Vine Brook Watershed Flood and Urban Heat Island Assessment Report

JUNE 2022

MVP
Municipal Vulnerability Preparedness

PREPARED FOR

The Town of Burlington, Massachusetts and the Massachusetts Executive Office of Energy and Environmental Affairs

Acknowledgments

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Contents

Contents

1. Project Summary

The Vine Brook Watershed Inland Flood and Urban Heat Island Assessment was conducted to address urban flood impacts from extreme precipitation and urban heat island effect from projected extreme climate events. The project evaluated the highly developed Vine Brook Watershed for opportunities to implement Nature-based Solutions to address anticipated impacts due to climate change. Nature-based Solutions build resilience to the effects of climate change through protection, restoration, and management of natural resources. This year long-assessment was led by the Town of Burlington with funding from the Massachusetts Municipal Vulnerability Preparedness (MVP) grant program.

The effects of climate change present significant social, environmental, and economic risk to the long-term sustainability of Burlington. Climate data projections predict higher total annual precipitation in Burlington, with most of this increased rainfall occurring as extreme rainfall events in the winter and spring months. In the Vine Brook Watershed, where significant urban development is situated within proximity of high value natural resources such as rivers and streams, there is a risk of flood impacts to infrastructure and natural resources. Similarly, Burlington can expect to see an increase in extreme heat impacts from climate change. The presence of built infrastructure such as buildings, roadways, and parking lots increase the overall temperature of the region compared to naturalized areas with “green-space.” Extreme temperature conditions not only present public health impacts to residents or visitors to Burlington, but also adversely impact the natural environment such as water quality within wetlands, including rivers and streams.

To mitigate for the predicted flood and extreme heat conditions expected as climate change persists over the coming decades, the implementation of Nature-based Solutions throughout the Vine Brook Watershed is needed. The flexibility afforded by Nature-based Solutions, which refer to climate adaptation measures focused on the protection, restoration, and management of ecological systems to safeguard public health, provide clean air and water, increase natural hazard resilience, and sequester carbon, can benefit the community in many ways. Examples of co-benefits provided by ecosystem services include cost-effective alternatives to modernizing aging infrastructure, improving natural ecological systems, creating economic prosperity, and improved human health and well-being through physical connections to outdoor spaces.

To better understand how and under what conditions Nature-based Solutions might be incorporated into the interdependent residential, commercial, and natural landscape within the Vine Brook Watershed, a combination of desktop data analysis and field data collection were used to identify and prioritize locations within the watershed for Nature-based Solutions suitability.

The remainder of this report summarizes the assessment approach and resulting priority resilience actions, informed by stakeholder priorities and interests, along with specific Nature-based Solutions opportunities at representative sites within the watershed. The report appendices provide further detail and implementation steps to guide the Town as it takes steps to increase community resilience to climate change.

1.1 Summary of Resilience Actions

Resilience Actions can broadly guide municipal departments and other community stakeholders as they advance their resilience goals. These actions were derived from the stakeholder assessment developed as part of this project. The stakeholder assessment methodology and findings are provided in Appendix A. Recommendations associated with each Resilience Action are provided in Section 2 of this report narrative.

Resilience Action 1: Sustainable/Climate Resilient Development: Sustainable development refers to development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs. Stakeholder feedback for this action focused on development that preserves or restores habitats and ecosystems and addresses urban heat.

Resilience Action 2: Public/Open/Recreational Space: For this action, stakeholder priorities identified support for a walkable community, fewer cars, more pedestrian and bike paths, and increasing access to natural resources and Vine Brook.

Resilience Action 3: Restoration of Developed Areas: Stakeholders felt it was important to restore existing development by reducing hardscaped areas, adding back trees and green spaces, and restoring natural flood mitigation systems.

Resilience Action 4: Community Education to Support Climate Resilience: Some stakeholders were not aware of the climate change vulnerabilities in the Vine Brook watershed or ways to build resilience. Activities under this action would create awareness to support community participation, informed engagement, and regulatory updates.

Resilience Action 5: Reduce and Avoid Adverse Public Health Impacts: Public health impacts, especially resulting from rising temperatures and extreme heat events, were of importance among community stakeholders. Implementation of Resilience Actions 1-4 and 6 will all positively impact the Vine Brook watershed environment, reduce impacts of climate hazards, and thereby reduce or avoid adverse public health impacts.

Resilience Action 6: Protect Residential Properties from Flooding: Protect residential properties experiencing new flooding or flooding in the future due to expanded floodplain. Nature-based solutions could be employed to disperse stormwater over larger areas.

1.2 Prioritization of Nature-based Solutions as Resilience Measures

An assessment of risks and opportunities in the Vine Brook Watershed led to the selection of six study sites that could serve as representative locations to provide a more detailed example of how Nature-based Solutions and other best practices can be combined to greater effect than individual actions. Together, these sites provide an idea of what Resilience Actions 1-6 might look like when implemented and how Nature-based Solutions projects and policies can be stacked to best effect and efficiency on varying sites.

Priority Study Sites:

- Burlington Mall - South
- Lord Baron Apartments
- Decommissioned Water Treatment Facility
- 4th Avenue - North Development Complex
- Lexington Street Neighborhood - South
- New England Executive Park

See Appendix C for Nature-based Solutions memos providing additional detail and implementation guidance for the sites. Each of these sites were assessed using the Resilient Massachusetts Action Team (RMAT) Climate Resilience Design Standards Tool. RMAT tool outputs and engineering analysis for each of these six locations are provided in Appendix D.

2. Approach and Recommendations

This project was intended to identify Nature-based Solutions to address urban flood impacts from extreme precipitation and urban heat island effects from anticipated extreme climate events in the Vine Brook Watershed. Burlington's prior MVP planning efforts in 2019 sought to identify climate related hazards, community strengths and vulnerabilities, and develop solutions to address these considerations by using a community-driven workshop process. This project similarly identifies community challenges and opportunities, and a set of priority resilience actions, through the Stakeholder Engagement findings (Appendix A).

The Vine Brook Watershed was a logical first step to assess Burlington's vulnerability to inland flooding and urban heat island. The watershed is characterized by a combination of residential and commercial development, and intermittently dispersed wetlands and open space. A notable landscape feature in the watershed is the Burlington Mall commercial district situated at the Junction of Rt. 128 and Route 3. The area represents a significant percentage of the overall Vine Brook watershed area. Impervious surface within the watershed contributes to the increased vulnerability of flooding and diminished water quality to Vine Brook and downstream wetlands including the Shawsheen River located approximately 1-mile west of the Burlington/Bedford municipal boundary. There is significant overlap with floodplain and urban heat island in the Town of Burlington.

Urban heat island effect results in higher temperatures in locations with significant impervious surface compared to areas with vegetated ground cover. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures that are, on average, 1-7 degrees Fahrenheit (F) higher than outlying areas. Nighttime temperatures are about 2-5 degrees F higher[1]. The Vine Brook watershed is an example of a highly developed area that has a significant concentration of impervious surfaces with limited greenery. Currently, approximately 32% of the overall land area surrounding the Vine Brook is made up of impervious surface. This means that as the global climate continues to trend warmer, the watershed has a high exposure for extreme heat events.

Impervious surfaces do not just create urban heat islands, but also increase the risk of the surrounding areas to flooding. Climate data projections predict higher total annual precipitation in New England, as well as more intense precipitation events. In the coming decades, an additional 6-inches of annual rainfall is expected for the region, with most of the rainfall occurring as extreme precipitation events during the winter and spring seasons. The Shawsheen River drainage basin, for example, may see up to 20% more winter precipitation by mid-century (2050) and up to 36% more winter rainfall by the end of the century (2100)[2] . Undersized drainage infrastructure and natural drainage features in the watershed are inadequate to handle future extreme rainfall conditions. High percentages of impervious surface result in increased runoff and lower levels of groundwater recharge. For example, areas with 35-50% impervious surface, like the Vine Brook

[1] Environmental Protection Agency (EPA). (2022, June 6). Heat Island Effect. Retrieved from https://www.epa.gov/heatislands

[2] Northeast Climate Adaptation Science Center (2018). Massachusetts Climate Change Projections - Statewide and for Major Drainage Basins. Retrieved from: https://resilientma.mass.gov/resources/resource::2152

watershed, have 30% runoff and 15% deep groundwater infiltration compared to 10% runoff and 25% deep infiltration areas with natural ground cover[3]. In the 2019 Town of Burlington Community Resilience Building Summary Findings report, the Town concluded that increased runoff will quickly overwhelm Town's stormwater infrastructure and will cause a significant risk to state and local roadways, as well as properties, within Burlington. Evidence of this was seen during the field visits BSC Group conducted in the Fall of 2021. The Lexington Street neighborhoods, which surround Long Meadow Brook, have culverts that allow the Brook to pass under the streets. The culverts were observed to be inundated with trash and debris. Culverts that are not properly sized and clean of trash and debris are unable to properly function and during extreme storm events and will flood, putting the properties surrounding the Brook at risk of flooding.

The effects of urban heat island and flooding can result in adverse health effects for Burlington residents, workers, and visitors. Flood waters can carry chemical pollutants as well as bacterial and viral contamination. Heatwaves can increase temperature-sensitive marine pathogens creating challenges for water supplies. Adverse health effects are expected to be felt disproportionately across the community. For example, during extreme heat events older adults, pregnant women, and children are at a high risk of experiencing heat related illnesses and death[4]. Over one-quarter of Burlington's population falls within this high-risk category[5]. People can experience physical and mental illness during heat related power outages and flood events that require people to evacuate and take refuge in crowded shelters; those with limited financial resources or are already experiencing isolation are more likely to go to shelters. The Town of Burlington indicated in their 2019 Community Resilience Building Summary Findings report[6] that in order to prepare for extreme temperatures and flooding the Town needs to improve the capacity of existing shelters/cooling centers so they can better support their vulnerable populations. Depression and anxiety, which can persist for years after an event, is higher among households that experience flooding, and the impacts are greatest on children. Additionally, low-income households will have the greatest challenge building back after an event. Burlington's two environmental justice census blocks are both located within highly vulnerable areas of the community with respect to inland flooding and urban heat island effect. Census block 1 is an area of significant flood risk within the watershed, situated within the 100-year and 500-year floodplain at the confluence of Vine Brook and Sandy Brook. Additionally, this area is characterized as subject to urban heat island effect. As temperatures continue to climb and heat waves become more frequent and prolonged heat-related deaths have the potential to become more prevalent.

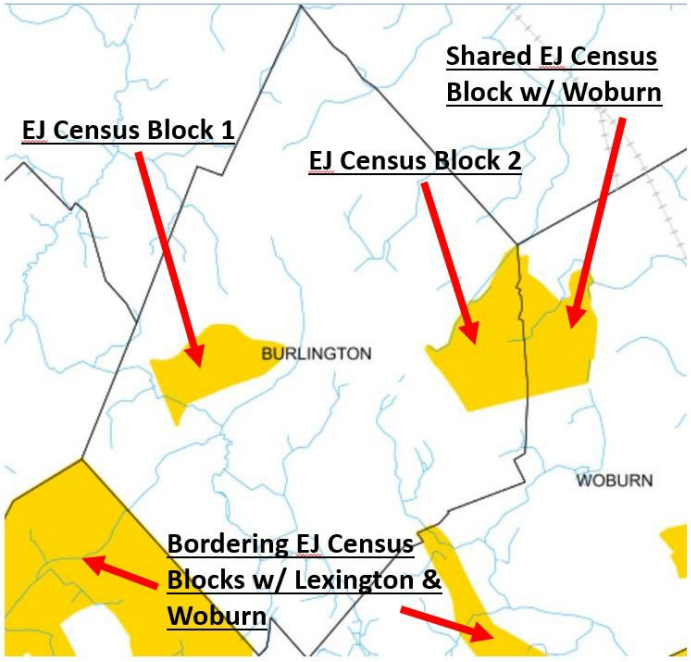


Image Source: US EPA Environmental Justice Screen Viewer

[3] Stormwater education. Environment, Health and Safety. (2021, June 15). Retrieved June 28, 2022, from https://ehs.unc.edu/stormwater/education/

[4] USGCRP, 2018: Chapter 14: Human Health [Reidmiller, D.R., et al.]. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

[5] U.S. Census Bureau. (2020). QuickFacts. Retrieved from https://www.census.gov/quickfacts/fact/table/burlingtontownmiddlesexcountymassachusetts/AFN120217.

[6] Malloy, J. T., Echandi, A., Rimol, K. (2019, June). Town of Burlington Community Resilience Building Summary of Findings. Retrieved June 28, 2022, from https://www.mass.gov/doc/burlington-report/download

2.1 Assessment Methodology

To better understand how and under what conditions Nature-based Solutions could be incorporated into the interdependent residential, commercial, and natural landscape within the Vine Brook Watershed, multiple layers of analysis were used to identify and prioritize locations within the watershed for Nature-based Solutions suitability.

