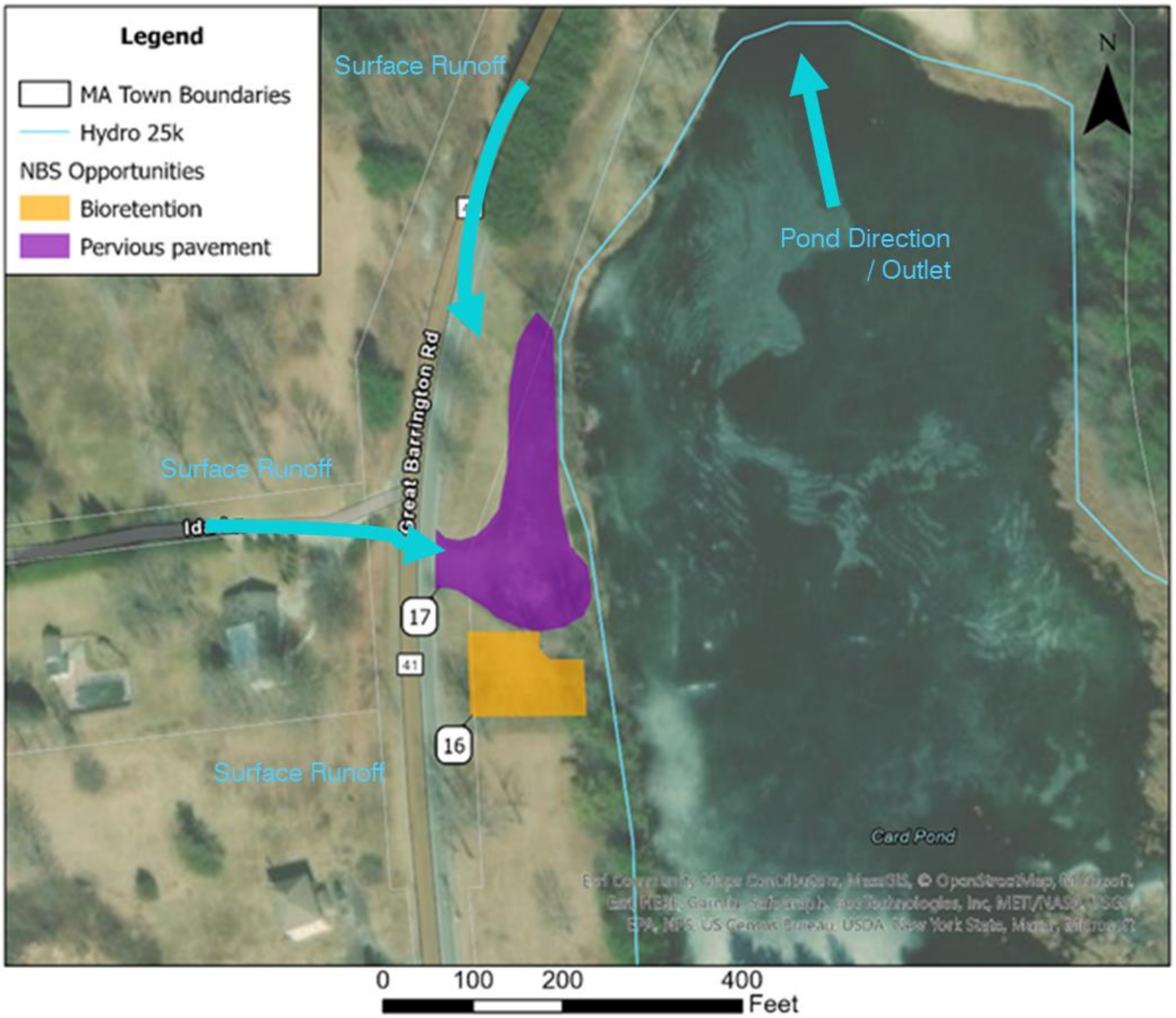


Figure 20. NBS Alternatives 16 and 17

Modeling Summary

<u>Great Barrington Road @ Card Pond bioretention</u>

- No significant benefits are expected in baseline or future scenarios.

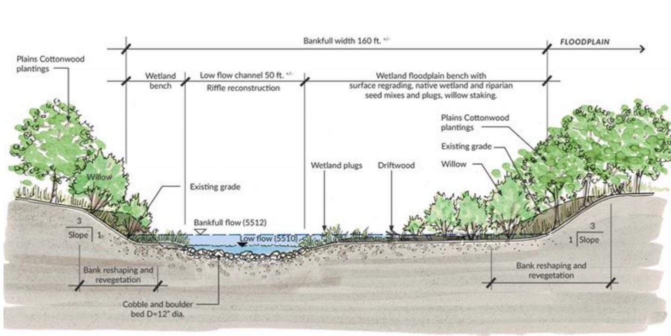
Great Barrington Road @ Card Pond pervious pavement

- No significant benefits are expected in baseline or future scenarios.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
Great Barrington Rd	16	Bioretention	5,860	NA	NA	Minimal
Great Barrington Rd	17	Pervious Pavement	15,230	NA	NA	Minimal

18. West Center Rd

The West Center Road road-stream crossing is noted by the Town as a priority area that experiences frequent flooding. This alternative would include working with the private landowner to restore the floodplain around Baldwin Brook and increase flood storage upstream of the culvert. The proposed project would offset the top of bank away from the stream channel to increase storage capacity, providing additional floodplain and bank stabilization. Combined with road stream crossings, the flood reduction benefits could be even greater.



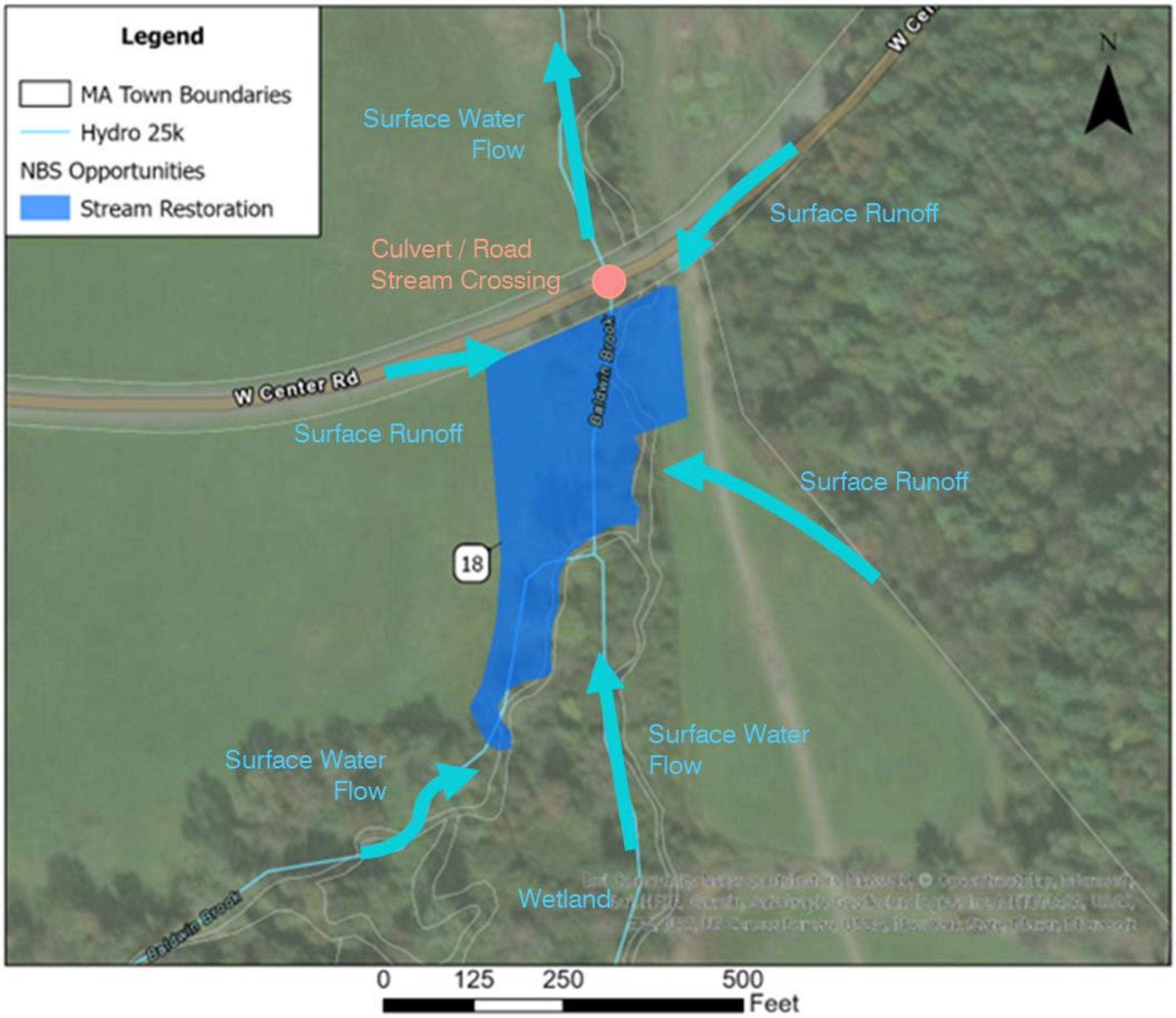


Figure 21. NBS Alternative 18

Modeling Summary

- No peak or volume reductions expected under baseline.
- This project is straddling two subcatchments: J3 and J4. No reductions are expected in subcatchment J4. Subcatchment J3 would see a runoff volume reduction of up to 0.4 MG and peak runoff reductions up to 3.6 cfs under 2070 climate.

Scenario	Project Number	NBS Type	Area (SF)	10-year Reduction in Subasin Runoff Volume (MG)		
				2030	2070	Flood Reduction Benefits
West Center Rd	18	Stream Restoration	49,450	NA	0.4	Significant

19. Iron Mine Road Bioretention

In discussion with the Town, a bioretention area on Iron Mine Road was included as an additional alternative storage opportunity. The project was not incorporated into the modeling and hydrologic results are not included here, but the Town is familiar with the flood benefits of this project as it was formerly a designed bioretention area before recent development. This alternative would involve working with the private landowner to re-establish a low-lying, flood prone area of the property as a bioretention area that can receive and hold stormwater runoff. The proposed bioretention area is 2,700 square feet. Overflow from this area would continue into a wooded, seasonal stream. Combined with proper gravel road management, the functionality and maintenance regiment can be improved.

Figure 22. NBS Alternative 19

Costs of Proposed NBS Projects

Unit pricing by square foot or cubic foot was determined for the NBS. A materials and labor subtotal was obtained for each opportunity based on this unit pricing. The following costs were added to the materials and labor subtotal for each opportunity to obtain a total materials and installation labor cost:

- A 3% mobilization/demobilization cost
- A 20% materials and labor contingency, to account for the high variability in prices over recent years
- A 20% contingency for unknowns

The following items were added to the materials and labor cost to obtain an overall subtotal cost for each opportunity:

- Daily surveying
- Estimated permitting
- Design and bidding, based on experience with previous projects
- A lump sum item for construction administration, based on project size, which assumes work associated with construction related to change order requests and field directives, part-time field oversight, review and approval of pay requests, and status meetings.
- Finally, a 20% general contingency was applied to the overall subtotal for each opportunity to account for any unknown costs that may be incurred, considering that these opportunities are still in the very early stages of design.

The Opinions of Cost for the proposed Richmond and West Stockbridge NBSs are shown in Table 6, below.

Table 6: NBS Opinion of Cost

Project #	Location	Opinion of Cost
4	West Rd near State Rd @ Furnace Brook crossing	$$$
5	Swamp Rd near Dublin Rd	$$$
6	West St at Rossiter Rd	$$$$
7	Osceola Rd at Swamp Rd	$$
8	Town Beach Rd / Richmond Fen Wildlife Management Area	$$
9	Woodruff Rd @ Red Rock Rd	$$
10	Pixley Hill Rd	$$

Project #	Location	Opinion of Cost
11	State Line Rd @ Smith Rd	$$$$$
12	Red Rock Rd	$$
13	Austerlitz Rd	$$
14	South St	$$$$$
15	South St	$$$$
16	Great Barrington Rd @ Card Pond	$$$
17	Great Barrington Rd @ Card Pond	$$$
18	West Center Rd	$$$$$

Downtown West Stockbridge Green Infrastructure Opportunities

The team's exploration of small-scale opportunities to reduce localized flooding and improve water quality focused on the downtown of West Stockbridge, because of its contiguous impervious cover that discharges to a local waterbody with noted water quality impairments. This analysis identified locations within the downtown where, based on the desktop GIS analysis, the topography was directing flows and contributing to flooding of abutting properties (See Figure 23 and Table 7). This analysis also looked for areas where impervious reduction could mitigate localized flooding. These opportunities were focused on engineered solutions, specifically green infrastructure practices.

Characteristics of a desirable site include:

- Low points in topography
- Open space on slopes to intercept flows and encourage infiltration
- Open space parcels
- Open space adjacent to road crossings
- Large areas of impervious surfaces

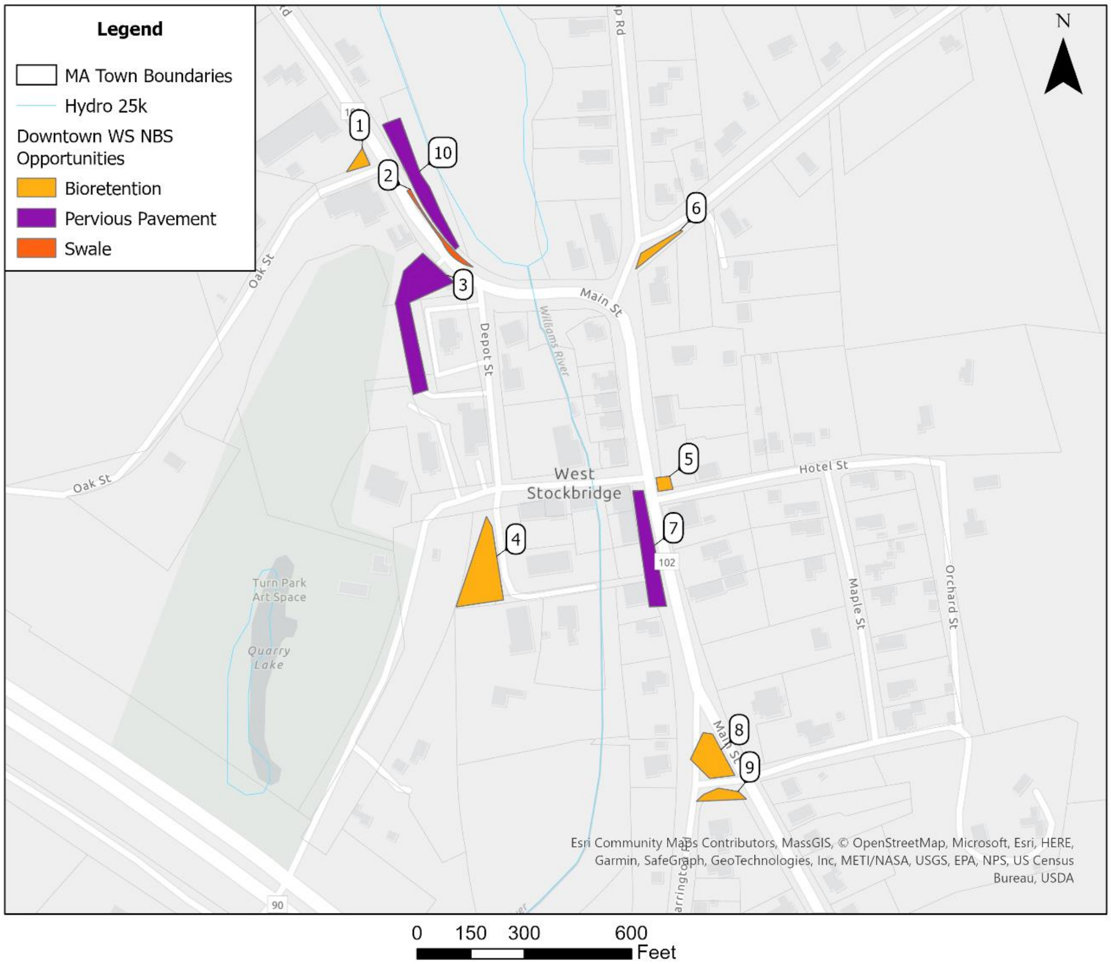


Figure 23. Downtown West Stockbridge Green Infrastructure Opportunities

Table 7: Downtown West Stockbridge Green Infrastructure Opportunities

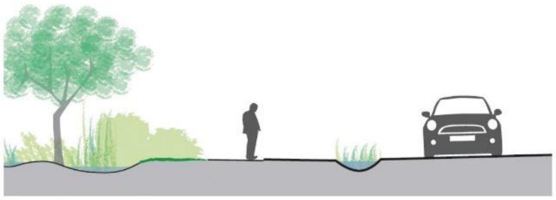
Project #	Estimated Volume CF	Green Infrastructure Type	Location	Description
1	980	Bioretention	Intersection of Oak Street and Main St	Bottom of hill on Oak Street and Main Street flowing down to here. Currently cars parked on corner could better use space
2	1,220	Bioswale, Infiltration Trench, Porous Strip	Down Main St past Oak toward downtown	Could disconnect catch basin and capture flow. There is a grassed strip, may have enough room for narrow bioretention
3	12,510	Permeable Paving	Gravel parking down 102 before Depot Street	Not sure if parcel is publicly owned, but good opportunity to reduce impervious and add porous or rain gardens in the parking lot

Project #	Estimated Volume CF	Green Infrastructure Type	Location	Description
4	9,380	Bioretention	Intersection Of Harris St. and Moscow Road green space	Not sure if parcel is publicly owned but large open greenspace could be formalized as bioretention, reforested, tree trenches
5	830	Bioretention	Intersection of Hotel St. and 102	Low point of Hotel Street, there is a catch basin that catches flow on the bottom left. Room to potentially disconnectit and tie into rain garden for infiltration
6	1,360	Bioretention	Intersection of Lenox and Swamp Rd	Lenox and Swamp Road low point. Intercept with bioretention beforecatch basin connection
7	7,020	Permeable Paving	Downtown past Hotel St	Porous stalls @downtown
8	4,910	Bioretention, Rain Garden, Mini Forest	Intersection of Old Great Barrington and 102	Formalize reen infrastructure at this location; existing stormwater feature located here, but pave
9	1,710	Bioretention, Tree planters, Infiltration Trench Along Curb	Intersection of Old Great Barrington and 102	Bottom of the property where it slopes down, intercept what appears to be atch basin flow.
10	8,050	Permeable Paving, Infiltration	Parking strip down Main St past Oak toward downtown	Replace existing informal gravel parking lot along pond edge with permeable paving lot with treatment

The examples in Figure 24 include diagrams & photographs of the types of Green Infrastructure the team investigated as part of the Downtown GI opportunities. Green infrastructure and low impact development are considered climate resilience best management practices. They use surface features including native vegetation, soils, and other natural processes to reduce flooding and improve water quality.

These systems collect and store runoff, aiding in infiltration and treatment of stormwater. Several options have been evaluated for the Resilient Stormwater Action and Implementation Plan (RSAIP) for Richmond and West Stockbridge.

Figure 24. Green Infrastructure Types



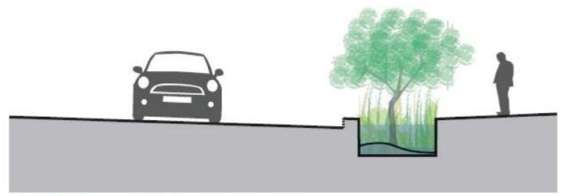
Bioswales

Benefits:

- Roots uptake water and nutrients in the runoff.
- Soil mycorrhizae improves water quality by removing pollutants.
- Retains stormwater for future use or detains it before it flows into the drainage system after the storm event.
- Provides habitat for pollinators.

Applications:

- Sidewalks
- Medians and parking lot edges



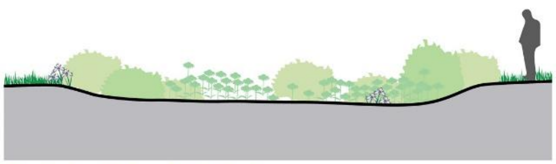
Tree Planting and Street Tree Box Filters

Benefits:

- Intercepts rainfall and treats water quality.
- Aids in reducing the urban heat island effect.
- Adds character and value to a neighborhood.

Applications:

- Streets
- Linear parks
- Can be installed in conjunction with bioswales



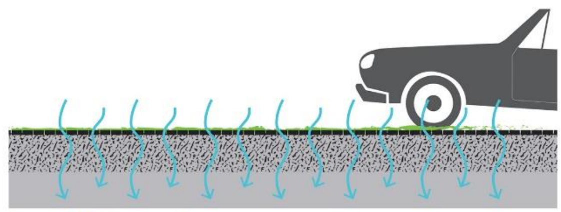
Bioretention Basins / Rain Gardens

Benefits:

- Roots uptake water and nutrients in the runoff.
- Soil mycorrhizae improves water quality by removing pollutants.
- Retains stormwater for future use or detains it before it flows into the drainage system after the storm event.
- Provides habitat for pollinators.

Applications:

- Residential and commercial yards
- Public right-of-way



Permeable Pavement

Benefits:

- Reduces stormwater runoff from roadways and sidewalks.
- Slows infiltration back into the ground or stormwater system.
- Prevents some surface pollution from entering gray infrastructure and downstream habitats.

Applications:

- Where stable, hard surfaces are needed along streets, sidewalks and in parking areas
- Can be used in conjunction with underground storage

Green Infrastructure Summary of Modeling Results

Below are the modeling results listing expected performance for each project. The modeling process compares each projects' performance within the context of the drainage area within which they are situated. When drainage areas are large, the expected benefits of smaller features may not be as evident by their size. So, as most of the results list hydrologic benefits as minimal, the potential co-benefits of the projects may be more compelling in terms of implementation. The co-benefits for each project will be documented as part of the prioritization matrix as part of Sub-task 3.5.

1. Intersection of Oak Street and Main St.

- No significant benefits are expected.

2. Down Main St. past Oak toward downtown

- No significant benefits are expected.

3. Gravel parking down 102 before Depot Street

- No significant benefits are expected under baseline or future scenarios.

4. Intersection of Harris St. and Moscow Road Green space

- No significant benefits are expected under baseline or future scenarios.

5. Intersection of Hotel St. and 102

- This project straddles two subcatchments, however, benefits are limited to one subcatchment.
- No peak or volume reductions expected under baseline.
- This subcatchment would not see a reduction in total runoff volume during 2070 climate but would see a slight reduction in peak runoff rate up to 0.04 cfs.

6. Intersection of Lenox and Swamp Rd.

- No significant benefits are expected under baseline or future scenarios.

7. Downtown past Hotel St.

- No significant benefits are expected under baseline or future scenarios.

8. Intersection of Old Great Barrington and 102

- No significant benefits are expected under baseline or future scenarios.

9. Intersection of Old Great Barrington and 102

- No significant benefits are expected under baseline or future scenarios.

10. Parking strip down Main St. past Oak toward downtown

- This project straddles two subcatchments.
- No peak or volume reductions expected under baseline.
- The subcatchments would see a reduction in total runoff volume up to 0.03 MG and peak runoff rate up to 0.1 cfs during 2070 climate.

Costs of Proposed Downtown Green Infrastructure Projects

Costs for the proposed downtown green infrastructure projects are based on the same assumptions as the

The Opinion of Cost for the Downtown Green Infrastructure projects are shown in Table 8, below.

Table 8: Downtown GI Opinion of Cost

Project #	Location	Opinion of Cost
1	Intersection of Oak Street and Main St	$
2	Down Main St past Oak toward downtown	$
3	Gravel parking down 102 before Depot Street	$$
4	Intersection Of Harris St. and Moscow Road green space	$
5	Intersection of Hotel St. and 102	$
6	Intersection of Lenox and Swamp Rd	$
7	Downtown past Hotel St	$$
8	Intersection of Old Great Barrington and 102	$
9	Intersection of Old Great Barrington and 102	$
10	Parking strip down Main St past Oak toward downtown	$$

Dam Opportunities

Dams play an integral role in the storage and conveyance of stormwater runoff in watersheds. Weston & Sampson identified dams within the Town limits of Richmond and West Stockbridge located within the three watersheds of interest: the Williams River watershed, the upper Green River watershed (Alford Brook watershed), and the West Branch Housatonic River watershed (Richmond Pond watershed). Of the dams identified within the watersheds, several were shown as having the potential for increased flood storage or to reduce flooding through dam removal. The following sections describe each dam and the potential alternatives.

These projects were entered into a hydrologic and hydraulic model to understand the flood reduction benefits they provide in their respective sub-watershed, using a 100-year storm event projected for both 2030 and 2070. Each site was provided with a Significant, Moderate, or Minimal flood reduction ranking based on the results. Rankings of "Significant, Moderate, or Minimal" considered both the 2030 and 2070 magnitude of reductions in the peak and total runoff volumes as well as the subbasin (size, contribution) within which the project falls. There are exceptions primarily caused by the subbasins/locations of the projects, i.e., a project with a lower total volume reduction may still be considered significant when the subbasin is very large and has a high % impervious area. Any results listing hydrologic benefits as minimal do not reflect the potential co-benefits of a project, which collectively may result in the project being prioritized for implementation on other grounds.

Dam Storage/Drawdown

Six dams were identified as having a potential for additional flood storage and were selected based on visual observations of significant storage capacity and their proximity to known problem areas, either in the field or using aerial imagery. A dam with large storage capacity can store significant flood volumes for long periods of time, which would reduce peak flood elevations downstream. Many of the dams are jurisdictional, meaning the dams have large enough storage capacity to be regulated by the Massachusetts Department of Conservation and Recreation's Office of Dam Safety. Further consideration was made for dams with known, operable low-level outlets or other operable spillways. Impoundments at dams with operable low-level outlets can be lowered ahead of a storm event to provide additional storage. Dams with operable spillways can be manipulated to release water at a slower rate or begin releasing water later in a storm. Table 9 below lists the dams identified for potential storage or drawdown potential. Figure 25 below shows the locations of these dams.

In addition to modifying operations of dams prior to storm events, there are also structural options for changing smaller scale ponds. The images on the next page illustrate some of the potential options for outlet structure modification, i.e., monk outlets with boards and screens and multi-stage outlets.