The assessment methodology included the following steps:

- A **stakeholder assessment** (detailed in Appendix A) engaged municipal staff, residents, and businesses to identify areas with known challenges as well as opportunities. It also identified stakeholder priorities. For example, following the COVID-19 pandemic, the town has observed changes in shopping patterns that are expected to remain. This creates an opportunity to reimagine land use for parts of the mall property such as increased green space, a stakeholder identified priority.
- A **desktop assessment** used GIS-based mapping tools to further explore climate vulnerabilities, land use, and habitat quality. Collectively, these data sources were used to identify potential locations to enhance resiliency by maximizing co-benefits that align with the municipal priorities.
- **Field data collection** was used to "field-truth" the desktop assessment. The field assessment included a series of site visits, conducted by two teams each comprised of a landscape architect/site designer, an ecologist, and a municipal representative. These teams explored sites and provided on-the ground assessment based on exiting information and data collected in the field including notes, representative photographs, and additional data collected on a wifi/cellular connected tablet device using an ARC GIS Field maps application.
- Following the field assessment, the project team **refined project maps** by adding new Nature-based Solution opportunities to existing suitability maps, and eliminated areas deemed unsuitable for the implementation of Nature-based Solutions. Additional criteria for selecting sites for Nature-based Solutions was the identification of representative sites (e.g., a residential neighborhood that could serve as a model for other residential neighborhood Nature-based Solutions) or sites that were significant to the watershed and unique in the opportunities they presented (e.g., the Burlington Mall). Maps were reviewed with municipal project stakeholders to further refine findings and vet potential barriers to effectiveness or feasibility.

Key outcomes of this assessment included:

- **Nature-based Solutions Memos** for each of the six priority study sites (Appendix C) providing Nature-based resilience actions for the site, project pre-requisites, order of magnitude budgets, and a high-level implementation schedule. The sites and corresponding solutions were developed as "case study" sites with the intent that they would provide recommendations specific to site as well as an example for change that could be duplicated in other similar locations
- **Vine Brook Nature-based Solutions Ecological Restoration and Resilience Opportunities Table** (Appendix E). This table analyzes the effectiveness and feasibility of Nature-based Solutions at the six project sites.

2.2 Recommended Resilience Actions

Six resilience actions were identified through the stakeholder assessment developed as part of this project (see Appendix A). Municipal staff, boards, and committees can use these actions as a shared reference for advancing climate resilience within their respective areas of authority. Following the summaries of resilience actions 1-6 is a discussion on possible pathways to implementation.

Resilience Action 1 - Sustainable and Climate Resilient Development within Study Area

Action Goal	**New, or changes to existing development in Burlington shall incorporate climate resilience into project design.**
Action Lead	**Municipal Departments including Planning, Conservation, and Public Works**
Risk or Opportunity	**Sustainable and climate resilient development may create short-term burdens during initial implementation; however, it provides long-term benefits for public health, the environment, and the economy. Sustainable buildings with access to natural resources are increasingly desired qualities for corporate campuses representing an economic development opportunity for the Town.**
RMAT Considerations	**The study area demonstrates high exposure to extreme precipitation (urban and riverine flooding) and high or moderate exposure for extreme heat.** ▪ Incorporate RMAT Design Guidelines for Extreme Precipitation into stormwater management standards for development and redevelopment projects. ▪ Incorporate RMAT Design Guidelines for Extreme Heat into performance standards for development and redevelopment projects. • Minimize the allowable impervious surface in lot coverage • Establish a minimum canopy cover standard for planting plans • Establish a treatment protocol to promote use of highly reflective and low heat absorption materials.
Timeframe	**Climate Resilience is a continuous process. Specific timelines include:** ▪ Current MVP analysis, planning feasibility and best practices for model sites ▪ FY2024 Site specific design and permitting to 30% completion ▪ FY2025 Site specific construction design and funding budget to 70% completion ▪ FY2027 Site specific design, bidding, implementation, and construction engineering 100% complete ▪ FY2030-FY2033 Site monitoring and establishment period 2-5 years from date of project completion
Implementation Methods	**Update local regulations to include climate resilient performance standards** ▪ Use local bylaw revisioning and development board authority to incorporate and uphold climate resilience performance standards and generate reference sites for future projects. ▪ Provide Nature-based Solutions scoping and feasibility resources to stakeholders in pre-application review for use in budgeting and grant funding opportunities to implement projects. ▪ Build community awareness and support by creating a Sustainability Committee to promote regulatory and standard development practices that align with MVP/resilience action goals.
Performance	**Adoption of local regulations requiring climate resilient performance standards. Completed projects built to RMAT Design Standards or updated local standards.**
Community Feedback	**Consider limiting impervious surfaces, restricting cutting down trees or requiring expanded tree canopy, and implementation of Nature-based solutions for flood mitigation.**

Resilience Action 2: Restoration of Developed Hardscapes within Study Area

Action Goal	**Convert passive landscapes to naturalized landscapes or structured landscapes with functional benefits.**
Action Lead	**Municipal Departments including Planning, Conservation and Public Works.** **Private landowners.**
Risk or Opportunity	**Landscape redevelopment is an opportunity to reduce runoff and peak storm flows, reduce heat islanding and increase biodiversity and habitat function.**
RMAT Considerations	**Open space presents opportunity to meet RMAT Design Guidelines for adjacent developed areas** ▪ Creation of open space in development and redevelopment planning will improve performance to RMAT Design Guidelines. ▪ Risk of flood damage and erosion are elevated during redevelopment and must be managed through construction access and erosion control monitoring.
Timeframe	**Immediate and ongoing individual landscape redevelopments to be completed on a case-by-case basis as resources allow.**
Implementation Methods	**Utilize updated local regulations that include climate resilient performance standards in all project proposals with land and water resources within the study area.** ▪ Performance standards for municipal and private projects, and public-private partnerships for infrastructure redevelopment must be the same. ▪ Develop best practices for maintenance of new and existing landscapes that support ecological restoration and ecosystem function and identify places where water can be stored to increase capacity in advance of flood events. ▪ Identify and increase funding incentives for Nature-based Solutions for alternative development and redevelopment. ▪ The Lexington Street – Neighborhood South (Map 5) and 4th Avenue South (Water Treatment Facility (Map 11)) returned high opportunity ratings for model Nature-based Solution implementations. These include forest and shrubland management and restoration, installation of pollinator buffers, and pocket forests where existing landscapes are presently low in ecological value ▪ Monitor indicators of successful ecosystem restoration and enhancement; including: • Increased stormwater carrying capacity and reduced runoff coefficient. • Increased species diversity and net biomass. • Increased urban tree canopy coverage.
Performance	**Functional Nature-based Solutions are applied to the extent feasible on new and existing landscape projects**
Community Feedback	**Restoration of green and blue spaces in the watershed. Focus on protection of ecosystems.**

Resilience Action 3: Restoration of Developed Hardscapes within Study Area

Action Goal	**Convert underutilized hardscape to naturalized landscapes or pervious surfaces with tree canopy for heat island reduction.**
Action Lead	**Municipal Departments including Planning, Conservation and Public Works.** **Private landowners.**
Risk or Opportunity	**Landscape reclamation is an opportunity to reduce runoff and peak storm flows, reduce heat islanding and increase biodiversity and habitat function.**
RMAT Considerations	**Converted hardscape presents opportunity to meet RMAT Design Guidelines for adjacent developed areas.** ▪ Conversion of hardscape in development and redevelopment planning will improve performance to RMAT Design Guidelines. ▪ Risk of flood damage and erosion are elevated during redevelopment and must be managed through construction access and erosional control monitoring.
Timeframe	**Immediate and ongoing individual landscape reclamations to be completed on a case-by-case basis as resources allow.**
Implementation Methods	**Utilize updated local regulations that include climate resilient performance standards in all project proposals with land and water resources within the study area.** ▪ Performance standards for municipal and private projects, and public-private partnerships for infrastructure redevelopment must be the same. ▪ Develop best practices for conversion of existing hardscape to landscapes that support ecological restoration and ecosystem function. Identify places where water can be stored to increase capacity in advance of flood events. ▪ Identify and increase funding incentives for Nature-based Solutions for conversion of hardscape. ▪ The Burlington Mall (Map 2) and Burlington High School (Map 6) returned high opportunity ratings for model landscape reclamation projects that promote ecological awareness and access to outdoor spaces. These include installation of pervious trail surfaces, interpretive signage, gathering spaces and additional tree canopy where currently underutilized surface parking or unstructured landscape exists. ▪ Monitor indicators of successful ecosystem restoration and enhancement; including: • Increased stormwater carrying capacity and reduced runoff coefficient. • Increased species diversity and net biomass. • Increased urban tree canopy coverage
Performance	**Functional Nature-based Solutions are applied to the extent feasible on landscape reclamation projects.**
Community Feedback	**General reduction in hardscaping with increases in pervious surfaces and natural features such as rain gardens and green roofs.**

Resilience Action 4: Community Education to Support Climate Resilience within the Study Area

Action Goal	**Promote and standardize an ecologically centered vision, practice, and informed community, through consistent and meaningful public engagement.**
Action Lead	**Municipal Departments including Planning, Conservation, Public Works, Public School District, Council on Aging, Housing Authority**
Risk or Opportunity	**Community education is an opportunity to advance climate resilient best practices at private residences and institutions where direct intervention is not feasible.**
RMAT Considerations	**None**
Timeframe	**Immediate and ongoing with an emphasis on the next 2-5 years**
Implementation Methods	**Inform the citizen and business communities to generate support for climate resilient practices and policies.** ▪ Combine promotion of shared information and event-based direct action that provide examples or resources for practice by individuals and institutions ▪ Identify key stakeholders and develop long-term relationships to facilitate discussion in the community about climate resilient performance standards. ▪ Engage news media outlets with tailored messages for key stakeholder groups that empower participation in policy development and implementation of performance standards. ▪ Develop interpretive signage and links to resources where they will be encountered by the public in the study area.
Performance	**Demonstrated broad dissemination of information with resources provided in multiple languages, Attendance goals for focus groups, surveys and public meetings are set and achieved.**
Community Feedback	**Stakeholders were unaware for flood and urban heat island vulnerability in the area as well as the role Nature-based solutions play in resilient design.**

Resilience Action 5: Reduce or Avoid Adverse Public Health Impacts within the Study Area

Action Goal	**Mitigate existing heat island, and air and water quality impacts, to avoid adverse public health impacts.**
Action Lead	**Municipal Departments including Planning, Conservation, Public Works, Health, Council on Aging, Housing Authority**
Risk or Opportunity	**Climate resilient performance standards and nature-based solutions provide an opportunity to enhance positive heath impacts as a co-benefit of healthy community design.**
RMAT Considerations	**Use public health indicators to direct co-benefit potential of implementation of climate resilience performance standards and nature-based solutions.** ▪ Mitigating flooding protects against structural damage as well as pollutants and vector borne illnesses in floodwaters. ▪ Performance standards for minimizing urban heat islands can reduce incidences of heat stress conditions and improve the air quality to lessen respiratory issues. ▪ Restored open spaces and increased tree plantings improve air quality, walkability and active transit, safety from traffic, social cohesion, and mental health.
Timeframe	**Immediate and ongoing with an emphasis on the next 2-5 years**
Implementation Methods	**Co-benefits for public health outcomes depend on the achievement of resilience actions outlined in recommendations.** ▪ New, or changes to existing development in Burlington shall incorporate climate resilience into project design. ▪ Convert passive landscapes to naturalized landscapes or structured landscapes with functional benefits. ▪ Convert underutilized hardscape to naturalized landscapes or pervious surfaces with tree canopy for heat island reduction. ▪ Promote and standardize an ecologically centered vision, practice, and informed community, through consistent and meaningful public engagement. ▪ Educate and incentivize best management practices for stormwater management on private residential properties.
Performance	**Public health outcomes should be assessed by health impact and as a separate exercise with the goal of viewing all community considerations. The data gathered as part of this exercise can be repeated after the implementation of climate resilient performance standards to explore the relationship between temperatures, nutrient loads, access to green space and storm events and public health outcomes.**
Community Feedback	**Community members focused primarily on the effects of extreme heat events.**

Resilience Action 6: Protect Residential Properties from Flooding within the Study Area

Action Goal	**Educate and incentivize best management practices for stormwater management on private residential properties.**
Action Lead	**Municipal Departments including Planning, Health, and Inspectional Services.** **Private landowners**
Risk or Opportunity	**Implementing best management practices for stormwater management on private residential properties is an opportunity to protect local dwellings and infrastructure and reduce storm impacts for downstream communities.**
RMAT Considerations	**Implementation of the RMAT Design Guidelines for Extreme Precipitation and Extreme Heat will help meet this Resilience Action directly.** ▪ Reduction of Impervious surfaces and increased tree canopy will reduce stormwater runoff and help protect against site and downstream flooding. ▪ Restoration of open space and improvements to both Vine Brook and Long Meadow Brook can also be utilized to create expanded floodplain in areas away from residential properties.
Timeframe	**Immediate and ongoing individual improvements to be completed on a case-by-case basis as resources allow.**
Implementation Methods	**Establish municipal programs to educate and incentivize the use of best management practices on private residential properties.** ▪ Promote municipal rain barrel and/or cistern program to encourage the capture and reuse of water on site ▪ Offer incentives for the installation of a green roof, permeable pavement, and updated drainage systems that include rain gardens and planting plans for residential property owners
Performance	**Record best management practice for stormwater improvements within the residential property class in the study area to the extent feasible. Compare pre- and post-net storm event flows at existing monitoring stations.**
Community Feedback	**Restoring sites to allow the natural flow of waterways; increasing plantings for managing stormwater runoff.**

2.3 Resilience Actions Implementation Discussion

The Town of Burlington is currently reviewing and considering new and updated bylaws relating to stormwater management and redevelopment in the study area. The Planning and Conservation departments have a good opportunity to include the use of climate resilient performance standards in their policy updates. The complete activation period for the Resilience Actions presented in this report is about ten years.

The Town is currently reviewing their existing Municipal Separate Storm Sewer System (MS4) Stormwater bylaw, which has a significant jurisdictional scope in that it includes lot sizes as small as 10,000 square feet. The revision of this bylaw should adopt a performance checklist which itemizes an approved set of established landscaping requirements and a scoring system for rating a project against these requirements. Feasibility and alternatives analyses narratives should be required as a part of any request for relief, and financial constraints should not be accepted as a reasonable hardship. Also, the Town may consider reviewing and updating its Wetlands Bylaw to capture smaller matters that have a cumulative impact on the watershed like tree clearing and poor drainage and grading design. This could be something as simple as requiring the submission of a landscape plan for projects altering Buffer Zone and Riverfront Areas. The Commission could then implement a 2:1 tree replacement policy, a mitigation of new impervious surface standard, and operation and management plans for rain gardens on all landscape projects.

Burlington has recently approved the placement of the Community Preservation Act (CPA) on its November 2022 ballot. This is a good indicator of a community's motivation for improved quality of life through capital investments in open space, historic preservation, and housing production. The campaign to approve the CPA in Burlington is an excellent platform to begin host a public education delivery system in the community around the use of Nature-based Solutions to minimize or off-set the negative climate and public health impacts of extreme heat and extreme precipitation. CPA projects are typically highly visible in the community by design, and by prioritizing some of the high feasibility and best value resilience opportunities described in Appendix E and highlighted in Resilience Actions 2 and 3; the Town has an opportunity to coopt the traction of the CPA as a new program to promote the positive change that climate resilient performance standards can deliver.

The Town is considering the establishment of a zoning overlay district for redevelopment in the same envelope as the study area. This overlay district provides an excellent opportunity for the economic development and planning interests of the town to collaborate with private interests to achieve significant progress in climate resilience through land use planning. In addition to the conversion of use in redevelopment, restrictions on impervious surface and building footprint can create opportunities for landscape reclamation in the development process. The Town should also consider the mobilization of a TIF program as an incentive for projects that perform above the standards set by the overlay. Examples of performance measures could include maximizing the use of Nature-based Solutions, Low-Impact Design Strategies, and LEED certification levels for the site, roadways and parking and structure. In addition, negotiating responsibility for culvert improvements and surface water management in the overlay district is a space where the municipality and can engage private developers in the effort to build a more sustainable and functioning watershed area. All of these should be adjudicated in preapplication and design review before the Town commits to development incentives.

Finally, the Town should consider the creation of a Sustainability Committee to support the implementation of these Resilience Actions. The municipal commitment to climate resiliency is most effective in the company of an engaged and informed populace. The mandate of such a committee could be to serve as the coordinating body for community education, project support and representation in the planning and development decision making process.

The Resilience Action goals described in this Report can be implemented through thoughtful policy review and implementation, and the expansion of participatory stakeholders in the planning and development process. Beginning with the demonstration of need and subsequent update to local regulations to include climate resilient performance standards; Burlington can move forward through the recommended Action Goals by focusing on expanding the scope of stakeholders involved in raising visibility of the benefits of implementing those performance standards with a Sustainability Committee, a Community Preservation Act Program and new private sector partnerships that understand and share the values of restoration, resilience, and sustainability.

Appendix A: Stakeholder Engagement Methodology and Findings

BSC GROUP

MEMORANDUM

150 DOW STREET, MANCHESTER, NH 03101 - www.bscgroup.com
TEL 617-896-4300

To:	John Keeley, Town of Burlington	**Date:**	May 20, 2022
From:	Katie Kemen, Director of Climate Resilience Services Max Charney, Community Planner	**Proj. No.**	28397.01
Re:	Vine Brook Watershed Inland Flooding and Urban Heat Island Assessment Stakeholder Assessment – Technical Memorandum		

cc:

This technical memorandum outlines the stakeholder assessment prepared for the Vine Brook Watershed Inland Flood and Urban Heat Island assessment project ("the project"). This project, funded by the Massachusetts Municipal Vulnerability Preparedness (MVP) program, is intended to address urban flood impacts from extreme precipitation and urban heat island effects from anticipated extreme climate events. This project will evaluate the highly developed Vine Brook watershed for opportunities to implement nature-based solutions to address anticipated impacts due to climate change.

Stakeholder Assessment

This stakeholder assessment was conducted to inform project decision-making through an analysis of stakeholder interests, goals, and priorities. The following considerations were assessed:

- Who are the stakeholders and who should participate in the assessment process?
- What are the stakeholders' goals and underlying interests?
- Who cares about the problem and/or who is affected by the problem?
- Who has the expertise to contribute to this process?
- Who must be included to ensure the process is inclusive?

Stakeholder Assessment Methodology

The following methodology used for this project follows an approach common in consensus building exercises and are often referred to as issues assessment or stakeholder analysis. The methodology outlined below was developed as a unique approach to accommodate the goals of this project.

1. Develop a project website (https://climateresilientburlington.wordpress.com/) to communicate important project information such as climate data and climate vulnerability within the Vine Brook watershed.
2. Develop and distribute a survey/questionnaire to municipal government stakeholders within the Town of Burlington. Sample survey questions are provided as an attachment to this memo.
3. Conduct a document review of relevant planning documents for the Town of Burlington, for example previous climate resilience reports.
4. Hold a meeting within Town of Burlington municipal stakeholders to gather additional assessment data.
5. Refine survey/questionnaire to accommodate an expanded stakeholder group.
6. Distribute survey to expanded stakeholder group through community newsletters, stakeholder networks, Burlington Public Schools, and project website. Ultimately, 44 responses were received

from across the community.

7. Compile Stakeholder Assessment data and conduct assessment mapping to define and prioritize project goals and objectives.
8. Ongoing analysis/refinement of stakeholder interests to support ongoing public engagement efforts.

Stakeholder Priority Areas

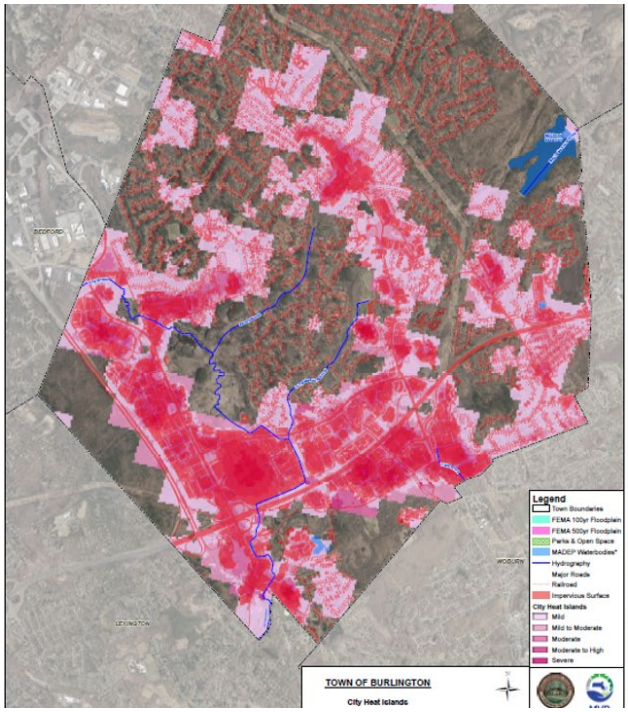
The following priority areas resulted from the stakeholder assessment:

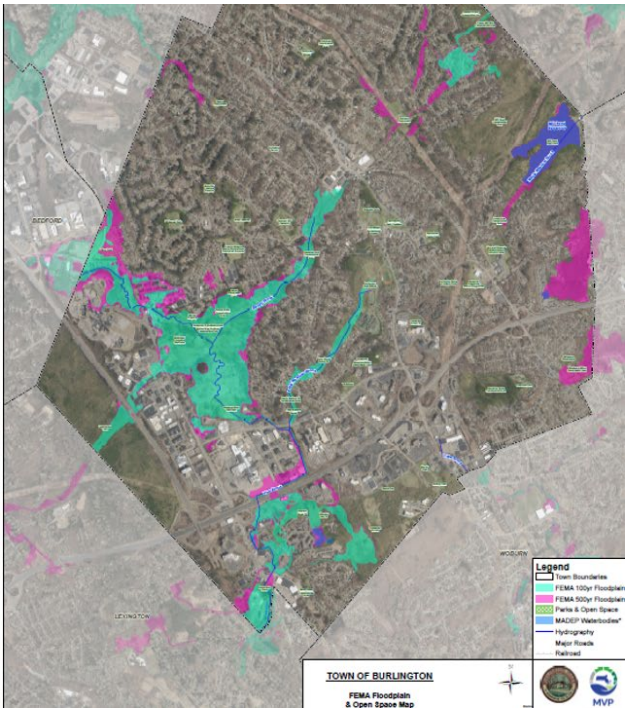
Attachments:

Attachment A: Vine Brook Watershed Flooding and Urban Heat Island Assessment - Municipal Department Stakeholder Survey

This questionnaire/survey is intended to support project decision-making relative to the impacts of extreme precipitation/flooding and urban heat island effect within the Vine Brook watershed area of Burlington. Questionnaire responses will be used to characterize municipal/community interests within the Vine Brook Watershed and better understand which non-municipal stakeholders should participate in this process.

Name: **Affiliation:**





1. Have you been involved with previous or ongoing climate change resilience efforts in Burlington? If so, please describe.
2. What do you consider the biggest risk/problem/issue for the community related to flooding in the Vine Brook Watershed?
3. What do you consider the biggest risk/problem/issue for the community related to Urban Heat Island Effect in the Vine Brook Watershed?
4. Are you familiar with the term “Nature Based Solutions” and how they may be applied to increase the resilience of the community to climate change? If so, are there particular nature-based **solutions** you feel are most appropriate for implementation in the Vine Brook Watershed?
5. Are there particular **areas** within the Vine Brook Watershed that you feel would be appropriate for Nature-Based Solutions? If so, please describe.
6. What do you envision the Vine Brook Watershed should look like in 2030?
7. What do you envision the Vine Brook Watershed should look like in 2050?

8. Who in Burlington do you recommend should participate in this assessment process? Community/Neighborhood organizations? Local interest groups? Etc.? What is the best way to reach these groups of people?
9. Are there specific locations within the Watershed that you feel should be assessed by the project team?

Attachment B: Summary of Stakeholder Survey Comments by Priority Area

Sustainable/Climate Resilient Development
Upgradient construction of wetlands to slow water flow rate
One step for starters would be to limit future causes of heat generation - land development
Not cutting down trees because they can provide a cooling effect for the island and prevent the increasing heat
Plant Trees - lowers heat island effect and mitigates flooding issues with increased infiltration and trans evaporation.
Reduced impervious surface and more LID stormwater solutions
green and blue space improvements; reclaim natural course of river/stream flows; implement nature-based water absorption solutions like rain gardens; increase tree canopy in our most dense heat island areas; green roofs;
consider limiting or banning future development in area that are within wetlands zones (specifically relating to waivers/culverts)
By avoiding any construction or adding impervious surfaces
the mall/Lahey/ etc. need increase tree canopies and reduced impervious surfaces; need green/white roof structures.
Have a pedestrian walkway with more shade trees and a pedestrian bridge through the Vine Brook Aquifer District for walks and wildlife viewing.
Following serious guidelines an area that addresses the natural habitat of wildlife and green plantings throughout.

Public/Open/Recreational Space
Green and blue spaces, and protection of ecosystems.
Pass the Community Preservation Act to help fund open space acquisition and preservation.

Restoration of Developed Areas
Limit tree cutting, especially for new development and teardown of houses. Plan AND MAINTAIN street trees and other public trees.
1) Decrease hardscape/ increase native plantings 2) Decrease impervious surfaces 3) Rain gardens & green roofs to manage storm water 4) Tree program
Restoration of eco system
I believe adding greenery and restoring more land will be good in the implementation of the

Vine Brook Watershed.
introduce to rain gardens, recapture systems (reduce impervious surfaces) in both residential areas and businesses (Blanchard road; businesses along 95 on the Blanchard road side; all residence around great meadow; and businesses on the "other side of Francis Wyman that are "down stream"
A program to plant municipal trees along roadways.
Reduce pavement area at Burlington Mall. Require structured parking there and anywhere else in Town where it would be feasible. Top these parking structures with solar panels. Replace reduced paved areas with green space.
Areas that are presently highly developed with little vegetation, Mall Road & Middlesex Turnpike
I think areas such as parking lots, and places where there are office buildings are would be appropriate for Nature-Based solutions

Community Education to Support Climate Resilience
I don't know what they are but advocacy and informational sessions, so people understand what is going on and what has to be done.
I would love to learn more!
Some Nature-Based solutions that we as a town should be responsible for is educating the public about the extreme flooding/heating, providing town-wide benefits in order to promote town participation and contributions, and taking new measures/designing processes that adjust to both the environment and the town.
I don't know what they are but advocacy and informational sessions, so people understand what is going on and what has to be done.
Is it possible to enrich the soil in the area so it can better support our rivers and fight erosion? I also think healthier soil will promote plant growth that may strengthen the banks of the rivers.
I feel as though there should be better information on the matter because I, and many others, did not know about the flooding/heating. Maybe better measures should be taken for informing citizens of Burlington. Through the publications, it would also be a good idea to promote town benefits to influence contributions from the town.