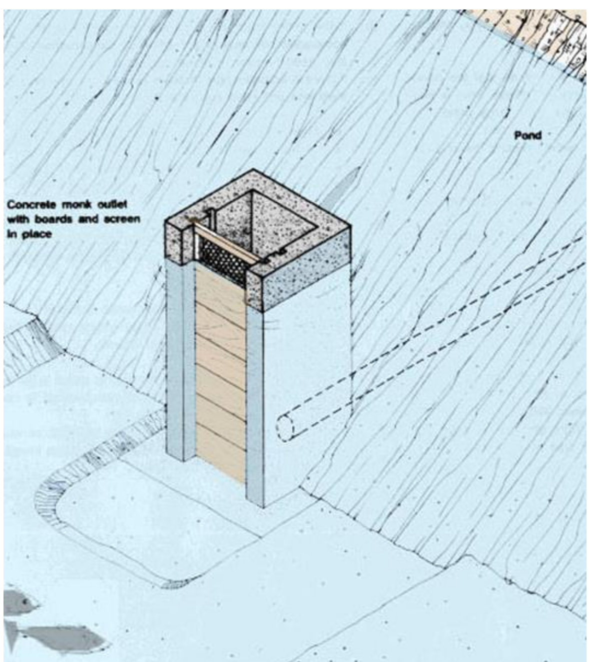
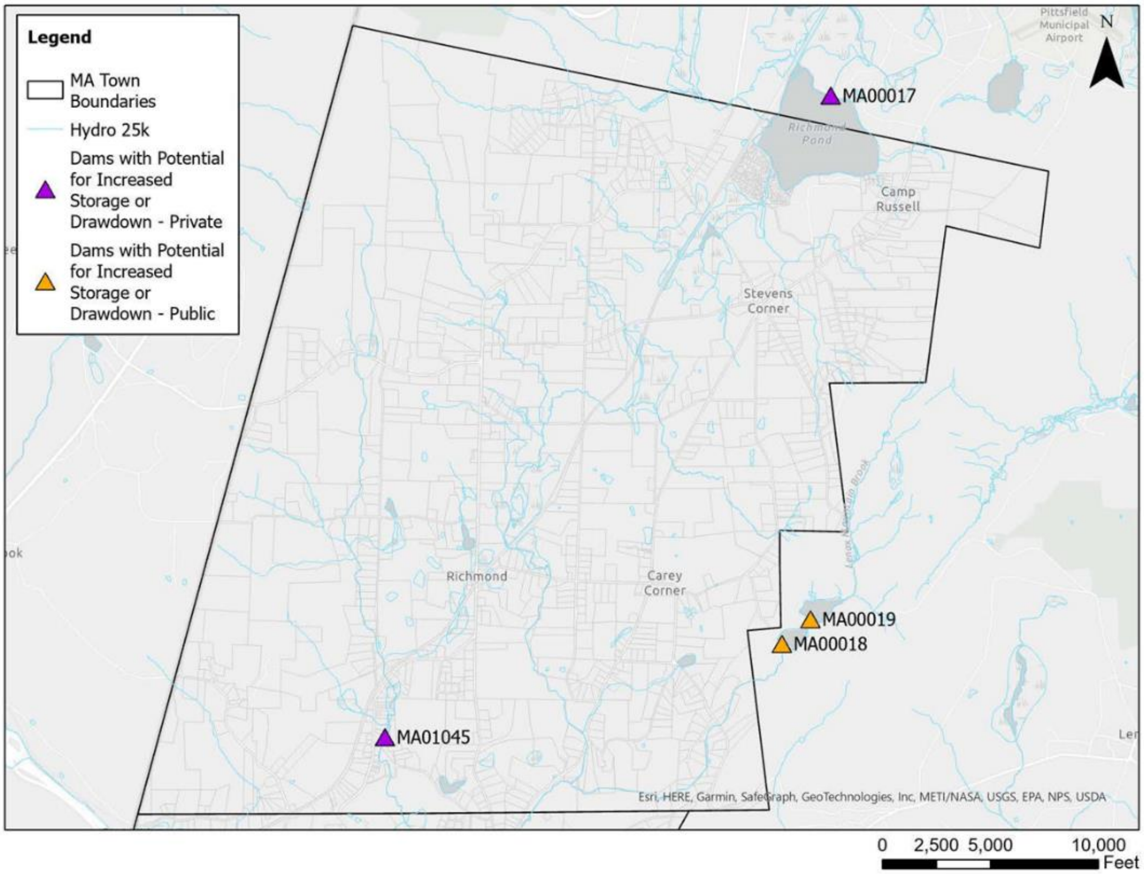


Table 9: Dams with Potential for Increased Storage or Drawdown

Dam Name (NID #)	Location	Ownership	Notes
Upper Root Reservoir Dam (MA00019)	Lenox	Public	Lenox water supply dam; Large, High hazard dam; owned by Lenox Board of Selectmen; large storage capacity; can likely be drawn down ahead of storms; lower Root Reservoir & Dam immediately downstream; upstream end of model
Lower Root Reservoir Dam (MA00018)	Lenox	Public	Lenox water supply dam; Large, High hazard dam; owned by Lenox Board of Selectmen; large storage capacity, can likely be drawn down ahead of storms; R.PA-22 downstream
Richmond Pond Dam (MA00017)	Pittsfield, at Richmond Pond	Public	Recreation dam; Large, High hazard; privately owned; if there is a low-level outlet, drawdown prior to event is suggested; downstream limit of the West Branch Housatonic River watershed model; R.PA-6 upstream
Richmond Iron Works Dam (MA01045)	Richmond, at driveway for 2871 State Road	Private	Non-jurisdictional; privately owned; dam is approximately 16 feet tall; uncontrolled spillway (14-foot high by 12-foot-wide culvert) with significant capacity, spillway could be modified to control discharge and allow for more storage; no low-level outlet, low-level outlet could be installed to drawdown prior to storm – only worth it if spillway discharge can also be reduced to temporarily store water
Shaker Mill Pond Dam (MA00732)	West Stockbridge, in downtown	Public	Recreation dam; unsure of size classification, High hazard; owned by West Stockbridge Board of Selectmen; drawdown prior to storms could minimize flooding around the pond
Card Pond Dam (MA01047)	West Stockbridge, at Card Pond Recreation Area	Public	Recreation dam; unsure of size classification, Low hazard; owned by West Stockbridge Board of Selectmen; drawdown could provide some storage; upstream end of model


Legend
MA Town Boundaries
Hydro 25k
Dams with Potential for Increased Storage or Drawdown - Private
Dams with Potential for Increased Storage or Drawdown - Public
MA00017
Richmond Pond
Camp Russell
Stevens Corner
Pittsfield Municipal Airport
N
Richmond
Carey Corner
MA00019
MA00018
MA01045
Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA
0 2,500 5,000 10,000
Feet

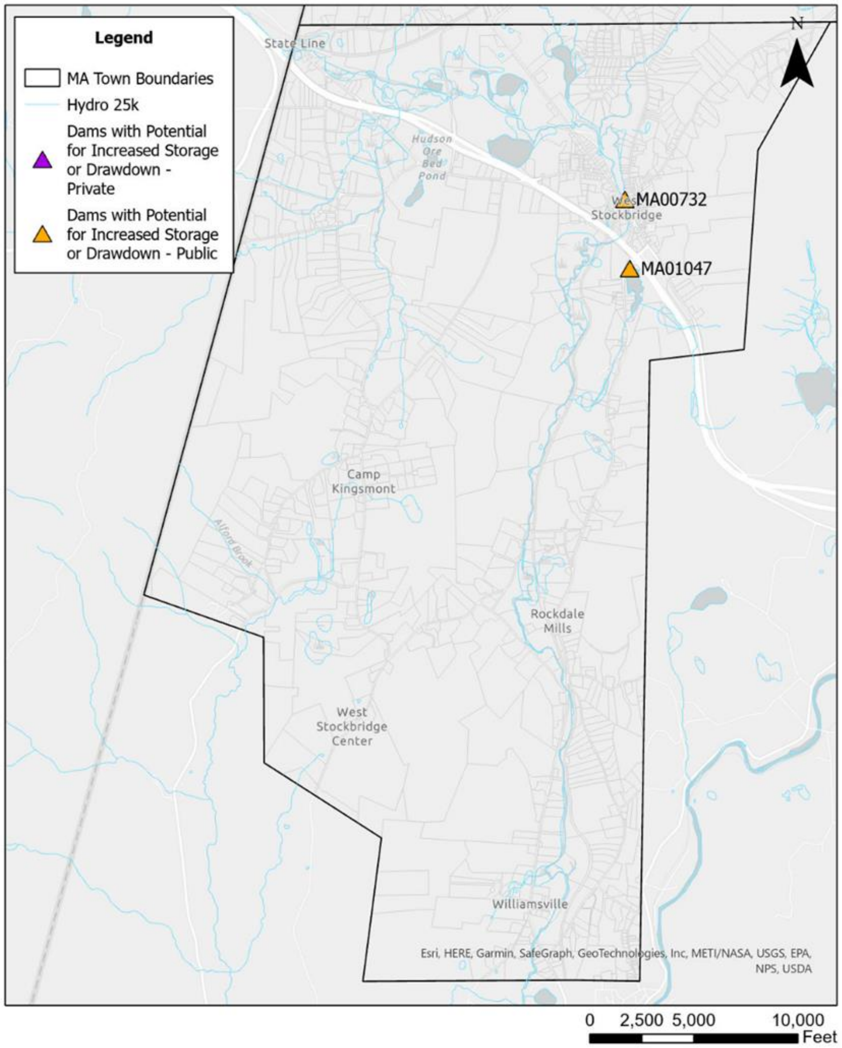


Figure 25.a & 25.b (a - top) Richmond & (b - bottom) West Stockbridge Dams with Potential for Increased Storage or Drawdown

Dam Drawdown Summary of Modeling Results

<u>Upper Root Reservoir Drawdown</u>

- Peak flood levels at the project dam are expected to be reduced by approximately 1.9 feet during baseline climate and 0.6 feet during 2070 climate.
- Several downstream stream crossings will experience slight peak flood level reductions during the baseline 100-year storm event, including Lenox Road, Swamp Road, and Cone Hill Road crossings.

- Several additional stream crossings experience up to 1.1 feet of peak flood level reduction benefits during the 2070 100-year event, including two Lenox Road crossings, Stevens Glen Road, Swamp Road, and Cone Hill Road crossings.
- Peak flood levels at two unnamed, private dams are expected to decrease by up to approximately ¼ foot during the 2070 100-year event.
- No buildings are expected to experience significant benefits.
- Pond Drawdown Project Flood Reduction Benefits: Significant

Richmond Pond Dam Drawdown

- Peak flood levels at the project dam are expected to be reduced by approximately 1.1 feet during baseline climate and 0.6 feet during 2070 climate.
- Several upstream stream crossings, affected by Richmond Pond backwater during large events, experience approximately 0.5-foot peak flood reduction during the baseline 100-year storm event.
- Benefits to stream crossings during the 2070 100-year are similar or smaller in magnitude.
- Several buildings along the shoreline may also be expected to experience a reduction of up to about one foot in flooding during the 100-year storm event. – Buildings are visible in inundated 2D cells, however the closest junctions to the buildings are NOT inundated junctions, therefore they show no benefit.
- Pond Drawdown Project Flood Reduction Benefits: Moderate

Lower Root Reservoir Dam Drawdown

- Peak flood levels at the project dam are expected to be reduced by approximately 0.9 feet during baseline climate and 1.0 feet during 2070 climate.
- Several downstream stream crossings will experience slight peak flood level increases during the baseline 100-year storm event.
- No buildings are expected to experience significant benefits.
- Pond Drawdown Project Flood Reduction Benefits: Moderate

Richmond Iron Works Dam Drawdown

- No significant downstream benefits are expected.
- The spillway is large and creates only a small impoundment behind it, drawdown does not have a significant impact on peak flood levels.
- Pond Drawdown Project Flood Reduction Benefits: Minimal

Shaker Mill Pond Dam Drawdown

- Peak flood levels at the project dam are expected to be reduced by approximately 1.9 feet during baseline and 1.7 feet during 2070 climate.
- Several upstream stream crossings would experience up to 1.9 feet of peak flood level reductions during the baseline 100-year storm event, including two Albany Road crossings.

- These crossings would experience up to 1.6 feet of peak flood level reductions during 2070 climate.
- Several buildings adjacent to Shaker Mill Pond and upstream Flat Brook would see flood reductions up to 1.1 feet during baseline and 1.5 feet during 2070 climate.
- A handful of buildings in the downstream area could see up to a 0.3-foot increase in peak flood level during baseline. A handful of additional buildings downstream could see a peak flood level increase up to 0.6 feet. The increases caused by the Shaker Mill Pond Dam drawdown are not causing new buildings to flood.
- Pond Drawdown Project Flood Reduction Benefits: Significant

Card Pond Dam Drawdown

- Peak flood levels at the project dam are expected to be reduced by up to approximately 0.5 feet during both baseline and 2070 climate.
- No significant downstream benefits are expected.
- Pond Drawdown Project Flood Reduction Benefits: Minimal

Dam Removal Opportunities

Weston & Sampson identified 12 dams that may have dam removal potential. Of the dams that were explicitly modeled in the hydraulic model, dams were selected for removal potential if a dam appeared to serve no purpose other than aesthetics, if the removal would increase aquatic connectivity, and based on a high benefit percentile score in DER's Dam Removal and Ecological Benefit Estimation Tool.[4] This DER tool estimates the ecological benefit of removing a dam and assigns a score with high scores having the greatest ecological benefit. Although we did not evaluate condition in this analysis, further consideration for dams in poor condition should be made as poor condition dams are more likely to fail.

Tables 10 and 11 summarize dams impacting Richmond and West Stockbridge that could be good candidates for dam removal. Figures 26 and 27 show the locations of these dams.

Table 10: Dam Removal Candidate Dams Impacting Richmond

Dam Name (NID #)	Location	Ownership	Notes
Unnamed Dam	Pittsfield, near 98 Central Berkshire Boulevard	Private	Small, non-jurisdictional, stone dam; privately owned; impounds small pond with wetlands upstream
Unnamed Dam	Richmond, behind 1018 Dublin Road	Private	Small, non-jurisdictional dam with pedestrian bridge over spillway; privately owned; impounds small pond; R.PA-20 downstream

[4] https://mass-eoeea.maps.arcgis.com/apps/MapTools/index.html?appid=f573dc437265480f87e31f413e527a3c

Unnamed Dam	Richmond, on driveway for 350 West Road	Private	Small, non-jurisdictional, concrete dam; privately owned; no impoundment under normal conditions; no storage capacity; no aquatic passability
Sherrill Pond Dam (MA02203)	Richmond, on pond behind 2040 State Road	Private	Small, non-jurisdictional, earthen embankment dam; privately owned; DER benefit percentile = 75
Richmond Iron Works Dam (MA01045)	Richmond, at driveway for 2871 State Road	Private	Non-jurisdictional; privately owned; recreational dam with driveway over embankment; significant (15-20-foot) drop-off downstream, large spillway, does not impound much under normal pool conditions; DER benefit percentile = 90