Reduce and Avoid Adverse Public Health Impacts
Not cutting down trees because they can provide a cooling effect for the island and prevent the increasing heat
Areas with a dense population of buildings, such as the Mall or Third Ave, may benefit from nature based solutions like green spaces to combat the Urban Heat Island Effect
Limit development and remediate the polluted Vine Brook area
I envision that the Vine Brook Watershed should improve conditions by 2030, limiting the Urban Heat Island Effect, as well as flooding. Currently, the conditions are not ideal, but I hope in the future, with the use of Nature-Based Solutions, that there can be positive change.

Seven springs and the surrounding area would be appropriate for Nature-Based solutions because there are mass amounts of people in a small area, so heat health hazards are common.
Areas within the Watershed that contain dense cities and populations should address the impacts of the urban heat island effect to stop cities from suffering the side effects.
Yes, near the Burlington Mall, Network Drive and Burlington Square areas- where the Urban heat island effect is more prominent- I feel it would be appropriate for Nature-Based Solutions to address the impacts from the Urban heat island effect. This is so it does not damage property, or create dangerous conditions for those going near those areas.
I'm not sure I am an expert on how the urban heat island impacts my area. From what I've read on your site I do understand it is a growing issue but as I do not live in Burlington during the warmer seasons I do not have much of an opinion.

Protect Residential Properties from Flooding
Continued planting of trees and shrubs to absorb water.
Providing space for rivers to flow naturally would protect Burlington from flooding since the excess water would have somewhere to go instead of flooding. This would be most useful in the area where all three rivers meet.
I believe that the Vine Brook Well fields (located across from the Burlington Mall and Lexington Street) could benefit from water and forest protection. The protection of the wetlands and its surrounding vegetation could ensure that the Vine, Longmeadow, and Sandy Brooks maintain their natural flow while also providing more opportunity for flood protection.
Areas that are near residential areas or areas with settlements are the biggest priority for nature-based solutions.
Yes, near the Sandy Brook and Vine Brook areas- where flooding is more prominent- I feel it would be appropriate for Nature-Based Solutions to address the impacts from flooding. This is so they do not become a larger issues later, and do not damage the neighborhoods surrounding them.
Introduce to rain gardens, recapture systems (reduce impervious surfaces) in both residential areas and businesses (Blanchard Road; businesses along 95 on the Blanchard road side; all residence around great meadow; and businesses on the "other side of Francis Wyman that are "down stream"

Appendix B: Field Data Collection and Site Assessment Methodology

BSC GROUP

MEMORANDUM

150 DOW STREET, MANCHESTER, NH 03101 - www.bscgroup.com
TEL 617-896-4300

To:	John Keeley, Town of Burlington Conservation Administrator and Eileen Coleman, Town of Burlington Assistant Conservation Administrator	**Date:**	December 14, 2021
From:	Jeffrey T. Malloy, PhD, Climate Adaptation Services Lead, BSC Group, Inc.	**Proj. No.**	28397.01
Re:	Vine Brook Watershed Inland Flood and Urban Heat Island Assessment Field Data Collection Methodology Technical Memorandum/Report		

Key Points

- Vine Brook Watershed is vulnerable to the effects of climate change, notably inland flooding due to extreme precipitation events and urban heat island effect.
- The climate vulnerability of Vine Brook Watershed is influenced by the high level of impervious surface which accounts for approximately 32% of the overall land area in the watershed.
- The implementation of Nature-based Solutions may be implemented to mitigate the adverse effects of climate change and extreme weather events within the Vine Brook Watershed.
- The methodology outlined within this technical memorandum draws upon publicly available data and in-person field data collection. This assessment methodology is flexible allowing for the use of data sources and field data collection approaches that meet specific project goals or objectives.

Introduction and Purpose

The Vine Brook Watershed Inland Flood and Urban Heat Island Assessment is intended to address urban flood impacts from extreme precipitation and urban heat island effect from projected extreme climate events. This project evaluates the highly developed Vine Brook Watershed for opportunities to implement Nature-based Solutions to address anticipated impacts due to climate change. Nature-based Solutions build resilience to the effects of climate change through protection, restoration, and management of natural resources.

The effects of climate change present significant social, environmental, and economic risk to the long-term sustainability of Burlington. Climate data projections predict higher total annual precipitation in Burlington, with most of this increased rainfall occurring as extreme rainfall events in the winter and spring months. In the Vine Brook Watershed, where significant urban development is situated within proximity of high value natural resources such as rivers and streams, there is a risk of flood impacts to infrastructure and natural resources. Similarly, Burlington can expect to see an increase in extreme heat impacts from climate change. The presence of built infrastructure such as buildings, roadways, and parking lots increase the overall temperature of the region compared to naturalized areas with "green-space." Extreme temperature conditions not only present public health impacts to residents or visitors to Burlington, but also adversely impact the natural environment such as water quality within wetlands, including rivers and streams.

To mitigate for the predicted flood and extreme heat conditions expected as climate change persists over the coming decades, the implementation of Nature-based Solutions throughout the Vine Brook Watershed is needed. The flexibility afforded by Nature-based Solutions, which refer to climate adaptation measures focused on the protection, restoration, and management of ecological systems to safeguard public health, provide clean air and water, increase natural hazard resilience, and sequester carbon, can benefit the community in many ways. Examples of co-benefits provided by ecosystem services include climate resilience, cost-effective alternatives to modernizing aging infrastructure, improving natural ecological systems, creating economic prosperity, and improved human health and well-being through physical connections to outdoor spaces.

To better understand how and under what conditions Nature-based Solutions may be incorporated into the interdependent residential, commercial, and natural landscape within the Vine Brook Watershed, a combination of desktop data analysis and field data collection are used to identify and prioritize locations within the watershed for Nature-based Solutions suitability. An important facet of this identification and prioritization effort includes analysis of the effectiveness and feasibility of potential Nature-based Solutions. Additionally, the interests and priorities of municipal stakeholders are incorporated to support decision-making drawing upon information collected from stakeholder interviews, document review and online survey results. Key themes from stakeholder assessment priorities, interests, and concerns guide field data collection efforts.

The following bulleted items outline the key component of this Field Data Collection Methodology. This approach was formulated based on the characteristics of the Vine Brook Watershed and the requirements of this project. This methodology is flexible to allow for modifications that may be applied in other locations that share similar characteristics to the Vine Brook Watershed.

- Conduct Stakeholder Assessment
- Conduct Desktop Assessment and Develop Preliminary Nature-based Solutions Suitability Maps
- Field Data Collection
- Refinement of Mapping

Stakeholder Analysis

To support desktop data analysis, information derived from a stakeholder assessment of Town of Burlington municipal staff was evaluated. Stakeholder assessment data was collected from project team meetings and interviews with municipal staff, online survey, and publicly available document review of Town of Burlington Planning documents. Table 1.0 lists preliminary stakeholder assessment data used to support this field data collection methodology. Identifying important municipal priorities early in the process ensures that issues and interests of the community are considered when evaluating Nature-based Solutions.

Table 1.0 – Town of Burlington Preliminary Stakeholder Assessment Findings

Stakeholder Priority/Interest/Issue	Description for Context
Sustainable/Climate Resilient Development	Economic development in conjunction with natural resource protection.
Public/Open/Recreational Space	Walkable community, Less cars, Pedestrian/bike paths, Access to natural resources and Vine Brook
Restoration of Developed Areas	Too much pavement within Watershed; Mitigate for existing development to build resilience in community.
Community Education to Support Climate Resilience	Create awareness of the impacts of climate change and benefits of climate resilience to support community participation, informed engagement, and regulatory updates.
Reduce and Avoid Public Health Impacts	Mitigation for adverse impacts to public health from extreme climate events.
Protect Residential Properties from Increased Flood Risk	Residential properties in Vine Brook are experiencing new flooding or flooding in the future due to expanded floodplain.

Desktop Assessment

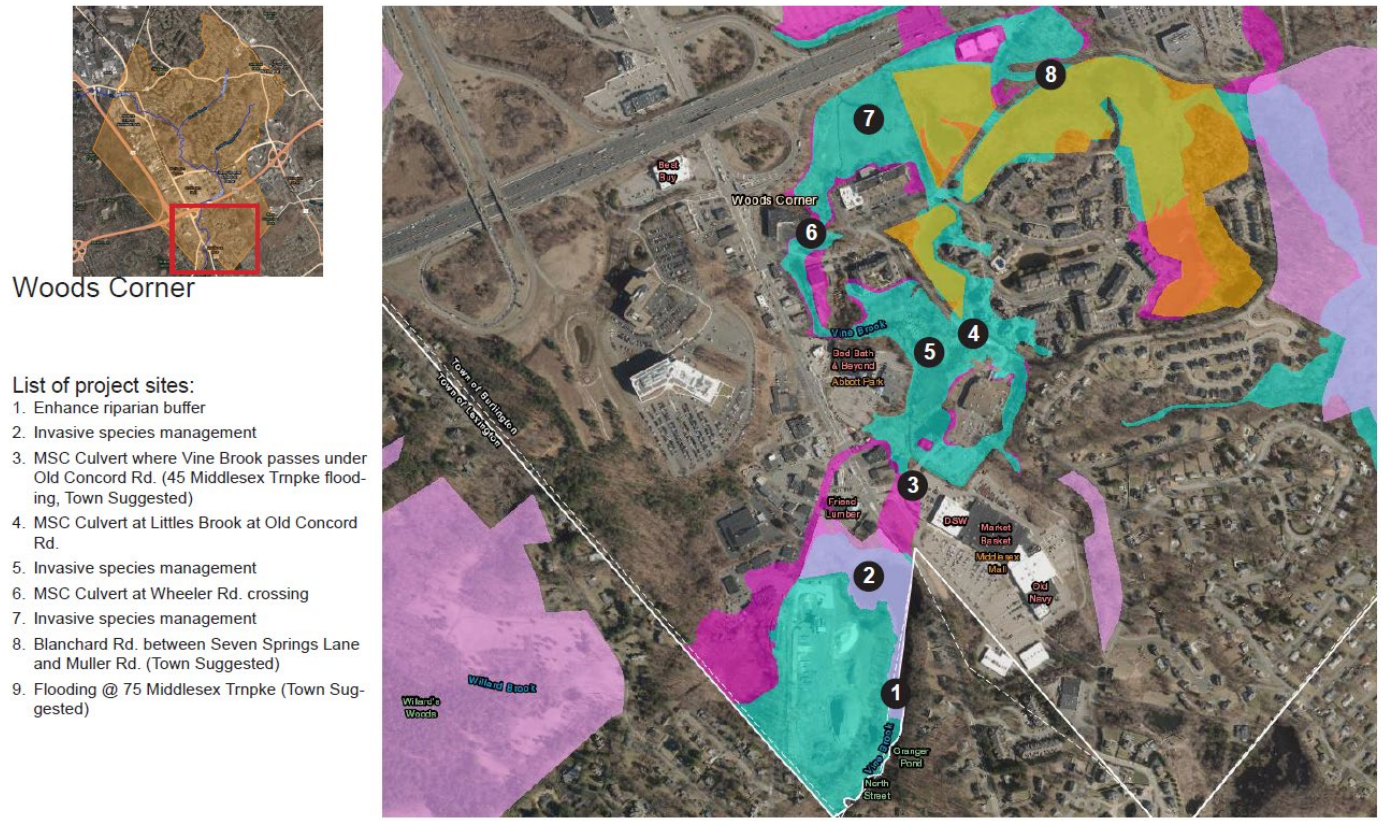
Publicly available online mapping tools are used to identify opportunities for protecting and enhancing ecosystem-based climate resiliency. A Geographic Information System (GIS)- based desktop assessment was initially conducted to understand geospatial data relevant to the project study area. Following this initial analysis, other online data sources were used to better understand land use characteristics and refine data collection needs. Collectively, these data sources were used to identify locations within the community to enhance resiliency by maximizing co-benefits that align with the municipal priorities outlined in Table 1.0. Common examples include public safety and reducing municipal liability through enhanced flood storage, improving water quality through wetland and floodplain restoration, and providing recreational opportunities and localized cooling by protecting and creating access to naturalized areas in the community. Table 2.0 summarizes data sources utilized for this project. Additional data resources that may be useful in other assessments of this type are provided in Table 4.0.

Table 2.0 – Desktop Assessment Data Sources

Data Source	Layers and Comments
MassGIS Data Layers - Online ArcGIS Data Viewer	The full suite of data layers made available on the ArcGIS data viewer prepared for the project were referenced. Key data layers referenced were: BioMap2, FEMA (100-year and 500-year floodplain), Urban Heat Island, Parcel Information (public vs. private ownership), Hydrologic connectivity, and Land Cover-Land Use, Impervious Surface, and Burlington Features & Infrastructure.
MA Coastal Resilience Tool	This tool helps communities identify where Nature-based Solutions can most effectively address natural hazards and contribute to resilience planning at a local level. This project leverages existing statewide datasets and analyses to create easily understandable layers that highlight a range of potential actions and next steps. The results are intended as a high-level screening tool to identify places where conservation and restoration can help combat drought susceptibility, inland and coastal flooding hazards, and contribute to ecosystem co-benefits.
Mass Audubon Mapping and Prioritizing Parcels for Resilience (MAPPR) Tool 2.0	This tool allows land conservationists to identify the parcels within an area of interest that are the highest priorities for protection based on habitat quality, climate change resilience, and other metrics such as parcel size and adjacency to existing protected parcels.
Massachusetts Municipal Vulnerability Preparedness (MVP) Program Downscaled Data	Massachusetts Climate Change Projections (MCCP) provide downscaled climate data for 2030, 2050, 2070, and 2090 at the watershed-scale. For this project, projections for 2030 and 2050 are considered.
National Audubon New England Landscape Futures (NELF)	The New England Landscape Futures Project seeks to understand possible trends and impacts of landscape change in New England. Alternative landscape futures present scenarios for New England that may be used to inform real-world decisions about forest management, land use planning, green and gray infrastructure investment, and setting conservation priorities.

Figure 1.0 provides an example of a preliminary Nature-based Solutions suitability map used to support field data collection efforts. The area depicted on Figure 1 displays hazard information (e.g. floodplain) and the numerical identification of potential Nature-based Solutions. These locations were then visited in-person to 1) identify additional opportunity for Nature-based Solutions that may not have been captured during desktop analysis, 2) eliminate Nature-based Solution options that are not feasible or provide adequate efficacy, and 3) evaluate supporting conditions to improve proposed Nature-based Solutions such as species composition (invasives, biodiversity, etc.) access, contamination or soil erosion, and public perception.

Figure 1 – Sample Nature-based Solutions Location Map



Field Data Collection

The field data collection task for an assessment of this type is used to "field-truth" the desktop data review and make modification as necessary to develop the most robust and actionable Nature-based Solutions possible. The use of publicly available data is important to support preliminary decision-making, however an in-person field exercise is necessary to identify additional opportunities for Nature-based Solutions, verify and/or make corrections to perceived solutions and value of Nature-based Solutions, and identify other potential barriers that may exist to successful implementation. The field assessment utilized two field teams to carry out this field data collection exercise. Each team was comprised of an ecologist and a landscape architect that were involved in the desktop assessment and development of preliminary suitability mapping (Figure 1). The project teams visited selected locations within the watershed taking notes and collecting representative photographs and collecting additional data on a wifi/cellular connected tablet device using an ARC GIS Fieldmaps application.

Additional, on-the-ground detail is collected to support the feasibility and value of proposed Nature-based Solutions. Information such as adjacent land use conditions, infrastructure hazards relative to hydrologic connectivity (e.g. crushed culverts or inadequate stormwater drainage systems), micro-terrain, microclimate, species composition, access, public perception, maintenance, contamination or opportunity for fill removal, and compatible use is considered. Table 3.0 provides a summary of categories considered during the field data collection exercise. As described throughout this memorandum, the factors considered during the field exercise are flexible and may be modified based on context or project need.

Table 3.0 – Sample of Natural, Social, and Infrastructural Considerations for Field Data Collection

Categorical Features	Identifiers
Natural Ecosystems	• Presence of invasive species • Habitat improvement along forest edges • Opportunities for pocket forests or tree planting • Opportunity to diversify native species • Restoration opportunity in degraded wetland or waterways. • Stream/Riverbank stabilization
Social Resilience	• Presence of socially vulnerable groups or resources that support socially vulnerable groups (e.g. senior center)
Infrastructural/Built Environment	• Undersized or damaged culverts or stormwater conveyance infrastructure • Opportunities for Stream Daylighting • Opportunities for wetland restoration/creation within known flood prone areas in previously developed locations • Fill removal within proximity to floodplains

Pulling It All Together – Mapping & Analysis

Following the field data collection effort, the project team collaborates on findings by cross-referencing data and collaborating on feasibility and value scoring. The project team adds new Nature-based Solution opportunities to existing suitability maps, and eliminates areas deemed unsuitable for the implementation of Nature-based Solutions. Maps are reviewed with municipal project stakeholders to further refine findings and vet potential barriers to effectiveness or feasibility. Refined suitability maps are used for subsequent field data collection efforts when additional stakeholder information is collected. Final suitability maps are generated for the final project report and public information sessions following the prioritization process which identifies certain locations as better than others for implementation of Nature-based Solutions.

Generalized Recommended Next Steps

The following recommendations are presented as a generalized approach for how to use the information generated from a data collection effort of this type. Each of the recommended next steps will be applied to the Vine Brook Watershed Flood and Urban Heat Island Assessment project.

- Conduct a site walk with the community at select locations to inform and educate the public about the benefits of Nature-based Solutions.
- Display project information (e.g., maps, infographics, ArcGIS story maps) in public locations to educate the public about benefits of Nature-based Solutions
- Present project findings in a public listening session format to educate the public about benefits of Nature-based Solutions.
- Draw upon the information collected as part of this exercise and the preparation of a project summary report to identify and prioritize the implementation of Nature-based Solutions. Identify grant programs that provide financial assistance to implement these types of projects. Apply for grant funding to support community resilience goals.

Table 4.0 - List of Additional Resources

The following data sources may be considered when conducting an assessment like the **Vine Brook Watershed Inland Flood and Urban Heat Island Assessment**.

Data Resource	Description
A Catalogue of Nature-based Solutions for Urban Resilience	This comprehensive report, created as a resource for those aiming to shape urban resilience with nature, provides technical assistance to help support cities and/or urbanized areas identify potentially viable nature-based investments that help cities address resilience challenges.
The Nature Conservancy Resilient Land Mapping Tool	The Nature Conservancy's Resilient and Connected Landscapes tool used for mapping climate-driven resilient lands and connected landscapes and develop and support conservation strategies like carbon storage, road mitigation, and land and water protection. This online mapping tool drawing upon geospatial data that includes geologic setting, landform diversity, local connectedness, regional connectedness, and biological conditions/ecological integrity.

cc:

Appendix C: Nature-based Solution Memos

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	April 6, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: 4th Avenue Public/Private Renovation with NbS Elements

Introduction:

This is provided as an example of how a program of Nature-based Solutions could be applied to a commercial property of this type for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Coordination with DPW (Set new construction standards requiring BMP redevelopment).
- Restoration is coordinated with MVP or other funding source requirements.
- Town, Concom./ land owner approval.
- Appropriate permits are obtained.
- Soil testing for structural feasibility, infiltration and contamination. LSP (Licensed Site Professional) available for unexpected hazards.
- Accessible surface to meet ADA/ or AAB trails requirements. Asses MAAB lighting requirements at certain facilities and asses roadside hazards/ impacts.
- Asses connection to drainage systems structures and waterways where necessary.

Description:
This category covers a number of project options. Included here are basic descriptions for common elements followed by details affecting each project.

A. Infiltration street tree planting: Tree plantings with expanded sub sidewalk soil space, and curb cuts allowing Stormwater infiltration, with connections to overflow drainage often coordinated with pervious pavement.
B. Bio swales: Roadside swales with heavy sediment trap inlets, sub drain storage chambers, and or filter media, paired with flood/drought adapted vegetation.
C. Rain Gardens: Infiltration basins with native flood/drought adapted vegetation.
D. Shade tree & habitat understory or groundcover planting elimination of curbs and depression of grades for infiltration instead of raised turf margins/ shoulders.
E. Catch-basin infiltration trench modification. Adding subgrade infiltration pockets to existing basins.
F. Pervious Parking, and walking areas.
G. Application of Green roofs/ solar/ hi-SRI surfaces, and trellises on building face.

<u>The following are conditions or activities necessary to achieve NbS elements above:</u>

- Evaluation of water table & soil profile for effective establishment, drainage connection(s).
- Site preparation to include erosion control & stockpile/mobilization staging area
- Significant traffic and soil disruption required.
- Connection to existing or new drainage systems.
- Replacement/ amendment of soils, installation of drainage connections.
- Stone entry weirs and pipes for overflow and infiltration control
- Planting of select species Stormwater infiltration species, mulching, watering, and weeding during maintenance period followed by naturalization.
- Plan for construction period and post-construction period environmental monitoring.
- Follow up: Establishment period (2) two years. Establishment period to include biannual removal of invasive

plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to but different than standard roadside drainage and planting features.

- Installation of access control measures where required.
- Moderate soil disruption.
- Site preparation to include erosion control & stockpile/mobilization staging area.
- Installation of pavement and related improvements.

Recommendation:
- Survey true parking utilization. Remove excess parking and install permeable pavement where practical.
- Connect sub grade soil channels between green spaces that are currently broken up by pavement.
- Reduce the amount of maintained lawn, abandoned over-seeded, or planted.
- Create more areas for natural bio swales or rain gardens, convert raised beds to bioswales.
- Assess daylighting the hydrologic connection located to the east of the intersection of 4th Avenue and the Middlesex Turnpike so it can connect to the wetland southwest of 4th Avenue.
- Consider retrofitting buildings with green roofs and walls.
- Assess potential for vertical parking.
- The large green space adjacent to the intersection of 4th Avenue and the Middlesex Turnpike has potential to become a pollinator area with pond, or floodplain storage.
- Assess potential erosion contamination impacts and options for onsite soil management and phyto-remediation.
- Establish standard procedures and requirements for future infrastructure and new development projects to include storm resiliency measures and NbS features.
- Assess opportunities for coordinated habitat enhancement in stormwater and flood storage areas.
- Evaluate cost to value and project life cycle.
- Assess visibility and safety concerns.
- For Parking: Consider volume of regular visitors and turf or naturalized overflow parking of event visitors.
- Consider pervious surface alternatives and benefits.
- Assess potential risks to water quality and contingency for controls.

Budget Factors to consider:
Order of Magnitude estimate for combined NbS sitework operations per Acre: $$50,000-$175,000

Schedule:
- Pre-construction Analysis, Design, and Permitting One year.
- 1-3 months construction
- Establishment care 2 years.

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	April 19, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: **Burlington Mall South Parking Lot Renovation with NbS Elements**

Introduction:

This is provided as an example of how a program of Nature-based Solutions could be applied to a commercial property of this type for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Coordination with DPW (Set new construction standards requiring BMPs for restoration and redevelopment).
- Restoration is coordinated with current MVP best practices and other funding source requirements.
- Land owner lead, Town/ State incentivized, Planning and Conservation Commission approval.
- Appropriate permits are obtained (i.e. Chapter 91 license for navigable waters).
- Soil testing for structural feasibility, infiltration, and contamination. LSP (Licensed Site Professional) available for unexpected hazards.
- Accessible surface to meet ADA or AAB trail requirements.
- Assess MAAB lighting requirements and assess roadside hazards and impacts for ecological controls.
- Assess connection to drainage systems, structures, and waterways where necessary.
- Asses parking projections for future peak utilization with automation and ride share factored in as opposed to current standards.

Description:
This category covers a number of project options. Included here are basic descriptions for common elements followed by details affecting each project.

A. Infiltration street tree planting: Tree plantings with expanded sub sidewalk soil space and curb cuts allowing stormwater infiltration with connections to overflow drainage (often used in conjunction with pervious pavement).
B. Bio swales: Roadside swales with heavy sediment trap inlets, sub drain storage chambers, and filter media paired with flood/drought resistant vegetation.
C. Rain Gardens: Infiltration basins with native flood/drought resistant vegetation.
D. Shade tree and groundcover plantings: Native plantings to mitigate heat islands, create green buffers, and develop a sense of privacy within the green space.
E. Catch-basin infiltration trench modification: Adding subgrade infiltration pockets to existing basins.
F. Pervious parking and walking areas: Installation of pervious pavement, as well as mulch, stone, or vegetated foot paths to increase stormwater infiltration.
G. Stream re-direction and expansion: Re-developing natural shapes and meanders to existing stream systems in order to slow water velocity and improve storm water catchment.

<u>The following are conditions or activities necessary to achieve NbS elements above:</u>

- Evaluation of water table & soil profile for effective establishment, drainage connection(s).
- Site preparation to include erosion control and stockpile/mobilization staging area.
- Traffic redirection and soil disruption required.
- Connection to existing, or new drainage systems.

- Replacement or amendment of soils and the installation of drainage connections.
- Stone entry weirs and pipes for overflow and infiltration control.
- Planting of select stormwater infiltration species.
- Mulching, watering, and weeding during maintenance periods, followed by naturalization.
- Include recreational and educational opportunities.
- Plan for construction period and post-construction period environmental monitoring.
- Establishment period of (2) two years. This would include biannual removal of invasive plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to but different than standard roadside drainage and planting features.
- Installation of access control measures where required.

Recommendation:

- Survey true parking utilization. Remove excess parking and install permeable pavement or green space where practical.
- Connect sub grade soil channels between green spaces that are currently broken up by pavement.
- Expand and redirect portions of Vine Brook to allow for more natural meandering and improved processing of stormwater discharge.
- Assess potential for vertical parking.
- Assess potential erosion contamination impacts and options for onsite soil management and phyto-remediation.
- Establish standard procedures and requirements for future infrastructure and new development projects to include storm resiliency measures and NbS features.
- Assess opportunities for coordinated habitat enhancement in stormwater and flood storage areas.
- Evaluate cost to value and project life cycle.
- Assess visibility and safety concerns.
- Consider pervious surface alternatives and benefits.
- Assess potential risks to water quality and contingency for controls.

Budget Factors to consider:
Order of Magnitude estimate for combined NbS sitework operations per Acre: $90,000-$185,000

Schedule:

- Pre-construction Analysis, Design, and Permitting One year.
- 3-6 months construction
- Establishment care 3 years.