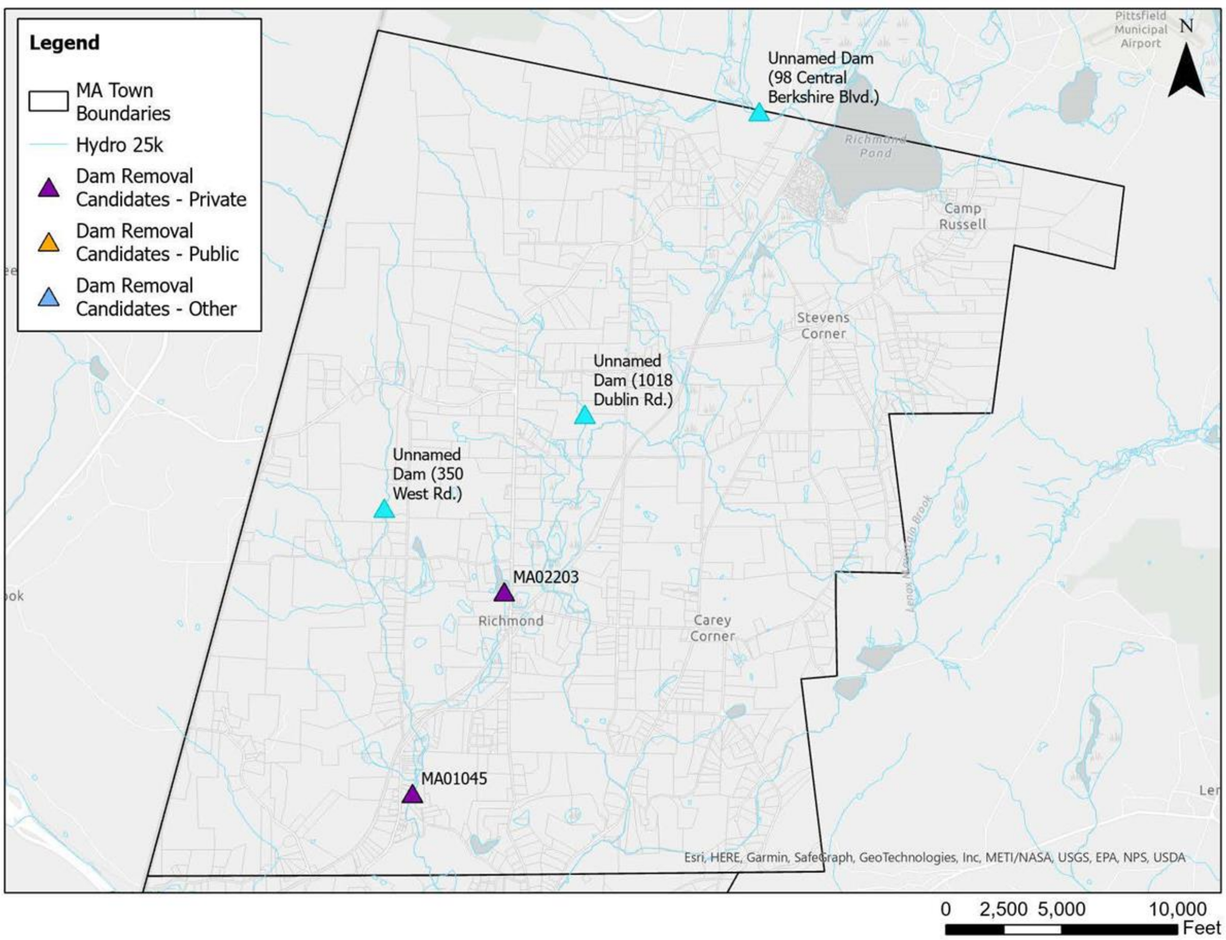


Figure 26. Dam Removal Candidate Dams Impacting Richmond

Table 11: Dam Removal Candidate Dams Impacting West Stockbridge

Dam Name (NID #)	Location	Notes
Kingsmont Dam (MA02223)	West Stockbridge, at 41 West Alford Road	Non-jurisdictional; recreational dam; privately-owned; WS.PA-10 downstream; DER benefit percentile = 75
Alford Brook Club Dam (MA02224)	West Stockbridge, 0.09 miles southeast of the West Alford Road and Wilson Road Intersection	Non-jurisdictional; recreational dam; privately-owned; WS.PA-10 upstream; DER benefit percentile = 90
Rose Lower Dam (MA02631)	West Stockbridge, between 5 Woodruff Road and Red Rock Road	Small, non-jurisdictional; rock pile dam; privately-owned; upstream end of model; discharges to stream that impacts WS.PA-3; DER benefit percentile = 75
Shaker Mill Pond Dam (MA00732)	West Stockbridge	Recreation dam; unsure of size classification, High hazard; owned by West Stockbridge Board of Selectmen; drawdown prior to storms could minimize flooding around the pond
Unnamed Dam	West Stockbridge, behind 46 Main Street	Small, non-jurisdictional; stone block, run-of-river dam; privately-owned; no impoundment, only impedes aquatic passage under low flows
Unnamed Dam	West Stockbridge, adjacent to 30 Great Barrington Road	Not a designed dam, just a small earthen embankment in the woods; privately-owned; no impoundment under normal pool, would flood small wetland upstream and possibly road during large storms
Unnamed Dam	West Stockbridge, adjacent to 245 Great Barrington Road	Non-jurisdictional; concrete run-of-river dam; privately-owned; no impoundment, impedes aquatic passage

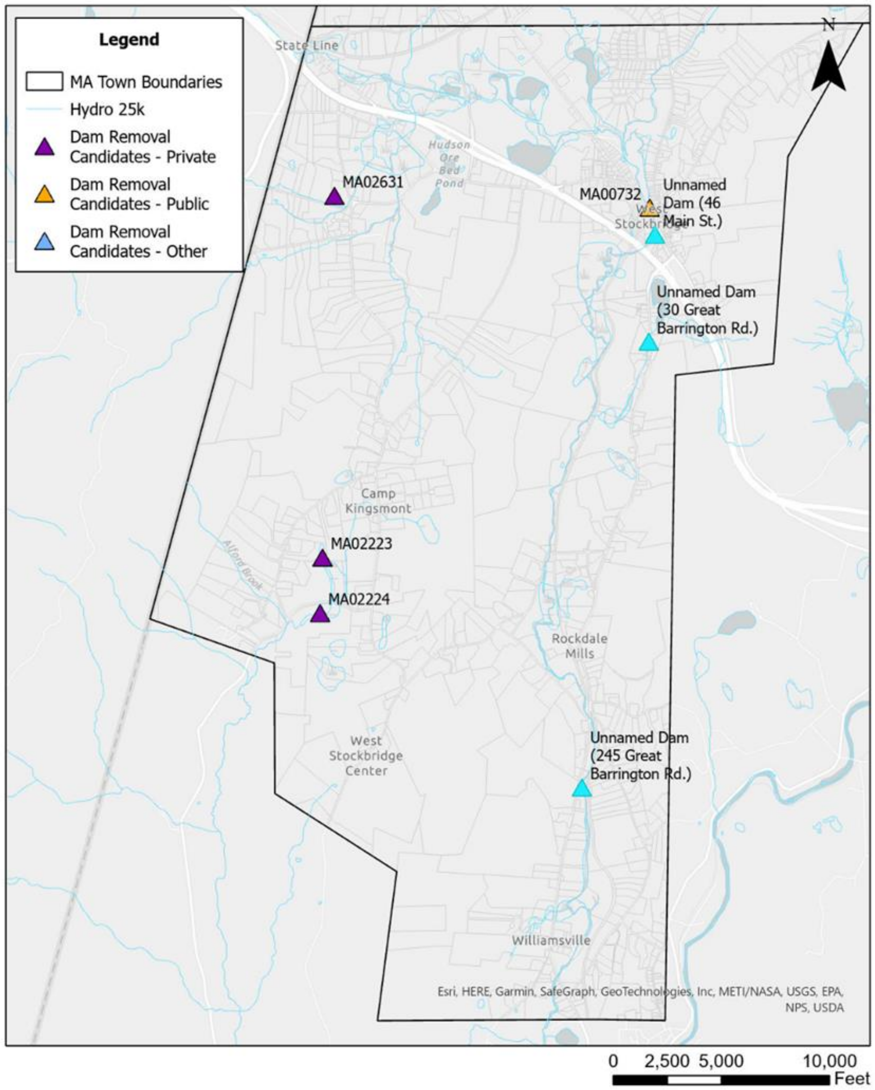


Figure 27. Dam Removal Candidate Dams Impacting West Stockbridge

Dam Removal Summary of Modeling Results

Richmond

Unnamed dam near 98 Central Berkshire Boulevard Removal

- Removal would decrease flood levels in the impoundment by approximately 3.6 feet during both the baseline and 2070 100-year events.
- The house adjacent to the impoundment could see a flood reduction of approximately 0.4 feet during the 2070 100-year event, causing it to no longer flood.

- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Moderate

Unnamed dam behind 1018 Dublin Road Removal

- Removal would decrease flood levels in the impoundment by approximately 0.7 feet during both baseline and 2070 100-year events.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Low

Unnamed dam on driveway for 350 West Road Removal

- Removal would decrease flood levels in the upstream stream channel by approximately 1.5 feet during the baseline and 1.9 feet during the 2070 100-year events.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Minimal

Sherrill Pond Dam Removal

- Removal would decrease flood levels in the impoundment by approximately 0.2 feet during the baseline event and 1.7 feet during the 2070 100-year event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Minimal

Richmond Iron Works Dam Removal

- Removal would decrease flood levels in the impoundment by approximately 2.3 feet during the baseline and 5.0 feet during the 2070 100-year event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Moderate

West Stockbridge

Kingsmont Dam Removal

- Removal would decrease flood levels in the impoundment by approximately 4.3 feet during both the baseline and 2070 100-year events.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Moderate

Alford Brook Club Dam Removal

- Removal would decrease flood levels in the impoundment by approximately 4.9 feet during the baseline event and 5.7 feet during the 2070 100-year event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Significant

Rose Lower Dam Removal

- Removal would decrease flood levels in the impoundment by approximately 1.7 feet during both the baseline and 2070 100-year events.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Minimal

Shaker Mill Pond Dam Removal

- Removal would decrease flood levels in the upstream impoundment by approximately 9.0 feet during the baseline and 9.3 feet during the 2070 100-year events.
- Several upstream stream crossings would experience up to 8.3 feet of peak flood level reductions during the baseline 100-year storm event, including two Albany Road crossings.
- These crossings would experience up to 9.2 feet of peak flood level reductions during 2070 climate.
- Several buildings adjacent to Shaker Mill Pond and upstream Flat Brook would see flood reductions up to 1.1 feet during baseline and 3.2 feet during 2070 climate.
- A handful of buildings in the downstream area could see up to a 0.3-foot increase in peak flood level during baseline. A handful of additional buildings downstream could see a peak flood level increase up to 0.6 feet. The increases caused by the Shaker Mill Pond Dam drawdown are not causing new buildings to flood.
- A few downstream road crossings could experience increases in peak flood levels during both climate scenarios, however all crossings will maintain at least 1 foot of freeboard during 2070 climate.
- Dam Removal Project Flood Reduction Benefits: Significant

Unnamed dam behind 46 Main Street Removal

- Removal would decrease flood levels in the river channel upstream by approximately 0.7 feet during the baseline event but increase by up to 0.4 feet during the 2070 100-year event.
- Upstream crossings, including Harris Street and Center Street, would see limited flood reductions under baseline climate but increases, up to 0.1 feet, under 2070 climate. These increases would not cause the roads to overtop.
- Upstream buildings could see increased peak flood levels by up to 0.2 feet during the 2070 event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Minimal

Unnamed Dam Adjacent to 30 Great Barrington Road Removal

- Removal would decrease flood levels in the upstream wetland by approximately 0.7 feet during the baseline event and 0.9 feet during the 2070 100-year event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Minimal

Unnamed dam adjacent to 245 Great Barrington Road Removal

- Removal would decrease flood levels in the upstream river channel by approximately 8.0 feet during the baseline event and 9.6 feet during the 2070 100-year event.
- No significant downstream benefits are expected.
- Dam Removal Project Flood Reduction Benefits: Significant

Costs of Proposed Dam Projects

An Opinion of Cost was not developed for dam removal or dam drawdown projects. The cost of these projects is highly dependent on the site conditions and the scale of the dam. Further studies are needed in order to develop an accurate Opinion of Cost.

Culvert Opportunities

Like dams, culverts (also known as road-stream crossings) provide conveyance for stormwater runoff in channels and other natural waterways. The Towns and Weston & Sampson identified culverts with known issues in the three watersheds to inform potential alternatives or replacements. Issues of focus included but were not limited to collapsed headwalls, rusted metal pipes, and exposed piping.

Identification Process

The North Atlantic Aquatic Connectivity Collaborative (NAACC) has an extensive GIS database with known culverts[5] and associated conditions of the structures. The NAACC GIS shapefile and metadata was imported into a GIS map to filter and select culverts with known issues. All fields were left unchanged in the exported culverts. Culverts that were not noted as a priority in the NAACC layer were not included in the final feature class used here. Some of the major issues that NAACC identified are buried culverts, sediment blockage, and beaver activity.

The team reviewed the Housatonic Valley Association (HVA) Road-Stream Crossing (RSC) Plans[6] to compare the priority culverts listed by the Towns and the culverts in the NAACC database. The Towns categorized the priority culverts according to Flood Risk, Town Priorities, Coldwater, Town Workshops, and Top-Ranked Culverts. Each priority culvert had a unique NAACC ID which allowed the team to locate the culverts in the database and export them into a new layer. Categories from RSC were added to the NAACC fields – Flood risk, Town Priorities, Coldwater, Town Workshops, and Top-Ranked Culverts, and each culvert was identified as belonging to one of the categories by marking "Yes" in the name of the field. An additional "Notes" field was added to comment on culverts from the RSC report that were not already covered in NAACC fields. Additionally, two culverts were added from the report that were not in the RSC Appendices Overall Prioritization Ranking of All Non-Bridge Structures – one bridge and one unranked culvert. The team matched missing ID's with ID's in the NAACC database and exported to a new feature class. This feature class was then merged with feature class from the previous NAACC export. The fields "Tier" and "Rank" from the RSC report ("Town Managed Crossings" section) were added to the feature class records. Lower rankings indicate higher priority for replacement, 1 being the highest priority.

To verify that all culverts with replacement priorities from the sources had been identified, the team searched through the NAACC database for any additional culverts with "severe barrier" or "poor condition" not already in GIS and not in the HVA, but no inconsistencies or additional culverts were found.

Engineers from Weston & Sampson visited the two Towns to identify and access any additional culverts that were in poor condition that were not listed in other databases. The field work[7] consisted of identifying the locations of the culverts, measuring their dimensions, and describing the conditions. The indicators that the team looked for included completely collapsed, corroded metal pipes, or completely buried. Six culverts were added to the existing database due to their condition as identified by field investigations

[5] NAACC Data Center. January 2023.
[6] Town of Richmond and Town of West Stockbridge Road-Stream Crossing Management Plans. May 2016.
[7] Task 3.4 Draft Deliverable Richmond and W Stockbridge. October 2022.

as well as comments received from the Towns. Their locations were matched with the NAACC database; if the culvert had been assessed in NAACC, the specific culvert info was exported from NAACC and merged with the working feature class, but if the culvert was not assessed by NAACC, the culvert was exported from the field work feature class and merged with the working feature class.