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	April 6, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: **Executive Park Public Green Space Expansion with NbS**

Introduction:

This is provided as an example of how a program of Nature-based Solutions could be applied to a commercial property of this type for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Coordination with DPW (Set new construction standards requiring BMP redevelopment).
- Restoration is coordinated with MVP or other funding source requirements.
- Town, Concom./ land owner approval.
- Appropriate permits are obtained.
- Soil testing for structural feasibility, infiltration and contamination. LSP (Licensed Site Professional) available for unexpected hazards.
- Accessible surface to meet ADA/ or AAB trails requirements. Asses MAAB lighting requirements at certain facilities and asses roadside hazards/ impacts.
- Asses connection to drainage systems structures and waterways where necessary.

Description:
This category covers a number of project options. Included here are basic descriptions for common elements followed by details affecting each project.

A. Infiltration street tree planting: Tree plantings with expanded sub sidewalk soil space, and curb cuts allowing Stormwater infiltration, with connections to overflow drainage often coordinated with pervious pavement.
B. Bio swales: Roadside swales with heavy sediment trap inlets, sub drain storage chambers, and or filter media, paired with flood/drought adapted vegetation.
C. Rain Gardens: Infiltration basins with native flood/drought adapted vegetation.
D. Shade tree & habitat understory or groundcover planting elimination of curbs and depression of grades for infiltration instead of raised turf margins/ shoulders.
E. Catch-basin infiltration trench modification. Adding subgrade infiltration pockets to existing basins.
F. Pervious Parking, and walking areas.
G. Application of Green roofs/ solar/ hi-SRI surfaces, and trellises on building face.
H. Include biannual removal of invasive plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.

Recommendation:

- Evaluate cost to value and project life cycle in material selections.
- Assess removing the current water swale between the parking lot and Vine Brook. Assess if an ecological friendly rain garden or bio swale would be more appropriate.
- Assess potential risks to water quality and contingency for controls.
- Assess for Brook rehabilitation and stream bank slope reduction.
- Assess for invasive species removal.
- Assess opportunities for coordinated habitat enhancement flood storage and storm water controls.
- Assess retrofitting parking lot with permeable pavement, more vertical parking, and green infrastructure.

Consider roof top gardens/green roofs and green walls on current buildings.

- Consider volume of regular visitors and of event visitors for pervious pavement or parking lawn.
- Ensure project budgets and contracts with private companies include sufficient retainage for maintenance and establishment period, and coordination costs for oversight.
- Leverage volunteer efforts, and stackable improvements.
- Evaluation of existing native shrub/tree species for effective naturalization/ introduction.
- Plan for significant soil disruption and applicable erosion controls.
- Installation of permeable pavement and related improvements.
- Site preparation to include erosion control & stockpile/mobilization staging area.
- Planting of select native species, mulching, watering, and weeding during maintenance period.
- Plan for construction period and post-construction period environmental monitoring.
- Site preparation to include invasive vegetation removal.
- Planting per conservation methods and adaptive management
  Follow up: maintenance period 60 days. Establishment period two (2) years. 60-day Maintenance period to include watering twice weekly, hand weeding & replacement of failed plantings. Establishment period to

Budget Factors to consider:
Order of Magnitude estimate for combined NbS sitework operations per Acre: $$50,000-$175,000

Schedule:

- Pre-construction Analysis, Design, and Permitting One year.
- 1-3 months construction
- Establishment care 2 years.

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	February 1, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: **Lexington Street – MSCS Culvert Improvement and Green Space Expansion**

This is provided as an example of how a program of Nature-based Solutions could be applied to a residential neighborhood in areas prone to flooding and where biological function is impaired by traditional residential landscape it offers recommendations for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Flow analysis
- Coordination with DPW (Set new construction standards requiring BMPs for restorations and redevelopment).
- Restoration is coordinated with current MVP best practices and funding source requirements.
- Town, Concom./ abutter notifications.
- Appropriate permits are obtained. Chapter 91 license for navigable waters. See discussion in Section 2.1.1 of report.
- Soil testing for infiltration, contamination, roadside hazards/ impacts.
- Many improvements can be implemented under exempt minor activities in riverfront areas and buffer zones see 310CMR 10

Description:

MSCS Culverts:

- Replacement of standard culvert with one or more MSCS structures such as graduated weirs, widened culverts and wildlife tunnels.
- Reconstruction of associated roadway/ dam.
- Reconstruction of stream channel.
- Reconstruction of abutting wetlands. (see also construction of new wetlands)
- Temporary diversion of flow.
- Evaluation of water table & soil profile for effective infiltration, groundwater monitoring well(s).
- Selection of native plant species adapted to Stormwater flood/ drought conditions.
- Installation of access control measures where required (fenced for standing water).
- Installation of pre-treatment drainage and collection structures.
- Site preparation to include erosion control & stockpile/mobilization staging area
- Significant traffic and soil disruption required.
- Connection to systemic drainage systems. (see roadside BMP's)
- Planting of select species Stormwater infiltration species, mulching, watering, and weeding during maintenance period.
- Plan for construction period and post-construction period environmental monitoring.
- Follow up: Establishment period (2) two years. Establishment period to include biannual removal of invasive plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to standard roadside drainage and planting features.

Upstream BMP's raingardens and bio swales. This category covers a number of project options. Included here are basic

descriptions for common elements followed by details affecting each project.:

A. Infiltration street tree planting: Tree plantings with expanded sub sidewalk soil space, and curb cuts allowing Stormwater infiltration, with connections to overflow drainage often coordinated with pervious pavement.
B. Bio swales: Roadside swales with heavy sediment trap inlets, sub drain storage chambers, and or filter media, paired with flood/drought adapted vegetation.
C. Rain Gardens: Infiltration basins with flood/drought adapted vegetation.
D. Shade tree & Habitat planting instead of turf margins/ shoulders.
E. Catch-basin infiltration trench modification. Adding subgrade infiltration pockets to existing basins.

- Evaluation of water table & soil profile for effective establishment, drainage connection(s).
- Site preparation to include erosion control & stockpile/mobilization staging area
- Significant traffic and soil disruption required.
- Connection to existing or new drainage systems.
- Replacement/ amendment of soils, installation of drainage connections.
- Stone entry weirs and pipes for passive overflow and infiltration control
- Planting of select species Stormwater infiltration species, mulching, watering, and weeding during maintenance period.
- Plan for construction period and post-construction period environmental monitoring.
- Follow up: Establishment period (2) two years. Establishment period to include biannual removal of invasive plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to standard roadside drainage and planting features.

Recommendation:

- Municipality to replace culverts with MSCS culverts (mass stream crossing standards)
- Municipality to develop a community wide IMP Invasive species management plan for individual home owner observation and management strategies.
- Municipality to establish standard procedures and requirements for all infrastructure and new development projects to include storm resiliency measures and NbS features.
- Removal of artificial banks and creating more naturally sloped banks.
- Assess potential erosion contamination impacts for each project.
- Promote green roofs in the neighborhood
- Promote transition to less maintained lawns for more natural green space that attracts more biodiversity and reduces the coefficient of runoff for peak flood reduction.
- Promote a neighborhood effort to monitor and remove debris from in and around the stream while establishing features for biodiversity.
- Promote private bioswales, rain gardens, and habitat features.
- Promote awareness of heat island and flood amplifying landscapes such as impervious un shaded pavement and turf.

Budget Factors to consider:
See individual project modules for assistance in developing and funding projects throughout the neighborhood
Schedule:

- Individual construction projects at this scale are typically completed in a matter of days but require several weeks of planning, design, permitting, and contract bidding. They are also limited by seasonal limitations driving construction to occur in dry summer-fall months. As such implementation of a project should begin the winter before completion is expected.
- Projects involving plantings typically require 2 years' establishment and management to thrive this must be planned for and funded prior to design.

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	April 19, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: **Lord Baron Apartment Complex Renovations with NbS Elements**

Introduction:

This is provided as an example of how a program of Nature-based Solutions could be applied to a commercial property of this type for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Coordination with DPW for public benefit infrastructure support.
- Restoration is coordinated with current MVP best practices and other funding source requirements.
- Landowner lead, Town/ State incentivized, Planning and Conservation Commission approval.
- Appropriate permits are obtained.
- Soil testing for structural feasibility, infiltration, and contamination.
- Accessible surface to meet ADA or AAB trail requirements.
- Assess connection to drainage systems, structures, and waterways where necessary.
- Many improvements can be implemented under exempt minor activities in riverfront areas and buffer zones see 310CMR 10

Description:
This category covers a number of project options. Included here are basic descriptions for common elements followed by details affecting each project.

A. Infiltration street tree planting: Tree plantings with expanded sub sidewalk soil space and curb cuts allowing stormwater infiltration with connections to overflow drainage (often used in conjunction with pervious pavement).
B. Bio swales: Roadside swales with heavy sediment trap inlets, sub drain storage chambers, and filter media paired with flood/drought resistant vegetation.
C. Rain Gardens: Infiltration basins with native flood/drought resistant vegetation.
D. Shade tree and groundcover plantings: Native plantings to mitigate heat islands, create green buffers, and develop a sense of privacy within the green space.
E. Catch-basin infiltration trench modification: Adding subgrade infiltration pockets to existing basins.
F. Pervious parking and walking areas: Installation of pervious pavement, as well as mulch, stone, or vegetated foot paths to increase stormwater infiltration.
G. Drainage re-direction and expansion: Restoring banks of existing drainage systems and creating new systems to increase hydrologic connectivity and storm water catchment.
H. Residential Energy efficiency and production enhancements.

<u>The following are conditions or activities necessary to achieve NbS elements above:</u>

- Evaluation of water table & soil profile for effective establishment, drainage connection(s).
- Site preparation to include erosion control and stockpile/mobilization staging area.
- Soil disruption required.
- Connection to existing, or new drainage systems.
- Replacement or amendment of soils and the installation of drainage connections.

- Stone entry weirs and pipes for overflow and infiltration control.
- Planting of select stormwater infiltration species.
- Mulching, watering, and weeding during maintenance periods, followed by naturalization.
- Plan for construction period and post-construction period environmental monitoring.
- Establishment period of (2) two years. This would include biannual removal of invasive plants and weeds, annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to but different than standard roadside drainage and planting features.
- Installation of access control measures.

Recommendation:

- Survey true parking utilization. Remove excess parking and install permeable pavement overflow parking turf or green space where practical.
- Connect sub grade soil channels between green spaces that are currently broken up by pavement.
- Restore and expand existing drainage systems within the apartment complex to increase hydrologic connectivity and improve storm water catchment.
- Assess potential erosion contamination impacts and options for onsite soil management and phyto-remediation.
- Establish standard procedures and requirements for future infrastructure and new development projects to include storm resiliency measures and NbS features.
- Assess opportunities for coordinated habitat enhancement in stormwater and flood storage areas.
- Evaluate cost to value and project life cycle.
- Assess visibility and safety concerns.
- Consider pervious surface alternatives and benefits.
- Assess potential risks to water quality and include a contingency for controls.

Budget Factors to consider:
Order of Magnitude estimate for combined NbS sitework operations per Acre: $50,000-$100,000

Schedule:

- Pre-construction Analysis, Design, and Permitting One year.
- 1-3 months construction
- Establishment care 2 years.

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300 - 800-288-8123

To:	Burlington Town Planner	**Date:**	April 19, 2022
From:	BSC Group Inc. -Ecological & Landscape	**Proj. No.**	28397.01
Re:	**Climate-Resilient Sites and Ecological Restoration Planning**		

Project Name: **Burlington Water Treatment Facility Repurposing with NbS Elements**

Introduction:

This is provided as an example of how a program of Nature-based Solutions could be applied to a commercial property of this type for enhanced storm resilience and ecological function. It does not represent a specific proposal.

Prerequisites:

- Restoration is coordinated with current MVP best practices and other funding source requirements.
- Town, Planning, Development, and Conservation Commission, approval.
- Appropriate permits are obtained (i.e. Chapter 91 license for navigable waters).
- Soil testing for structural feasibility, infiltration, and contamination.
- Accessible surface to meet ADA or AAB trail requirements.
- Assess MAAB lighting requirements and assess roadside hazards and impacts.
- Assess connection to drainage systems, structures, and waterways where necessary.
- Many improvements can be implemented under exempt minor activities in riverfront areas and buffer zones see 310CMR 10

Description:
This category covers a number of project options. Included here are basic descriptions for common elements followed by details affecting each project.

A. Solar pavilions: Construction of all season public facilities that provide shade and sustainable energy generation that can be used by the public.
B. Wetland replication: Using existing water treatment facility land to expand the current boundaries of the bordering vegetated wetland in order to increase stormwater filtration and storage.
C. Shade tree and groundcover plantings: Native plantings to increase water filtration within the existing treatment facility and to develop a sense of privacy within the public green space.
D. Soil remediation: Removal of water treatment facility infrastructure and establishment of designated foot paths in order to reduce impervious surfaces and mitigate soil compaction.
E. Foot bridge construction: Limiting water treatment facility land to pedestrian foot traffic only, while at the same time allowing for increased hydrologic connectivity and storm water catchment within adjacent wetlands.