Table 12: Richmond Priority Culverts

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4238821173359291	1	1	Sleepy Hollow Road	Moderate barrier
xy4235998673337146	2	2	Lenox Road	Severe barrier
xy4239565073364284	3	3	Summit Road	Severe barrier
xy4238844273344633	3	3	Sleepy Hollow Road	Severe barrier
xy4237637073380220	4	5	West Road	Severe barrier
xy4237922473387778	5	6	Rossiter Road	Insignificant barrier
xy4240864073314750	5	6	Swamp Road	Severe barrier
xy4239729973349044	6	8	Summit Road	Severe barrier
xy4241946873350313	7	9	Dublin Road	Moderate barrier
xy4236798373380589	7	9	West Road	Minor barrier
xy4237954673384991	7	9	Rossiter Street	Minor barrier
xy4240461673325215	7	9	Boys Club Road	Moderate barrier
xy4240438573321758	7	9	Swamp Road	Significant barrier
xy4241751473357439	7	9	Seace Brook Road	Moderate barrier
xy4237429773368575	7	9	Meadowview Lane	Minor barrier
xy4236491973342938	8	16	Stevens Glen Road	Severe barrier
xy4237802373329800	8	16	East Road	Severe barrier
xy4237813373329689	8	16	Driveway	Severe barrier

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4237976773391922	8	16	Rossiter Road	Severe barrier
xy4238911873367374	8	16	State Road	Severe barrier
xy4239069373324768	8	16	Osceola Notch Road	Severe barrier
xy4240877073353130	8	16	Dublin Road	Severe barrier
xy4236049873380815	8	16	State Road	Moderate barrier
xy4236579573379619	8	16	West Road	Moderate barrier
xy4237381373358467	8	16	Lenox Road	Moderate barrier
xy4241671373331317	8	16	Town Beach Road	Minor barrier
xy4236472273343008	9	27	Stevens Glen Road	Severe barrier
xy4241833973351293	9	27	Dublin Road	Minor barrier
xy4236596073347720	9	27	Cheever Road	Severe barrier
xy4239490273383088	9	27	Canaan Road, Route 295	Severe barrier
xy4237246073341940	9	27	East Road	Minor barrier
xy4235702073396000	9	27	Dean Hill Road	Minor barrier
xy4236154073338680	9	27	Lenox Road	Moderate barrier
xy4240493073319690	9	27	Swamp Road	Moderate barrier
xy4236555473342245	10	35	Cheever Road	Significant barrier
xy4237905173369721	10	35	Rossiter Road	Moderate barrier
xy4239900773336303	10	35	Summit Road	Insignificant barrier
xy4240811973314679	11	38	Cemetery Road	Minor barrier
xy4238850873324584	11	38	Osceola Rd	Moderate barrier
xy4236095673353262	12	40	Swamp Road	Minor barrier
xy4239463573381850	12	40	Canaan Road	Moderate barrier
xy4240082573328625	13	42	Swamp Rd.	Minor barrier

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4241370873312876	13	42	Swamp Rd	Insignificant barrier
xy4241370073312945	13	42	N/A	Insignificant barrier
xy4235516373378755	13	42	Furnace Road	Minor barrier
xy4239751773367080	13	42	Rossiter Road	no score - missing data
xy4238434473342936	13	42	Swamp Road	Moderate barrier
xy4238825773361420	13	42	Sleepy Hollow Road	Moderate barrier
xy4238826773364059	13	42	Sleepy Hollow Road	Moderate barrier
xy4240873573350846	13	42	State Road, Route 41	Moderate barrier
xy4240888673331581	13	42	Beech Road	Minor barrier
xy4241108973330957	13	42	Richmond Shore Road	Minor barrier
xy4241093873353140	13	42	Dublin Road	Moderate barrier
xy4239131773354305	13	42	Dublin Road	Minor barrier
xy4239751773367080	13	42	State Road	Moderate barrier
xy4240082573328625	13	42	Swamp Road	Moderate barrier
xy4241370873312876	13	42	Swamp Road	Minor barrier
xy4241370073312945	13	42	Swamp Road, off of	Minor barrier
xy4241046673316601	14	55	Lake Road	Moderate barrier
xy4242001273360099	14	55	Driveway of 10 Dublin Road	Minor barrier
xy4239457173335321	14	55	Swamp Road	Minor barrier
xy4239464473385251	14	55	Canaan Road	Insignificant barrier
xy4240151473353700	14	55	Dublin Road	Insignificant barrier
xy4240259273353867	14	55	Private driveway off Dublin Road	Minor barrier
xy4235641073367970	14	55	Cone Hill Road	Moderate barrier
xy4235798073397320	14	55	Dean Hill Road	Minor barrier

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4236589073347300	14	55	Cheever Road	Minor barrier
xy4236593073346300	14	55	Cheever Road	Minor barrier
xy4236594073346760	14	55	Cheever Road	Minor barrier
xy4236604073347850	14	55	Cheever Road	Minor barrier
xy4237815073345370	14	55	Swamp Road	Minor barrier
xy4241046673316601	14	55	Lake Road Extension	Moderate barrier
xy4240522073319860	14	55	Off of Swamp Road	Moderate barrier
xy4236370073385260	-	-	Dean Hill Road	no score - missing data
Identified through Field Work	-	-	Lake Road Extension	Corrugated Metal
Identified through Field Work	-	-	Seace Brook (Hancock)	Metal - washed out
Identified through Field Work	-	-	Off of Central Berkshire Boulevard (Pittsfield)	Corrugated metal
Identified through Field Work	-	-	Off of Central Berkshire Boulevard (Pittsfield)	Corrugated metal

Table 13: West Stockbridge Priority Culverts

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4232063473392685	1	1	Maple Hill Rd	Road sediment is being washed into stream at both inlet and outlet
xy4230764073408930	1	1	West Alford Road	Beaver dam and impoundment upstream. Beaver dam and debris at inlet is creating inlet drop.
xy4229803373416298	2	3	Easland Rd	Severe erosion downstream; road sediment filling channel at inlet
xy4234539073356710	2	3	Lenox Road	-
xy4233177873405779	3	5	West Center Road	Bedrock controlled at outlet
xy4229773273408268	3	5	Willson Road	Difficult to see pipes, road surface in bad shape, beaver activity, wetland

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
				connection, pipes completely submerged
xy4233551873405805	4	7	Woodruff Road	Stormwater pipe discharging to river, could be a good site for green infrastructure
xy4234225573402368	4	7	Smith Road	Difficult to get a photo with the full inlet in view due to very deep water. The fencing at the inlet is severely clogged with debris, which is restricting the water flow.
xy4234464173390891	4	7	Baker Street	Crossing is somewhat inaccessible due to very deep water in wetlands. Some measurements were estimated and photos difficult to get
xy4232954773400898	4	7	Bailey Lane, private	Note: Man-made dam upstream. Difficult access for inlet photo
xy4235159773397034	5	11	Cross Road	Crossing overtopped summer July 2021 per local resident
xy4226874573379942	5	11	Great Barrington Road	-
xy4227925873377435	6	13	Great Barrington Road	-
xy4229032073379770	6	13	Cobb Road	Crossing is caving downward around halfway through the pipe about 20 percent
xy4230886073406040	6	13	West Alford Road	Sediment from storm water in inlet wetland area, beaver impoundment up and downstream of the crossing
xy4231871573369487	6	13	Quarry Road	Inlet pipe is not visible possibly buried under rip rap. Road fill estimated
xy4230717073409590	6	13	West Alford Road	Eroded banks evident up and downstream. Difficult to measure bankfull width. Intermittent flow
xy4229580573413930	7	18	Willson Road	Scour pools on both culverts. Outlet picture is structure 1, structure 2 outlet will be under other photo 2.
xy4233474373406366	7	18	Red Rock Road	-
xy4229820073374840	7	18	Great Barrington Road	-
xy4232061273368365	7	18	Day Farm Road	One side of pipe completely buried, possibly outlet The side measured had very thick vegetation and upstream was difficult to access.
xy4234819673407336	7	18	Trail	Both inlets are buried
xy4232289173367775	8	23	Great Barrington Road	Culvert connects wetlands on either side of road. Culvert is partially inaccessible

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
xy4234249473400518	8	23	State Line Road	-
xy4234286273397623	9	25	I-90	This culvert extends across both spans of the Mass Pike and the median. In the database it is shown as two crossings, but there is only a single one.
xy4230618873402182	9	25	West Center Road	-
xy4231681573397208	9	25	Maple Hill Road	Pipe is rotting in multiple locations
xy4226699073383260	9	25	Samantha Lane	Road fill measured for structure 2
xy4229845073374780	9	25	Great Barrington Road	Inlet is buried under a grate
xy4234704873403117	9	25	Trail north of State Line Road	Crossing impossible to find in 2020, data and photos taken from original assessment in 2011.
xy4234661873400834	9	25	Trail north of Stateline Road	Unable to find a crossing in 2020. Data and photos taken from original assessment in 2011.
xy4234850073352330	9	25	Lenox	Inlet inaccessible due to concrete slab over top. Other photo 2 is a closeup of the outlet. May be for stormwater.
xy4234505073391100	10	33	Baker Street	-
xy4232722073405550	10	33	West Center Road	-
xy4234925873410446	10	33	State Line Road	Stream crossing and many measurements and photos are almost completely inaccessible due to high water from wetland. May be more accessible during extremely low flow conditions.
xy4231787073402080	10	33	West Center Road	Deep water at inlet
xy4234204673400440	10	33	Smith Road	Crossing appears to connect wetlands across the road. Bankfull difficult to measure and was estimated.
xy4234135073399031	10	33	State Line Road	-
xy4229313073402340	10	33	West Center Road	Thick vegetation
xy4229551073384850	10	33	Shaw Road	Property owner nearby, John Masiero, reported that this crossing overtops about once every couple of years. This occurs when there is a long period of rain or a significant rain when the ground is frozen. He

CrossCod	Tier (HVA)	Rank (HVA)	Location	Description
				indicated that there are trout in this stream
xy4233983073397020	10	33	State Line Road	Appears to be for stormwater runoff
xy4234080073398210	10	33	State Line Road	-
xy4234896073365460	10	33	Iron Ore	
xy4235175073386740	10	33	Baker St	Inlet is a box with a drop inside to a plastic pipe that is inaccessible.
xy4234469073357330	10	33	Lenox Road	Large fallen log and thick vegetation
xy4233240073364680	10	33	South Street	Three tributaries upstream feed into pipe, bank full width of each is 8 feet, 3 feet, and 3 feet. Farm fields upstream are mowed right to the water's edge. Water has never overtopped South Street, but flooding occurs downstream on property of 1 Stockbridge
xy4233204073365940	10	33	Stockbridge Road and Private Home	Property owner informed us that the stream is dry most of the time, except in 2021. Crossing goes under 1 Stockbridge Road probably built in the mid 1800s with the house. Flooding concerns are happening more frequently with the backyard flooding as well as street
xy4233538473399773	-	-	West Center Road	-
Identified through Field Work	-	-	Great Barrington Road	Buried
Identified through Field Work	-	-	Off Great Barrington Road	Buried

Baseline Model Setup & Description

The intent of the modeling was to identify which of the priority culverts listed above will also experience additional stresses under future hydrological conditions and scenarios, specifically 2030 and 2070 100-year storm events. The team reviewed existing conditions modeling results for culverts at risk of flooding and/or causing backwatering, leading to flooding. The team identified the top 5 priorities from each community as well as 5 additional crossings predicted to have a flood reduction benefit based on existing conditions model results. See Appendix B for more details on how culverts were selected for this analysis.

In discussion with the Towns, additional opportunities were identified to remove historically failing and undersized road stream crossings, if possible, without impacting homeowners, traffic, or public safety.

One specific example is the culvert crossing under Shaw Road in West Stockbridge. The Town has noted that this culvert has been washed out and replaced in the past and that Shaw Road may not need to be a through road.

The 15 culverts at highest risk identified through the baseline modeling are listed below:

Richmond

1. Summit Road (About 150 feet east of 477 Summit Road)
2. Lenox Road (By fire hydrant marked 14, and telephone pole 22)
3. Sleepy Hollow Road (About halfway down Sleepy Hollow Road)
4. Swamp Road (Quarter-mile southwest of Swamp Road and Osceola Road intersection)
5. Former Swamp Road
6. Summit Road (Near Telephone Pole MECO 36)
7. West Road (South, between red barn and railroad crossing beginning of West Road)
8. Dublin Road (Next to 10 Dublin Road)
9. West Road (North, between a 15 sign and 951 West Road)

West Stockbridge

1. Quarry Road (200 feet into Quarry Road, private, about 100 feet before gate)
2. West Alford Road (Adjacent to 15 West Alford Road driveway)
3. Baker Street (Adjacent to 22 Baker Street)
4. West Alford Road (Approximately 50 feet east 9 West Alford Road driveway)
5. Wilson Road (Between Alford Brook Club and telephone pole 7-84)
6. Smith Road (South of 3 Smith Road)

Culvert Upsizing Summary of Modeling Results

The proposed culvert projects listed above were modeled to identify the flood mitigation benefits of increased or upsized cross-sectional areas. The location, description, and modeling summaries are listed below for each culvert.

Richmond

<u>1. Summit Road</u> *(About 150 feet east of 477 Summit Road)*

- Upsizing crossing from a 3-foot culvert to one 3-foot high by 18-foot-wide culvert decreases peak flood level at the road by approximately 1.1 feet during baseline and 2.3 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Moderate

<u>2. Lenox Road</u> *(By fire hydrant marked 14, and telephone pole 22)*

- Upsizing the crossing from two 4-foot culverts to one 4-foot high by 15-foot-wide culvert decreases peak flood level at the road by approximately 0.7 feet during baseline and 2.5 feet during 2070 climate.

- Peak water levels at downstream crossings remain consistent during baseline but do increase by less than up to 0.4 feet, at Swamp Road, during 2070 event. The impacted downstream road crossings are still expected to maintain at least 2.5 feet of freeboard during the 2070 event.
- Culvert Upsizing Project Flood Reduction Benefits: Moderate

3. Sleepy Hollow Road *(About halfway down Sleepy Hollow Road)*

- Upsizing crossing from two 3-foot culverts to a 3-foot high by 18-foot-wide bridge decreases peak flood level at the road by approximately 3.0 feet during baseline and 1.1 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Significant

4. Swamp Road *(Quarter of a mile southwest of Swamp Road and Osceola Road intersection)*

- Upsizing crossing from a 1.5-foot culvert to one 2-foot high by 10-foot-wide culvert decreases peak flood level at the road by approximately 0.6 feet during baseline and 3.5 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Moderate

5. Former Swamp Road

- Upsizing crossing from a 15-inch culvert to one 2-foot high by 9-foot-wide culvert decreases peak flood level at the road by approximately 0.6 feet during baseline and 4.0 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Moderate

6. Summit Road *(Near Telephone Pole MECO 36)*

- Upsizing crossing from a 3-foot culvert to a 3-foot high by 20-foot-wide bridge decreases peak flood level at the road by approximately 3.0 feet during baseline and 9.9 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Significant

7. West Road (south) *(Between red barn and railroad crossing at the beginning of West Road)*

- Upsizing crossing from a 3-foot culvert and 5-foot high by 6.5-foot-wide ellipse to one 5-foot high by 24-foot-wide bridge decreases peak flood level during baseline by up to 0.9 feet.
- The proposed bridge would reduce peak flood level upstream by up to 1.5 feet during 2070 climate.
- No significant downstream benefits are expected.