<u>The following are conditions or activities necessary to achieve NbS elements above:</u>

- Evaluation of water table & soil profile for effective establishment, drainage connection(s).
- Site preparation to include erosion control and stockpile/mobilization staging area.
- Demolition of existing infrastructure.
- Soil disruption required.
- Amendment of soils and the installation of new drainage connections.
- Planting of select stormwater infiltration species.
- Mulching, watering, and weeding during maintenance periods, followed by naturalization.
- Plan for construction period and post-construction period environmental monitoring.
- Establishment period of (2) two years. This would include biannual removal of invasive plants and weeds,

annual replacement of failed plantings, and watering as needed to naturalize plantings.
- Annual maintenance comparable to but different than standard roadside drainage and planting features.
- Installation of access control measures where required.

Recommendation:
- Assess public recreation and conservation space alternatives for the existing water treatment facility land.
- Removal of existing water treatment facility infrastructure to make room for enhanced public green space and expanded wetland systems within the Town of Burlington's local water supply This may be an opportunity to market funding for developments seeking to offset or enhance their ecological value where onsite space is a limiting factor.
- Assess potential erosion contamination impacts and options for onsite soil management and phyto-remediation.
- Establish standard procedures and requirements for future infrastructure and new development projects to include storm resiliency measures and NbS features.
- Assess opportunities for coordinated habitat enhancement in stormwater and flood storage areas.
- Evaluate cost to value and project life cycle.
- Assess visibility and safety concerns.
- Consider pervious surface alternatives and benefits.
- Assess potential risks to water quality and plan a contingency for controls.

Budget Factors to consider:
Order of Magnitude estimate for combined NbS sitework operations per Acre: $10,000-$20,000 (Infrastructure $100,000-$165,000)

Schedule:
- Pre-construction Analysis, Design, and Permitting One year.
- 3-6 months construction
- Establishment care 2 years.

Appendix D: RMAT Resilience Design Standards Tool Outputs and Techinical Memorandum

RMAT Climate Resilience Design Standards Tool Project Report

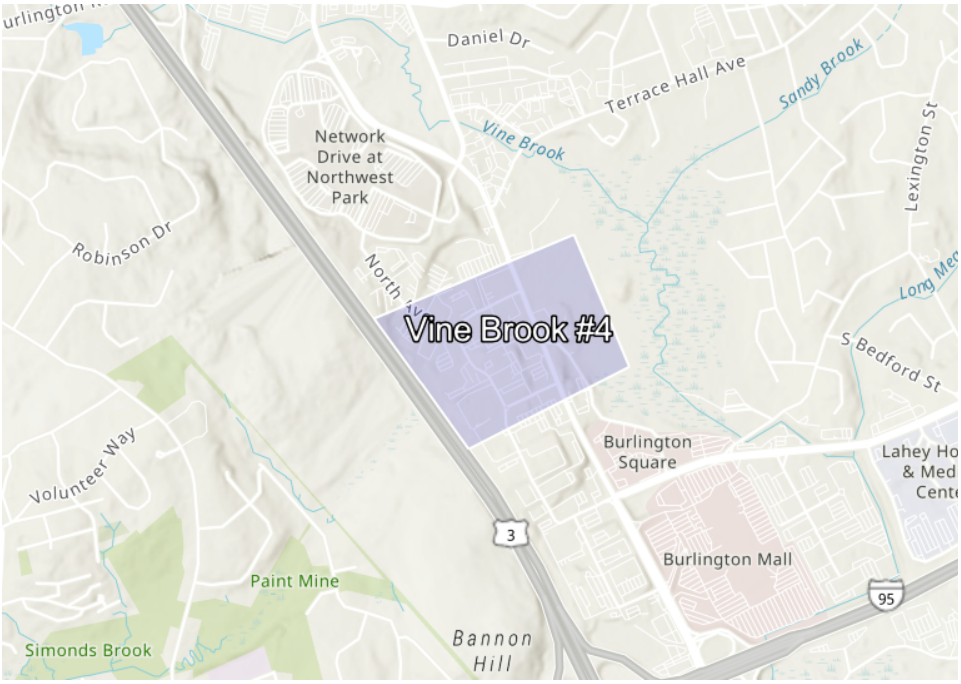
4th Ave.-North Development Complex
Date Created: 5/25/2022 3:04:04 PM
Created By: drinaldi@bscgroup.com
Download

Project Summary

Link to Project

Estimated Construction Cost: $175000.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: Yes

Ecosystem Benefits	Scores
Project Score	Moderate
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	Moderate Exposure



Asset Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Vine Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Vine Brook					
Extreme Precipitation					
Vine Brook	2050				Tier 2
Extreme Heat					
Vine Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No increase to impervious area

- Existing impervious area of the project site is between 10% and 50%

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 500ft of a waterbody and less than 20ft above the waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is between 10% and 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Vine Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Vine Brook — Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Vine Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	4th Ave.-North Development Complex
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$175,000
Who is the Submitting Entity?	City/Town Burlington John Keeley (jkeeley@burlington.org)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	The proposed project aims to address flooding and disjointed green space. The following Nature Based Solutions are proposed for this area: Create and connect green spaces throughout the development. Adding additional native shrubs and trees to aid with flood storage and canopy coverage. Assess daylighting the hydrologic connection located to the east of the intersection of 4th Avenue and the Middlesex Turnpike. Assess development for potential Massachusetts Stream Crossing Standards culvert improvement for flood mitigation and ecological connectivity.

Project Submission Comments:

Project Ecosystem Benefits

Factors Influencing Output

- ✓ Project provides flood protection through nature-based solutions
- ✓ Project reduces storm damage
- ✓ Project recharges groundwater
- ✓ Project filters stormwater using green infrastructure
- ✓ Project improves water quality

Factors to Improve Output

- ✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
- ✓ Incorporate nature-based solutions that sequester carbon carbon
- ✓ Increase biodiversity, protect critical habitat for species, manage invasive populations, and/or provide connectivity to other habitats
- ✓ Incorporate vegetation that provides pollinator habitat
- ✓ Identify opportunities to remediate existing sources of pollution
- ✓ Provide opportunities for passive and/or active recreation through open space
- ✓ Increase plants, trees, and/or other vegetation to provide oxygen production
- ✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
- ✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits	
Provides flood protection through nature-based solutions	Yes
Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Maybe
Provides oxygen production	Maybe
Improves air quality	Maybe
Prevents pollution	No
Remediates existing sources of pollution	Maybe
Protects fisheries, wildlife, and plant habitat	Maybe
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Maybe
Project Climate Exposure	
Is the primary purpose of this project ecological restoration?	No
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No
Project Assets	
Asset: Vine Brook	
Asset Type: Wetland Resource Area - Inland	
Asset Sub-Type: Riverfront Area	
Construction Type: Restoration or enhancement	
Construction Year: 2024	
Useful Life: 20	

Report Comments

N/A

RMAT Climate Resilience Design Standards Tool Project Report

Burlington Mall South
Date Created: 5/25/2022 1:41:13 PM Created By: drinaldi@bscgroup.com Download

Project Summary

Link to Project

Estimated Construction Cost: $185000.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: No

Ecosystem Benefits	Scores
Project Score	High
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	High Exposure

Asset Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Vine Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Vine Brook					
Extreme Precipitation					
Vine Brook	2050				Tier 2
Extreme Heat					
Vine Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- Existing impervious area of the project site is greater than 50%

- No increase to impervious area

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 100ft of a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "High Exposure" because of the following:

- Existing impervious area of the project site is greater than 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Vine Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Vine Brook — Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Vine Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	Burlington Mall South
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$185,000
Who is the Submitting Entity?	City/Town Burlington Person (person@burlingtonma.gov)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	This proposed project aims to address flooding, urban heat islands, lack of ecological biodiversity, and lack of green community spaces that promote healthy life styles. The goal is to encourage public interaction with natural landscapes, while at the same time addressing the ecological challenges outlined by the City of Burlington. The following NbS are proposed for this area: Replacement of existing pavement with pervious surfaces including rain gardens, catch basins, and pervious pavement. Native plantings and green buffer zones Expansion and re-direction of Vine Brook Interactive green community space with interpretive features
Project Submission Comments:	

Project Ecosystem Benefits

Factors Influencing Output

✓ This is an ecological restoration project
✓ Project provides flood protection through nature-based solutions
✓ Project reduces storm damage
✓ Project recharges groundwater
✓ Project filters stormwater using green infrastructure
✓ Project improves water quality
✓ Project remediates existing sources of pollution
✓ Project provides cultural resources/education

Factors to Improve Output

✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
✓ Incorporate nature-based solutions that sequester carbon carbon
✓ Increase biodiversity, protect critical habitat for species, manage invasive populations, and/or provide connectivity to other habitats
✓ Incorporate vegetation that provides pollinator habitat
✓ Provide opportunities for passive and/or active recreation through open space
✓ Increase plants, trees, and/or other vegetation to provide oxygen production

✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions

Is the primary purpose of this project ecological restoration?
Yes

Project Benefits	
Provides flood protection through nature-based solutions	Yes
Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Maybe
Provides oxygen production	Maybe
Improves air quality	Maybe
Prevents pollution	No
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Maybe
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Yes

Project Climate Exposure	
Is the primary purpose of this project ecological restoration?	Yes
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No

Project Assets

Asset: Vine Brook
Asset Type: Wetland Resource Area - Inland
Asset Sub-Type: Riverfront Area
Construction Type: Restoration or enhancement
Construction Year: 2024
Useful Life: 20

Report Comments

N/A

RMAT Climate Resilience Design Standards Tool Project Report

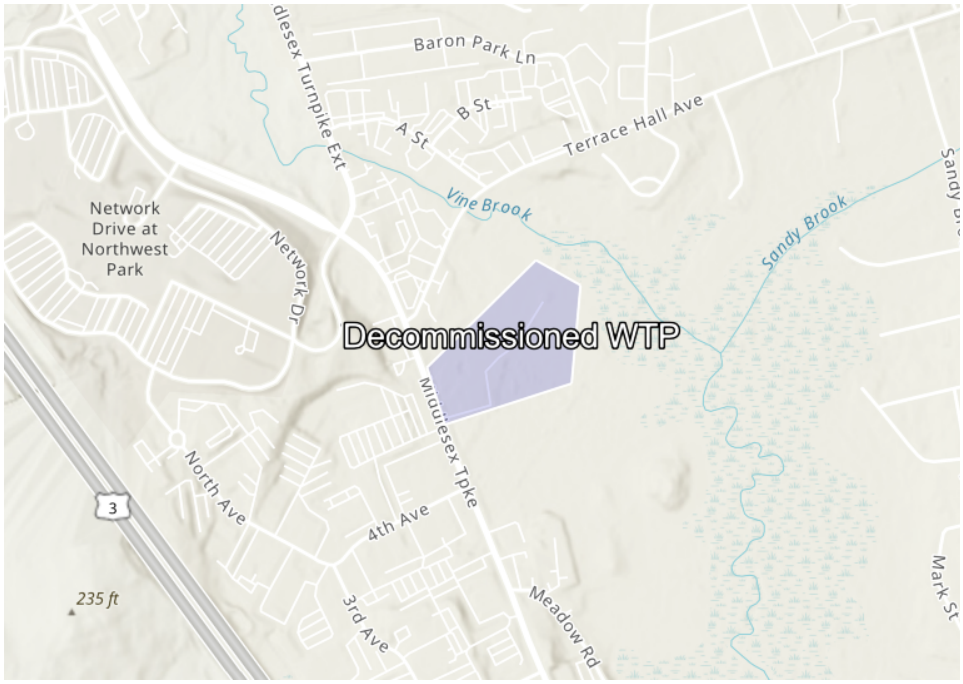
Decommissioned WTP
Date Created: 5/25/2022 3:41:54 PM Created By: drinaldi@bscgroup.com Download

Project Summary

Link to Project

Estimated Construction Cost: $185000.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: Yes

Ecosystem Benefits	Scores
Project Score	Moderate
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	Moderate Exposure



Asset Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Vine Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Vine Brook					
Extreme Precipitation					
Vine Brook	2050				Tier 2
Extreme Heat					
Vine Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No increase to impervious area

- Existing impervious area of the project site is less than 10%

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 500ft of a waterbody and less than 20ft above the waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Between 10% and 40% of the existing project site has canopy cover
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Vine Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Vine Brook — Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Vine Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	Decommissioned WTP
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$185,000
Who is the Submitting Entity?	City/Town Burlington John Keeley (jkeeley@burlington.org)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	This proposed project aims to address flooding and existing degraded green space. The following NbS are proposed for this area: Replacement of paved roads and concrete walkways with pervious surfaces including gravel, infiltration trenches, and pervious pavement. Amending compacted soils within current green space through rain garden installations. Shading and habitat enhancement plantings.