- Culvert Upsizing Project Flood Reduction Benefits: Moderate

8. Dublin Road *(Next to 10 Dublin Road)*

- Upsizing crossing from a 4-foot culvert to a 4-foot high by 20-foot-wide bridge decreases peak flood level at the road by approximately 1.6 feet during baseline and 4.7 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Significant

9. West Road (north) *(Between a 15 sign and 951 West Road)*

- Upsizing crossing from a 4-foot culvert and 4-foot high by 5.6-foot-wide ellipse to one 4-foot high by 20-foot-wide bridge decreases peak flood level during baseline by up to 0.2 feet.
- The proposed bridge would reduce peak flood level upstream by up to a foot during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Minimal

West Stockbridge

1. Quarry Road *(200 feet into Quarry Road, private, about 100 feet before gate)*

- Upsizing crossing from a 1-foot culvert to a 2-foot high by 20-foot-wide bridge decreases peak flood level at the road by approximately 2.3 feet during baseline and 5.9 feet during 2070 climate.
- The peak flood level at the Day Farm Road crossing upstream would not be expected to change significantly under baseline climate but would decrease by approximately 1.8 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Significant

2. West Alford Road *(Adjacent to 15 West Alford Road driveway)*

- Upsizing crossing from a 2.5-foot culvert to one 2.5-foot high by 9-foot-wide culvert decreases peak flood level at the road by approximately 1.4 feet during baseline and 1.9 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Moderate

3. Baker Street *(Adjacent to 22 Baker Street)*

- Upsizing crossing from two 5.5-foot culverts to a 5.5-foot high by 28-foot-wide bridge slightly decreases peak flood level during baseline by up to 0.5 feet.
- More limited benefits at the crossing are expected during the 2070 event.

- No significant downstream benefits are expected. Peak flood levels at downstream crossings, including two Albany Road crossings, and two dams, including Shaker Mill Pond Dam and the private, stone dam downstream, would see a small increase during 2070 climate, however no increases as a result of upsizing Baker Street cause these structures to overtop.
- Several buildings also see small increases in peak flood level, up to 0.1 feet, during 2070 100-year events.
- Culvert Upsizing Project Flood Reduction Benefits: Minimal

4. West Alford Road *(Approximately 50 feet east of private driveway for 9 West Alford Road)*

- Upsizing crossing from a 3-foot culvert to one 3-foot high by 6-foot-wide culvert decreases peak flood level at the road by approximately 0.4 feet during baseline.
- More limited benefits are expected during the 2070 event.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Minimal

5. Wilson Road *(Between Alford Brook Club and telephone pole 7-84)*

- Upsizing crossing from two 4-foot culverts to a 4-foot high by 25-foot-wide bridge decreases peak flood level at the road by approximately 0.5 feet during baseline and 0.8 feet during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Minimal

6. Smith Road *(South of 3 Smith Road)*

- Upsizing crossing from two 5-foot culverts to one 5-foot high by 20-foot-wide bridge slightly decreases peak flood level during baseline.
- The proposed bridge would reduce peak flood level upstream by up to nearly a quarter of a foot during 2070 climate.
- No significant downstream benefits are expected.
- Culvert Upsizing Project Flood Reduction Benefits: Minimal

Costs of Proposed Culvert Projects

Opinions of Cost for the priority culverts were developed based on the span of the culvert and shown in Table 14. A range of costs is shown for some culverts as cost is dependent on many site-specific factors.

Table 14: Culvert Opinion of Cost

Location	Opinion of Cost
Richmond	
1. Summit Rd	$$$$ - $$$$$
2. Lenox Rd	$$$$$
3. Sleepy Hollow Rd	$$$$ - $$$$$
4. Swamp Rd	$$$$ - $$$$$
5. Former Swamp Rd	$$$$ - $$$$$
6. Summit Rd	$$$$ - $$$$$
7. West Road (south)	$$$$$
8. Dublin Rd	$$$$ - $$$$$
9. West Road (north)	$$$$ - $$$$$
West Stockbridge	
1. Quarry Rd	$$$$ - $$$$$
2. West Alford Rd	$$$$ - $$$$$
3. Baker St	$$$$$
4. West Alford Rd	$$$$ - $$$$$
5. Wilson Rd	$$$$$
6. Smith Rd	$$$$ - $$$$$

Next steps

As a final step in the evaluation process of the nature-based and other stormwater mitigation solutions identified in this memo, a prioritization matrix will be developed to rank the solutions listed here on a variety of factors. The matrix will include criteria to rank projects based on the highest benefit for flood reduction, benefits to known problem areas, lowest installation costs and maintenance level of effort, as well as other co-benefits and implementation considerations. The forthcoming Implementation Plan (Subtask 3.5) will show this matrix and highlight the projects with the highest benefit for flood reduction and other co-benefits and offer strategies for implementation of each.

Appendix A: Gravel Road Solutions

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Road Surfaces					
Crown Roads	•Allows water to move quickly from road surface into ditches	Requires additional material and careful grading	•Crown should be ~0.5-0.75in per LF of width, or 4% to 6% •Graded multiple times per year or as needed	•Grader	•New construction •Maintenance
Road Shoulders	•Transfer water from the road to the ditch •Support the roadway surface •Collect winter sand and debris	•Require space on the roadway to accommodate a shoulder, not applicable for areas with space constrictions	•Blading is recommended •Remove woody roadside vegetation, winter sand, and debris frequently •When grading the road, blade the shoulder	•Grader •Backhoe	•New construction •Maintenance
Waterbars	•Inexpensive way to divert water from road surface and prevent erosion on long sloping roads •Diagonal channel across roadway can be shallow or deep depending on amount of runoff	•Only suitable for low volume or woods roads •Not suitable for higher traffic or faster speed roads	•Inspect regularly and rebuild when needed •Protect drainage at outflow using stone, grass, or sod	•Backhoe	•New construction •Retrofit
Sub-Surface Drainage					
French Mattress	•Stabilizes road base to address subsurface water •Allows water to flow through road base •Prevents gully erosion •Suitable for wetland areas to support roadbed and allow water to flow freely •Difficult for beavers to plug •Maintains natural vegetation and wildlife	•Not for concentrated overland flow, such as streams or ditches	•Long service life •Little maintenance needed	•Geotextile fabric •Large porous stone •Backhoe	•New construction •Retrofit

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Underdrain	•Collects and transports subsurface water •Can help dry out road base, ditches, and banks	•May clog if too many fine grained materials entering	•Should have separate outlet from road drainage, avoid mixing with surface runoff	•Geotextile fabric •Stone uniform in size with no fine material •Perforated pipe •Backhoe	•New construction •Retrofit
Ditches					
Ditches-General	•Ideal for collecting and dispersing surface water in a controlled manner •Opportunity for sediments and pollutants to be removed from runoff before entering natural waterways •Control, slow, and filter runoff through rock or vegetation lining •Will preserve roadbed and banks by removing runoff from roadway	•If become clogged due to improper maintenance, can cause overflows and washouts •Require adequate planning and maintenance to ensure the slope is correct, ditch is free from obstructions, and the ditch has a stable outlet	•Inspect regularly •Schedule cleaning every few years •Reshape the ditch to improve flow •Re-establish cover type •Check after major storm events •Regrade only when absolutely necessary •Clean when clogged with sediment or debris •Ensure critical sections free from snow and ice to prevent spring flooding	•Grader •Backhoe	•New construction •Retrofit •Maintenance
Ditches-Diversion Ditches and Berms (Earth Dikes)	•Used to re-direct stormwater runoff near steep or long slopes •Located at top of slope to prevent erosion	Same as Ditches-General	Same as Ditches-General	•Grader •Backhoe	•New construction •Retrofit
Ditches-Turnouts	•Extensions of ditches that route water to filtering areas	•Requires adequate outlet protection in either a structural (rock) or vegetative filtering area •Only for use where water will flow away from the road and surface waters	Same as Ditches-General	•Grader •Backhoe	•New construction •Retrofit

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Ditches-Velocity Controls and Energy Dissipaters (Check Dams) •Hay Bale Dikes •Stonedikes •Silt fence dikes	•Used to slow water in ditches and swales •Slower water velocity reduces erosion and allows sediments to settle •Effective at preventing debris from clogging culverts •Must be used where channels are not yet stabilized	•Can be difficult to maintain •Only in drainage areas of less than 2 acres	•Clear sediment out when half full •Monitor for performance and clean debris regularly, particularly after rain events	•Backhoe	•New construction •Retrofit
Culverts					
Culverts-General	•Used to convey water from one side of the road to the other •Preserve road base by draining water and keeping the sub-base dry •Installation is simple	•Installation is notorious for being done incorrectly, must take care to install culverts correctly •Erosion problems can develop at outlets due to improper design or installation •Must be correctly sized to prevent flood problems •Should be placed below frost depth to prevent heaving	•Inspect at minimum every spring and fall •Remover obvious blockage •During summer flush the inside of the pipe •Remove brush from culvert ends •Establish vegetation at ends to prevent erosion •Monitor during freezing weather and keep free of snow and ice to prevent flooding	•Backhoe	•New construction •Retrofit
Steel Culvert	•Strong •Lightweight •Service life estimate is 30 years •Readily available	•Subject to corrosion and abrasion •Shorter service life than concrete	Same as Culverts-General	•Backhoe	•New construction •Retrofit
Aluminum Culvert	•Very lightweight •Long service life •Corrosion resistant •Available in 20' sections	•Easily damaged •Requires special care when backfilling •Subject to abrasion	Same as Culverts-General	•Backhoe	•New construction •Retrofit
Concrete Culvert	•Strong •Corrosion and abrasion resistant •Service life estimate is 75 years	•Requires special handling and careful placing •Not always readily available •Maximum 8' sections	Same as Culverts-General	•Backhoe	•New construction •Retrofit

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Plastic Culvert	•Lightweight •Corrosion resistant •Available in 20' sections •Long service life	•Requires special care when backfilling •Possible UV light degradation •Possible damage due to low and/or high temperatures	Same as Culverts-General	•Backhoe	•New construction •Retrofit
Headers and Endwalls	•Protect culvert and embankment from damage •Help direct the flow of runoff into the culvert •Aesthetically attractive	•Higher construction effort than other BMPs	•Historically have been used and lasted over 100 years	•Stone construction •Backhoe	•New construction •Retrofit
Outlet Protection					
Rock Aprons	•Control erosion by reducing velocity and dissipating energy of the flow	•Use only where there is a minimum of 50' of vegetation between culvert and water body	• Inspect riprap outlet structures after heavy rains for erosion and stone displacement. • Add rock if sediment builds up in the pore spaces. • Make repairs immediately using appropriate stone sizes. Do not place stones above finished grade.	•Riprap generally used for construction •Backhoe	•New construction •Maintenance
RipRap Conveyance Channel	•Remove sediments from runoff •For use in areas without adequate vegetative strips •Use where an outlet directly goes into surface waters	•Use only in areas with fill slopes or steep slopes	Same as Rock Aprons	•Riprap generally used for construction •Backhoe	•New construction •Maintenance
Splash/Plunge Pools	•Control erosion at the outlet of channels, detain water, and allow sediment to settle out •Good for areas with concentrated flows and without adequate vegetation zones	•Limited to areas with less than 10% slope for easy sediment removal	•Clean when pool is 1/3 filled with sediment •Mechanized cleaning is possible if constructed properly	•Riprap generally used for construction •Backhoe	•New construction •Retrofit •Maintenance

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Level Spreaders	•Flat to ensure uniform spreading of runoff •Reduces erosion and encourages sedimentation by changing concentrated flow into sheet flow •Designed to release small volumes of water safely •Relatively low cost	•Drainage area limited to 5 acres	Same as Rock Aprons	•Materials •Backhoe	•New construction •Retrofit •Maintenance
Filter Zones	•Undisturbed vegetated area that slows flow of water to reduce erosion and runoff velocity •Provide critical wildlife habitat •Visibility and noise screen •Low maintenance and low cost •Preferred method of slowing and filtering runoff before it enters water bodies	•Excessive runoff or sediment may damage the area and require other types of controls	•Generally no maintenance	•Backhoe •Shovel •Rake	•New construction •Retrofit •Maintenance
Bank Stabilization					
Vegetation-seeding	•Most efficient and cost effective method and show be used wherever possible •Vegetation slow the movement of water, allow water to filter into the ground, and minimizes runoff	•Areas with maximum 2H:1V slope	•Seed areas as soon after a disturbance as possible	•Native seed mix •Fertilizer •Rake •Hand broadcasting or hydroseeding truck •Hay or straw for mulch •Disk harrow or sheepsfoot roller for anchor	•Maintenance
Vegetation-shrubs and trees	•Live plant materials help with stabilization and erosion control •Can be used on steep slopes	•Specialized design and environmental permitting required	• Allow seedlings to grow naturally or add/replace new small trees occasionally	•Shrubs and tree plantings •Shove/Fertilizer •Rake •Hand broadcasting or hydroseeding truck •Hay or straw for mulch •Disk harrow or	•New construction •Maintenance

Solution	Pros	Cons	Maintenance	Equipment Required	Application
				sheepsfoot roller for anchor	
Live Fascines-wattles or bundles	•Protect slopes from shallow slides •Can be used on steep slopes	•Must be implemented in dormant period (Nov-early March)	•Prune if shrubs grow too large • Periodically inspect for damage • Check for sprouting success and replant areas that do not succeed	•Bundles of live branches 5 to 30 ft long and 6 to 8 inches diameter that are installed in shallow trenches •Common plants used include willow, alders, dogwoods •Secured with live stakes and dead stout stakes •Install same say as plants are cut in dormant periods (Nov-early March)	•New construction •Retrofit •Maintenance
Live Stakes	•Inexpensive method •Can be used when time is limited	•For simple sites •For moderate slopes of original bank soil •For places where there is minimal active erosion and little chance of washout •Must be implemented in dormant period (Nov-early March)	• Periodically inspect for damage • Check for sprouting success and replant areas that do not succeed	•Cuttings of live branches 0.5-1.5 inches in diameter and 2-3 ft long capable of quickly taking root •Willow species work best, dogwood and alder can also work •Must be used when plant is dormant, plant same day as cut	•New construction •Retrofit •Maintenance
Brushlayering	•Used to break up slopes into a series of smaller slopes	•Must be implemented in dormant period (Nov-early March)	•Same as Live Fascine	•Live branches 0.5 to 2 inches diameter and 3-4 feet long are put perpendicular to the slope with growing tips outward •Backfill on top of branches and compact •Must be used when plant is dormant, plant same day as cut	•New construction •Retrofit •Maintenance

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Sprigs/Plugs	•Low cost •Quick growing •Can be planted any time of year	•More reliable shrubs from a nursery can be used, but they are more expensive	•Same as Live Fascine	•Individual plant stems with roots, can be seedlings or rooted cuttings •Can use shrubs from a nursery (more reliable but more expensive) •Often used on filled slopes along with special fiber rolls	•New construction •Retrofit •Maintenance
Grading Techniques	•Can often stabilize banks without the use of structures	•May not withstand storms and runoff without plants to hold soil in place.	•Inspect for damage and erosion after major storms and at least annually	•Grading slopes to a mx 2H:1V slope to help stabilize bank •Multiple techniques including: cut/fill, notching/keying, terracing, counterweights	•New construction •Retrofit •Maintenance
Structures-Gabions	•Easy to use method •Slows runoff velocity and protect from erosion •Permeable •Aid in sediment removal •Can be combined with woody vegetative stabilizers	•More expensive than other methods •Unnatural looking	•Inspect for damage and erosion after major storms and at least annually	•Level, hammer, rake, pick, fencing, post hole digger for support columns, and rock to fill baskets •May require gravel or concrete footer as a base layer	•New construction •Retrofit
Structures-Riprap	•Can be used where vegetation does not adequately protect from erosion or filter sediment •For use on steep slopes, sharp turns in streams, and where a bridge/culvert restricts flow	•Requires specialized design and permits for use on stream banks •Low habitat and aesthetic value	•Inspect for damage and erosion after major storms and at least annually • Remove woody vegetation annually	•Riprap generally used for construction •Backhoe	•New construction •Retrofit

Solution	Pros	Cons	Maintenance	Equipment Required	Application
Combinations-Live Cribwall	•Can be used on roadside slopes and streambanks •Can be used to repair streambank if constructed properly •Use 1/2 as much wood as in a timber or log crib, making it less expensive and more natural looking •Can be constructed in steps, which creates planting areas	•Only for low walls not higher than 6ft	•Same as Riprap and Live Fascine	•Rectangular framework made of logs/timbers, rock, or woody cuttings	•New construction •Retrofit •Maintenance
Combinations-Vegetated Gabion	•Provides a natural look and habitat on the wall	•Specialized design and environmental permitting required	•Same as Riprap and Live Fascine	•Gabion combined with live branches	•New construction •Retrofit •Maintenance
Combinations-Vegetated Rock Wall	•Same as Vegetated Gabion	•Only for low walls not higher than 5ft	•Same as Riprap and Live Fascine	•Rocks combined with live branches •Base of wall should be well-draining	•New construction •Retrofit •Maintenance
Combinations-Vegetated Riprap/Joint Planting	•Increases effectiveness of rock system by forming a live root mat at the base •Roots improve drainage and create a mat that reinforces soil •When used on streambanks, provides shade and promotes silt deposition	•Specialized design and environmental permitting required	•Same as Riprap and Live Fascine	•Combines riprap revetment with tamping of live stakes between joints or rocks	•New construction •Retrofit •Maintenance
Mats & Blankets	•More stable than normal mulch •Provide bank stabilization and prevent erosion on steep slopes temporarily •Can be used in ditches with high water velocities	• Can trap or hinder animal species if not replaced seasonally •Can sag or bulge •Need plants to germinate and hold in place	•Inspect for bulging from emerging seedlings or sagging •Cut large sags or bulges and stake	•Specific types include: Jute matting (undyed jute yarn), wood excelsior blankets (wood excelsior with photodegradable plastic mesh), mulch blanket (straw, coconut, or wood fibers between	•New construction •Retrofit •Maintenance

Solution	Pros	Cons	Maintenance	Equipment Required	Application
				photodegradable plastic)	
Encapsulated Soil Lifts	•Used on heavily eroded or steeply sloping areas	•Look stable but are vulnerable until plants establish to hold in place •Specialized design and environmental permitting required	•Fence to prevent people and wildlife from trampling	•Soil in biodegradable blankets folded to create lifts •Rock base using 6"-8" rocks •Stabilizing rocks 12"-15" placed at base of lifts •Seed and planted shrubs	•New construction •Retrofit •Maintenance
Sediment Controls & Traps					
Straw or Hay Bale Barriers	•Intercept small amounts of sediment downslope from disturbed areas •Inexpensive	•Effective only for ~ 3 months •Proper installation and maintenance is critical	•Inspect after each rainfall •Repair or replace damaged bales as needed •Remove sediments when they accumulate to 1/2 the height of the barrier	•By hand or with small trenching equipment	•Retrofit •Maintenance
Sediment Fence (Silt fencing)	•Intercept small amounts of sediment downslope from disturbed areas	•Temporary, can last up to 1 yr with proper maintenance	•Inspect after each rainfall •Repair or replace damaged fence as needed	•By hand or with small trenching equipment	•Retrofit •Maintenance
Sediment Trap	•Intercepts runoff and detains it so sediment settles out •Usually installed in drainage ways with small watersheds •Also can be used at a storm drain inlet or outlet •Inexpensive and simple to install	•Larger size traps should have a detailed design by an engineer	•Excavating a depression or placing earthen embankment across a low area •Outlet constructed of stones allows slow release of water	•Stone •Backhoe	•Retrofit •Maintenance
Geotextiles	•Used for: separation /stabilization, drainage/filtration, reinforcement, and erosion control	•Costly	•Limited	•Many types of geotextile	•New construction •Retrofit

Appendix B: Culvert Selection for Modeling

From the comprehensive inventory of culverts in the Towns, the team identified the top priorities from each community for modeling of future conditions, including crossings predicted to have a flood reduction benefit based on existing conditions model results. Culverts were scored using information about road overtopping, headwater/tailwater differentials, upstream or downstream impacts, and town-designated top priorities.

The table below shows the resulting scores for each culvert, 3 representing the best and 1 representing the worst. Weighted score is based on potential hydraulic benefit ONLY; priority was not factored in to weighted scores, as those sites were automatically selected for proposed conditions modeling and are noted in red.

			Weight:	25%	25%	25%	25%	0%	
Location Name	Watershed	Town		Overtopping Score	Headwater/Tailwater Differential Score	U/S Impacts	D/S Impacts	Top 5 priority scope	**Weighted Score**
Summit Road	Williams River	Richmond		2	3	3	3	1	2.75
Lenox Road	Williams River	Richmond		3	3	3	1	1	2.5
Sleepy Hollow Road	Williams River	Richmond		3	3	1	3	3	2.50
I-90 Access Road	Williams River	West Stockbridge		3	3	1	3	1	2.50
Swamp Road	Richmond Pond	Richmond		3	3	1	3	1	2.50
Rossiter Road	Williams River	Richmond		3	3	1	3	1	2.50
Private Driveway	Williams River	Richmond		3	3	1	3	1	2.50
Quarry Road	Williams River	West Stockbridge		3	3	1	3	1	2.50
West Alford Road	Alford Brook	West Stockbridge		3	3	1	3	3	2.50
Former Swamp Road	Richmond Pond	Richmond		3	3	1	3	1	2.50
Easland Road	Alford Brook	West Stockbridge		3	3	1	3	1	2.50
Swamp Road	Williams River	Richmond		2	3	1	3	1	2.25
Summit Road	Williams River	Richmond		2	3	1	3	3	2.25
Albany Road	Williams River	West Stockbridge		2	1	3	3	1	2.25
Private Driveway	Williams River	Richmond		2	3	1	3	1	2.25
West Center Road	Williams River	West Stockbridge		2	3	1	3	1	2.25
South Street	Williams River	West Stockbridge		2	3	1	3	1	2.25
Swamp Road	Richmond Pond	Richmond		2	3	1	3	1	2.25
Canaan Road	Williams River	Richmond		2	3	1	3	1	2.25
Rossiter Road	Williams River	Richmond		1	3	1	3	1	2
Sleepy Hollow Road	Williams River	Richmond		1	3	1	3	1	2
Scace Brook Road	Richmond Pond	Richmond		1	3	1	3	1	2
State Road	Williams River	Richmond		3	3	1	1	1	2
Former RR	Williams River	West Stockbridge		3	3	1	1	1	2
Baker Street	Williams River	West Stockbridge		3	1	1	3	3	2
Private Driveway	Williams River	West Stockbridge		3	1	3	1	1	2
State Road	Williams River	Richmond		3	1	1	3	1	2
West Road	Williams River	Richmond		1	3	1	3	1	2
Van Schaack Road	Williams River	West Stockbridge		3	3	1	1	1	2
Maple Hill Road	Williams River	West Stockbridge		1	3	1	3	1	2
West Alford Road	Alford Brook	West Stockbridge		3	1	1	3	3	2
Swamp Road	Richmond Pond	Richmond		1	3	1	3	1	2
West Road (south)	Williams River	Richmond		2	3	1	1	3	1.75
Rossiter Road	Williams River	Richmond		2	3	1	1	1	1.75
Dublin Road	Richmond Pond	Richmond		2	3	1	1	3	1.75
Lenox Road	Williams River	Richmond		1	3	1	1	1	1.5
Wilson Road	Alford Brook	West Stockbridge		1	1	1	3	3	1.5
Private Driveway	Richmond Pond	Hancock		3	1	1	1	1	1.5
Richmond Road	Richmond Pond	Hancock		3	1	1	1	1	1.5
Boys Club Road	Richmond Pond	Richmond		1	1	1	3	1	1.5
Former RR	Williams River	West Stockbridge		3	1	1	1	1	1.5
Bailey Lane	Williams River	West Stockbridge		1	3	1	1	1	1.5
West Center Road	Williams River	West Stockbridge		1	3	1	1	1	1.5
State Line Road	Williams River	West Stockbridge		1	1	3	1	1	1.5
Woodruff Road	Williams River	West Stockbridge		1	3	1	1	1	1.5
Great Barrington Road	Williams River	West Stockbridge		1	1	1	3	1	1.5
West Road (north)	Williams River	Richmond		1	1	1	3	3	1.5
State Line Road	Williams River	West Stockbridge		2	1	1	1	1	1.25
Town Beach Road	Richmond Pond	Richmond		1	1	1	1	1	1
West Center Road	Williams River	West Stockbridge		1	1	1	1	1	1
Smith Road	Williams River	West Stockbridge		1	1	1	1	3	1

APPENDIX E

Prioritization Matrix

Stormwater MVP Project 2023 - Resilient Stormwater Plan - Prioritization Matrix

Richmond, MA

Site Location	Project ID	Infrastructure Type	Project Type	Area (sqft)	Impact on Flooding		Co-Benefits 0 (No Impact) to 5 (High Impact)				Feasability 0 (least favorable) to 5 (most favorable)						Rank
					Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	
					5	5	6	6	12	16	10	10	5	5	10	10	
					Flooding Impact to Problem Areas Ranking	Model Flooding Ranking	Biodiversity/ Habitat/ Pollinators	Water Quality Improvements	Safety Improvements	Soil Stabilization and Hillside Protection	Opinion of Cost	Funding Availability	Permitting Difficulty	Land Ownership	Maintenance Frequency	Maintenance Effort	
West Road @ Furnace Brook	4	NBS	Stream Restoration	5577	5	1	5	5	1	3	3	1	1	1	5	5	**3**
Swamp Road near Dublin Road	5	NBS	Floodplain Restoration	17471	5	0	5	5	1	3	4	1	1	1	4	5	**4**
West Rd at Rossiter Rd	6	NBS	Bioswale	13846	5	3	5	3	3	5	2	1	1	1	3	3	**2**
Osceola Rd at Swamp Rd	7	NBS	Bioswale	4791	5	3	5	3	3	3	4	5	5	5	3	3	**1**
Town Beach Rd/Richmond Fen Wildlife Management Area	8	NBS	Floodplain Restoration	62480	0	5	5	5	0	1	4	3	1	3	4	5	**5**
Upper Root Reservoir Dam (MA00019)	D1	D	Potential for Increased Storage/Drawdown	N/A	0	3	0	0	0	0	3	0	1	5	1	1	**16**
Lower Root Reservoir Dam (MA00018)	D2	D	Potential for Increased Storage/Drawdown	N/A	0	2	0	0	0	0	3	0	1	5	1	1	**17**
Richmond Pond Dam (MA00017)	D3	D	Potential for Increased Storage/Drawdown	N/A	0	2	0	0	0	0	3	0	1	5	1	1	**17**
Richmond Iron Works Dam (MA01045)	D4	D	Potential for Increased Storage/Drawdown	N/A	0	0	0	0	0	0	3	0	1	1	1	1	**18**
Unnamed Dam, Pittsfield, near 98 Central Berkshire Boulevard	D7	D	Dam Removal Candidate	N/A	0	4	3	3	3	0	1	1	1	1	5	5	**13**
Unnamed Dam, Richmond, behind 1018 Dublin Road	D8	D	Dam Removal Candidate	N/A	3	1	3	3	3	0	1	1	1	1	5	5	**13**
Unnamed Dam, Richmond, on driveway for 350 West Road	D9	D	Dam Removal Candidate	N/A	3	3	3	3	3	0	1	1	1	1	5	5	**8**
Sherrill Pond Dam (MA02203)	D10	D	Dam Removal Candidate	N/A	3	2	3	3	3	0	1	1	1	1	5	5	**10**
Richmond Iron Works Dam (MA01045)	D11	D	Dam Removal Candidate	N/A	0	4	3	3	3	0	1	1	1	1	5	5	**13**
Summit Road (About 150 feet east of 477 Summit Road)	CR1	C	High Risk Culvert	N/A	0	2	1	1	5	1	1	1	1	5	3	3	**15**
Swamp Road (Quarter of a mile southwest of Swamp Road and Osceola Road intersection)	CR4	C	High Risk Culvert	N/A	3	3	1	1	5	1	1	1	1	5	3	3	**9**
Lenox Road (By fire hydrant marked 14, and telephone pole 22)	CR2	C	High Risk Culvert	N/A	0	2	1	1	5	1	1	1	1	5	3	3	**15**
Former Swamp Road	CR5	C	High Risk Culvert	N/A	5	4	1	1	5	1	1	1	3	5	3	3	**6**
Sleepy Hollow Road (About halfway down Sleepy Hollow Road)	CR3	C	High Risk Culvert	N/A	5	1	1	1	5	1	1	1	1	5	3	3	**9**
Dublin Road (Next to 10 Dublin Road)	CR8	C	High Risk Culvert	N/A	0	4	1	1	5	1	1	1	1	5	3	3	**14**
Summit Road (Near Telephone Pole MECO 36)	CR6	C	High Risk Culvert	N/A	5	5	1	1	5	1	1	1	1	5	3	3	**7**
West Road (South, between red barn and railroad crossing at the beginning of West Road)	CR7	C	High Risk Culvert	N/A	5	1	1	1	5	1	1	1	1	5	3	3	**9**
West Road (North, between a 15 sign and 951 West Road)	CR9	C	High Risk Culvert	N/A	5	1	1	1	5	1	1	1	1	5	3	3	**9**

Legend - Impact Score	
Lowest	**0**
	1
	2
	3
	4
Highest	**5**

Legend - Rank	
Highest	**1**
	4
	8
	12
Lowest	**18**

Stormwater MVP Project 2023 - Resilient Stormwater Plan - Prioritization Matrix

West Stockbridge, MA

					Impact on Flooding		Co-Benefits 0 (No Impact) to 5 (High Impact)				Feasability 0 (least favorable) to 5 (most favorable)						
					Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight	
					5	5	8	8	12	12	15	5	5	5	10	10	
Site Location	Project ID	Infrastructure Type	Project Type	Area (sqft)	Flooding Impact to Problem Areas Ranking	Model Flooding Ranking	Biodiversity/ Habitat/ Pollinators	Water Quality Improvements	Safety Improvements	Soil Stabilization and Hillside Protection	Opinion of Cost	Funding Availability	Permitting Difficulty	Land Ownership	Maintenance Frequency	Maintenance Effort	Rank
Woodruff @ Red Rock Rd	9	NBS	Bioretention	12265	5	0	5	3	3	5	4	5	3	5	3	3	4
Pixley Hill Rd	10	NBS	Bioretention	980	3	2	5	3	1	3	4	5	5	5	3	3	9
State Line Rd @ Smith Rd	11	NBS	Constructed Wetland	67430	3	4	5	5	3	1	1	5	1	5	4	5	10
Red Rock Rd	12	NBS	Bioswale	1725	5	2	5	3	1	3	4	1	3	1	3	3	15
Austerlitz Rd	13	NBS	Bioswale	1720	5	1	5	3	3	5	4	1	3	1	3	3	8
South St	14	NBS	Bioswale	17775	5	0	5	3	3	5	1	1	5	1	3	3	14
South St	15	NBS	Stream Restoration	17885	5	0	5	5	1	5	2	5	1	5	5	5	5
Great Barrington Rd @ Card Pond	16	NBS	Bioretention	5860	0	0	5	3	1	3	3	3	3	3	3	3	19
Great Barrington Rd @ Card Pond	17	NBS	Pervious Pavement	15230	0	0	0	3	3	3	3	3	3	3	3	1	28
West Center Rd	18	NBS	Stream Restoration	49450	3	5	5	5	3	5	1	5	1	5	5	5	1
Intersection of oak street and Main St	GI1	GI	Bioretention	150	0	0	5	3	3	3	5	5	3	5	3	3	7
Down Main St past oak toward downtown	GI2	GI	Infil., Trench, Swale, Porous Strip	431	0	0	3	3	3	3	5	5	3	5	3	3	11
Gravel parking down 102 before depot Street	GI3	GI	Porous	724	3	0	0	3	1	1	4	1	5	1	5	5	20
Intersection Of Harris St & Moscow Rd green space	GI4	GI	Bioretention	475	5	0	5	3	1	1	5	1	5	1	3	3	17
Intersection of Hotel St. and 102	GI5	GI	Bioretention	116	5	0	5	3	1	1	5	5	3	5	3	3	12
Intersection of Lenox & Swamp Rd	GI6	GI	Bioretention	260	5	0	5	3	3	3	5	5	5	5	3	3	3
Downtown past Hotel St	GI7	GI	Porous Stalls	545	5	0	0	3	1	0	4	5	3	5	5	5	16
Intersection of Old Great Barrington & 102	GI8	GI	Bioretention, Rain Garden, Mini Forest	287	5	0	5	3	3	5	5	5	3	5	3	3	2
Intersection of Old Great Barrington & 102	GI9	GI	Bioretention, Tree Pits, Infil. Trench Along curb	224	5	0	5	3	3	3	5	5	3	5	3	3	6
Parking Strip down Main St past Oak toward downtown	GI10	GI	Permeable Paving, Infil.	644	0	3	0	3	3	3	4	1	3	1	5	5	13
Shaker Mill Pond Dam (MA00732)	D5	D	Potential for Increased Storage/Drawdown	N/A	0	3	0	0	0	0	3	0	1	5	1	1	34
Card Pond Dam (MA01047)	D6	D	Potential for Increased Storage/Drawdown	N/A	0	1	0	0	0	0	3	0	1	5	1	1	35
Kingsmont Dam (MA02223)	D12	D	Dam Removal Candidate	N/A	3	3	3	3	3	0	1	1	1	1	5	5	22
Alford Brook Club Dam (MA02224)	D13	D	Dam Removal Candidate	N/A	0	3	3	3	3	0	1	1	1	1	5	5	26
Rose Lower Dam (MA02631)	D14	D	Dam Removal Candidate	N/A	0	2	3	3	3	0	1	1	1	1	5	5	29
Shaker Mill Pond Dam (MA00732)	D15	D	Dam Removal Candidate	N/A	0	5	3	3	3	0	1	3	1	5	5	5	18
Unnamed Dam, West Stockbridge, behind 46 Main Street	D16	D	Dam Removal Candidate	N/A	0	1	3	3	3	0	1	1	1	1	5	5	31
Unnamed Dam, West Stockbridge, adjacent to 30 Great Barrington Road	D17	D	Dam Removal Candidate	N/A	0	1	3	3	3	0	1	1	1	1	5	5	31
Unnamed Dam, West Stockbridge, adjacent to 245 Great Barrington Road	D18	D	Dam Removal Candidate	N/A	0	4	3	3	3	0	1	1	1	1	5	5	23
West Alford Road (Adjacent to 15 West Alford Road driveway)	CWS2	C	High Risk Culvert	N/A	5	4	1	1	5	1	1	1	3	5	3	3	21
West Alford Road (Approximately 50 feet east of private driveway for 9 West Alford Road)	CWS4	C	High Risk Culvert	N/A	5	0	1	1	5	1	1	1	3	5	3	3	24
Wilson Road (Between Alford Brook Club and telephone pole 7-84)	CWS5	C	High Risk Culvert	N/A	5	2	1	1	5	1	1	1	1	5	3	3	24
Quarry Road (200 feet into Quarry Road, private, about 100 feet before gate)	CWS1	C	High Risk Culvert	N/A	0	5	1	1	5	1	1	1	1	5	3	3	30
Baker Street (Adjacent to 22 Baker Street)	CWS3	C	High Risk Culvert	N/A	0	0	1	1	5	1	1	1	1	5	3	3	33
Smith Road (South of 3 Smith Road)	CWS6	C	High Risk Culvert	N/A	5	1	1	1	5	1	1	1	1	5	3	3	27

Legend - Impact Score	
Lowest	0
	1
	2
	3
	4
Highest	5

Legend - Rank	
Highest	1
	7
	14
	21
	28
Lowest	35

APPENDIX F

Potential Grant Sources

Appendix F: Potential Grant Sources

This table details all known potential grant funding sources for Resilient Stormwater projects, including the grant sources listed in the Implementation Plans (Section 4.1.1 and 4.2.1). Federal and private grant programs are noted with a *, and they are possible sources of matching funds for some state grant programs. The identification of funding sources herein is preliminary, and actual funding availability varies depending on numerous factors. These factors include, but are not limited to, if a project is conceptual or has been studied, evaluated, or designed. In most cases, the project will require a combination of funding sources. The funding sources identified are not a guarantee that a specific project will be eligible for, or receive, funding. The local representatives responsible for implementation should explore potential funding sources in more detail.

Potential Grant Sources						
Grant	Description	Category	Limitations & Stipulations	Maximum Award	Applications typically due	Match Required
604b Clean Water Act Grant Program*	Water quality assessment and management planning	Environment	None	~$70,000	August	No
Berkshire Taconic Community Foundation*	This foundation awards various of community grants.	Community Development	Nonprofits & Individuals	Varies	Varies	No
Chapter 90	Provides reimbursement for capital improvement projects for highway construction, preservation, and improvement that create or extend the life of capital facilities.	Public Works and Transportation	None	Varies by community	June 30	No
Complete Streets Funding Program (MassDOT)	Technical assistance and construction funding	Public Works and Transportation	To be eligible for funding, communities must pass a Complete Streets Policy and develop a Prioritization Plan	$38,000 in technical assistance; $500,000 in construction funding	Prioritization Plan: April 1, Sept. 1; Construction Application: May 1, October 1	No
DER Priority Project	DER selects high-priority wetland and river restoration projects that	Environment	Project must first receive Priority	$70,000	May	No

Potential Grant Sources						
Grant	Description	Category	Limitations & Stipulations	Maximum Award	Applications typically due	Match Required
	bring significant ecological and community benefits to the Commonwealth		Project status to be eligible for funding			
DER Culvert Replacement Municipal Assistance Grant Program	Grant to replace undersized, perched, and/or degraded culverts located in an area of high ecological value	Environment	None	$40,000	April	No
Dam and Seawall Repair Program (EEA)	Financial resources to qualified applicants for dam removal or repair projects to enhance, preserve, and protect natural resources and scenic, historic, and aesthetic qualities	Environment	None	Category 1: $250,000; Category 2: $500,000; Category 3: $250,000	February	25% (cash or in-kind)
Federal Land & Water Conservation Fund *	Funding for the acquisition, development, and renovation of parks, trails, and conservation areas.	Environment	Municipality must have an Open Space & Recreation Plan	$1M	January	No
FEMA Building Resilient Infrastructure and Communities (BRIC)*	Reducing risks from future disasters and natural hazards	Infrastructure	Must have a FEMA approved mitigation plan	$50M	December	25%
FEMA Hazard Mitigation Assistance Program (HMGP)*	Rebuilding community after a disaster to reduce future disaster losses	Transportation	Within 12 months after a declared disaster	$15M	June	25%
FHA PROTECT – Infrastructure Act	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program helps	Transportation	None	Varies	Varies	20%

Potential Grant Sources						
Grant	Description	Category	Limitations & Stipulations	Maximum Award	Applications typically due	Match Required
Resilience Improvement*	make surface transportation more resilient to natural hazards, including climate change, sea level rise, flooding, extreme weather events, and other natural disasters					
Flood Mitigation Assistance Grant Program (FMA) *	Implement cost-effective measures that reduce or eliminate the long-term risk of flood damage	Emergency Management and Planning	For buildings and other structures insured under the National Flood Insurance Program (NFIP).	Project scoping: $300,000; Community Flood Mitigation Projects: $900,000; Tech Assistance, and Individual Projects: $50,000	January	25% (cash or in-kind)
LAND (Local Acquisitions for Natural Diversity)	This program helps Cities and Towns acquire land for conservation and passive recreation purposes.	Environment	Must have an up-to-date Open Space and Recreation Plan	$500,000	July	Varies by Town (54% for the Towns)
MassWorks Infrastructure Program	Provides grants to communities to help them prepare for success and contribute to the long-term strength and sustainability of the Commonwealth.	Community Development	None	$1M	June	No

Potential Grant Sources						
Grant	Description	Category	Limitations & Stipulations	Maximum Award	Applications typically due	Match Required
Municipal Small Bridge Program	Funding for small bridge replacement, preservation, and rehab projects	Public Works and Transportation	Bridges with spans between 10' and 20'	Phase 1: $100,000; Phase 2: $500,000	June 30	No
Municipal Vulnerability Preparedness (MVP) Program	Provides support to implement climate change resiliency priority projects	Environment	Requires 25% match of total project costs	$3,000,000	May	25% (cash or in-kind)
NFWF Five Star and Urban Waters Restoration Grant Program*	The program seeks to develop nation-side community stewardship of local natural resources. Grants address water quality issues in priority watersheds, such as erosion, pollutions, and degraded shorelines.	Environment	None	$50,000	February	50%
Pre-Disaster Mitigation (PDM) Grant Program *	Provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event	Emergency Management and Planning	100 Selected projects	Planning: $400,000; Mitigation: $4M	April	25%
Section 319 Nonpoint Source Program*	Grants for technical assistance, education, training, demonstration projects and monitoring of nonpoint source pollution implementation projects.	Transportation, Environment	For communities implementing approved nonpoint source management programs	Varies	December	40%
Rural and Small Town Development Fund	Capital and community planning projects in rural and small towns for housing, transportation,	Public Works and Transportation	Towns less than 7,000 population	Planning: $100,000 Infrastructure: $500,000	June	No

Potential Grant Sources						
Grant	Description	Category	Limitations & Stipulations	Maximum Award	Applications typically due	Match Required
	infrastructure, economic development					
Transportation Alternatives (TA)	Funding for smaller-scale transportation projects such as pedestrian and bicycle facilities, recreational trails, safe routes to school projects, community improvements such as historic preservation and vegetation management, and environmental mitigation related to stormwater and habitat connectivity	Transportation	None	Varies	Varies	20%
USACE Flood Damage Reduction*	Funding for study, design, and construction of small flood control projects.	Environment, Public Works	100% federally funded up to $100,000	$10M	Rolling	Costs over $100,000 are shared 50/50
USDA Rural Community Funds*	This grant is awarded to help non-profit housing and community development organizations, low-income rural communities and federally recognized tribes support housing, community facilities and community and economic development projects in rural areas.	Community Development	For communities with a population less 50,000	$500,000	June	50% (cash)