Project Submission Comments:

Project Ecosystem Benefits

Factors Influencing Output

✓ Project provides flood protection through nature-based solutions
✓ Project reduces storm damage
✓ Project recharges groundwater
✓ Project filters stormwater using green infrastructure
✓ Project improves water quality
✓ Project protects fisheries, wildlife, and plant habitat

Factors to Improve Output

✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
✓ Incorporate nature-based solutions that sequester carbon carbon
✓ Incorporate vegetation that provides pollinator habitat
✓ Identify opportunities to remediate existing sources of pollution
✓ Provide opportunities for passive and/or active recreation through open space
✓ Increase plants, trees, and/or other vegetation to provide oxygen production
✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	Yes
Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Maybe
Provides oxygen production	Maybe
Improves air quality	Maybe
Prevents pollution	No
Remediates existing sources of pollution	Maybe
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Maybe
Project Climate Exposure	
Is the primary purpose of this project ecological restoration?	No
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No
Project Assets	

Asset: Vine Brook
Asset Type: Wetland Resource Area - Inland
Asset Sub-Type: Riverfront Area
Construction Type: Restoration or enhancement
Construction Year: 2024
Useful Life: 20

Report Comments

N/A

RMAT Climate Resilience Design Standards Tool Project Report

Lexington Street-Neighborhood South
Date Created: 5/25/2022 2:20:15 PM
Created By: drinaldi@bscgroup.com
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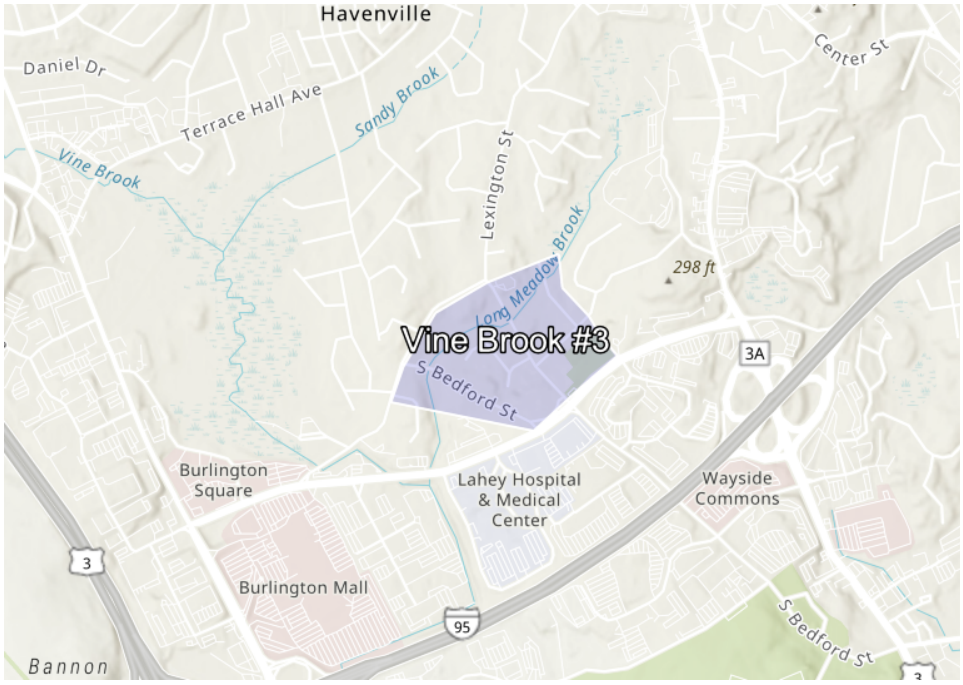
Project Summary

Link to Project

Estimated Construction Cost: $0.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: Yes

Ecosystem Benefits	Scores
Project Score	Moderate
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	Moderate Exposure



Asset Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Long Meadow Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Long Meadow Brook					
Extreme Precipitation					
Long Meadow Brook	2050				Tier 2
Extreme Heat					
Long Meadow Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- No increase to impervious area

- Existing impervious area of the project site is between 10% and 50%

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 100ft of a waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "Moderate Exposure" because of the following:

- Existing impervious area of the project site is between 10% and 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- Located within 100 ft of existing water body
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Long Meadow Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Long Meadow Brook — Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Long Meadow Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	Lexington Street-Neighborhood South
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$0
Who is the Submitting Entity?	City/Town Burlington John Keeley (jkeeley@burlington.org)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	This proposed project aims to address urban flooding, invasive species, and wildlife habitat enhancements. The following are Nature Based Solutions proposed for this area: Investment in replacing all culverts with MSCS culverts. Including the removal of artificial banks and slopes at the at the mouths of the culverts to ecologically natural banks and slopes. MSCS culverts will also allow for enhanced wildlife passage. Perform an invasive plant species assessment and replace invasive plants with native plants. Perform wetland restoration activities where there were historically wetlands through a photo study. Invasive species management along banks of Long Meadow Brook. Installation of roadside raingardens and bioswales along the public roadways Long Meadow Brook passes under. NBS lighting along the street to conserve power and reduce light pollution.
Project Submission Comments:	

Project Ecosystem Benefits

Factors Influencing Output

✓ Project provides flood protection through nature-based solutions
✓ Project reduces storm damage
✓ Project recharges groundwater
✓ Project filters stormwater using green infrastructure
✓ Project improves water quality

Factors to Improve Output

✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
✓ Incorporate nature-based solutions that sequester carbon carbon
✓ Increase biodiversity, protect critical habitat for species, manage invasive populations, and/or provide connectivity to other habitats
✓ Incorporate vegetation that provides pollinator habitat
✓ Identify opportunities to remediate existing sources of pollution
✓ Provide opportunities for passive and/or active recreation through open space

✓ Increase plants, trees, and/or other vegetation to provide oxygen production
✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions
✓ Incorporate education and/or protect cultural resources as part of your project

Is the primary purpose of this project ecological restoration?

No

Project Benefits	
Provides flood protection through nature-based solutions	Yes
Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Maybe
Provides oxygen production	Maybe
Improves air quality	Maybe
Prevents pollution	No
Remediates existing sources of pollution	Maybe
Protects fisheries, wildlife, and plant habitat	Maybe
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Maybe
Project Climate Exposure	
Is the primary purpose of this project ecological restoration?	No
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No
Project Assets	

Asset: Long Meadow Brook
Asset Type: Wetland Resource Area - Inland
Asset Sub-Type: Riverfront Area
Construction Type: Restoration or enhancement
Construction Year: 2024
Useful Life: 20

Report Comments

N/A

RMAT Climate Resilience Design Standards Tool Project Report

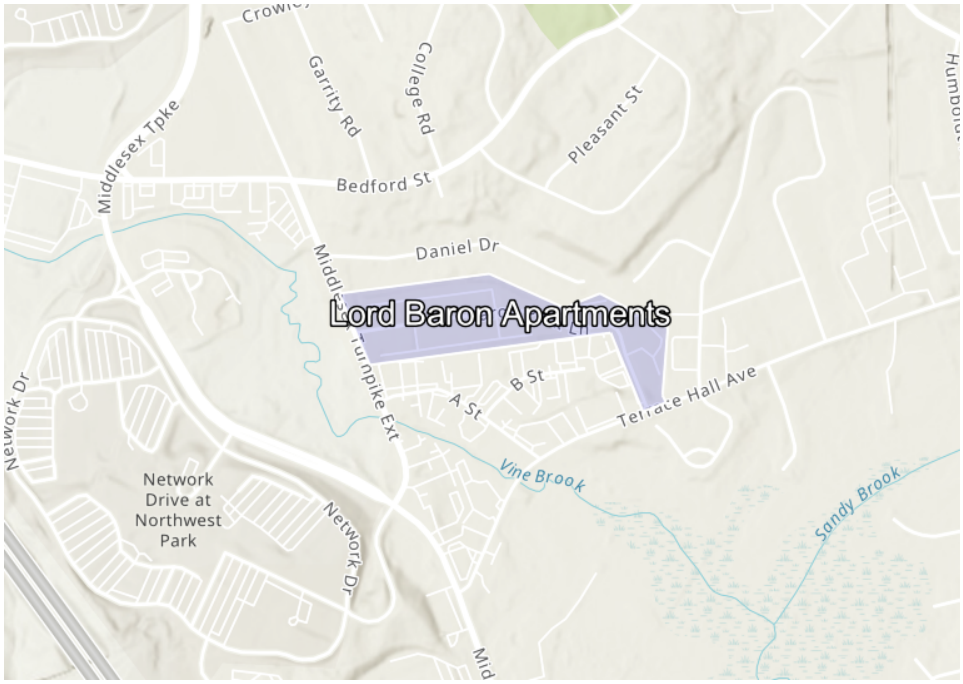
Lord Baron Apartments
Date Created: 5/25/2022 5:45:42 PM
Created By: drinaldi@bscgroup.com
Download

Project Summary

Link to Project

Estimated Construction Cost: $100000.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: Yes

Ecosystem Benefits	Scores
Project Score	Moderate
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	High Exposure



Asset Summary

Number of Assets: 2

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Roads and Walks	Low Risk	High Risk	High Risk	High Risk
Vine Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Roads and Walks					
Vine Brook					
Extreme Precipitation					
Roads and Walks	2050				Tier 2
Vine Brook	2050				Tier 2
Extreme Heat					
Roads and Walks	2050		50th		Tier 2
Vine Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- Existing impervious area of the project site is greater than 50%
- No increase to impervious area

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 500ft of a waterbody and less than 20ft above the waterbody
- Project is not likely susceptible to riverine erosion

Extreme Heat

This project received a "High Exposure" because of the following:

- Not located within 100 ft of existing water body
- Existing impervious area of the project site is greater than 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Roads and Walks
Primary asset criticality factors influencing risk ratings for this asset:

- Asset can be inaccessible/inoperable more than a week after natural hazard event without consequences
- Loss/inoperability of the asset would have impacts limited to the location of infrastructure only
- Inoperability of the asset would not be expected to result in injuries
- Inoperability may moderately impact other facilities, assets, or buildings, but is not expected to affect their ability to operate
- There are no hazardous materials in the asset

Asset - Vine Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Roads and Walks — Infrastructure

Sea Level Rise/Storm Surge — Low Risk

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation — High Risk

Target Planning Horizon: 2050
Return Period: No Return Period

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Roads and Walks	2050	0-Year (%)	N/A	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: No

Extreme Heat High Risk

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: Yes
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: Yes
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: Yes
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Asset: Vine Brook Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Vine Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	Lord Baron Apartments
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$100,000
Who is the Submitting Entity?	City/Town Burlington John Keeley (jkeeley@burlington.org)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	This proposed project aims to address flooding, urban heat islands, and existing degraded green space. The following NbS are proposed for this area: Replacement of paved roads and concrete walkways with pervious surfaces including gravel, infiltration trenches, and pervious pavement. Amending compacted soils within current green space through rain garden installations. Day lighting streams and installation of underground storm water catchment features to enhance hydrologic connectivity. Shading enhancement through solar pavilion installations.

Project Submission Comments:

Project Ecosystem Benefits

Factors Influencing Output

✓ Project provides flood protection through nature-based solutions
✓ Project reduces storm damage
✓ Project recharges groundwater
✓ Project filters stormwater using green infrastructure
✓ Project improves water quality
✓ Project provides cultural resources/education

Factors to Improve Output

✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
✓ Incorporate nature-based solutions that sequester carbon carbon
✓ Increase biodiversity, protect critical habitat for species, manage invasive populations, and/or provide connectivity to other habitats
✓ Incorporate vegetation that provides pollinator habitat
✓ Identify opportunities to remediate existing sources of pollution
✓ Provide opportunities for passive and/or active recreation through open space
✓ Increase plants, trees, and/or other vegetation to provide oxygen production
✓ Mitigate atmospheric greenhouse gas concentrations and other toxic air pollutants through nature-based solutions

Is the primary purpose of this project ecological restoration?

No

Project Benefits

Provides flood protection through nature-based solutions	Yes

Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Maybe
Provides oxygen production	Maybe
Improves air quality	Maybe
Prevents pollution	No
Remediates existing sources of pollution	Maybe
Protects fisheries, wildlife, and plant habitat	Maybe
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Yes

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	No
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No

Project Assets

Asset: Roads and Walks
Asset Type: Other
Asset Sub-Type: Other
Construction Type: Major Repair/Retrofit
Construction Year: 2024
Useful Life: 20

Identify the length of time the asset can be inaccessible/inoperable without significant consequences.
Infrastructure may be inaccessible/inoperable more than a week after natural hazard event without consequences.

Identify the geographic area directly affected by permanent loss or significant inoperability of the infrastructure.
Impacts limited to location of infrastructure only

Identify the population directly served that would be affected by the permanent loss or significant inoperability of the infrastructure.
Less than 5,000 people

Identify if the infrastructure provides services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.
The infrastructure does not provide services to populations that reside within Environmental Justice neighborhoods or climate vulnerable populations.

Will the infrastructure reduce the risk of flooding?
Yes

If the infrastructure became inoperable for longer than acceptable in Question 1, how, if at all, would it be expected to impact people's health and safety?
Inoperability of the infrastructure would not be expected to result in injuries

If there are hazardous materials in your infrastructure, what are the extents of impacts related to spills/releases of these materials?
There are no hazardous materials in the infrastructure

If the infrastructure became inoperable for longer than acceptable in Question 1, what are the impacts on other facilities, assets, and/or infrastructure?
Moderate – Inoperability may impact other facilities, assets, or buildings, but cascading impacts do not affect the ability of other facilities, assets, or buildings to operate

If the infrastructure was damaged beyond repair, how much would it approximately cost to replace?
Less than $10 million

Does the infrastructure function as an evacuation route during emergencies? This question only applies to roadway projects.
No

If the infrastructure became inoperable for longer than acceptable in Question 1, what are the environmental impacts related to natural resources?
No impact on surrounding natural resources is expected

If the infrastructure became inoperable for longer than acceptable in Question 1, what are the impacts to government services (i.e. the infrastructure is not able to serve or operate its intended users or function)?
Loss of infrastructure is not expected to reduce the ability to maintain government services

What are the impacts to loss of confidence in government resulting from loss of infrastructure functionality (i.e. the infrastructure asset is not able to serve or operate its intended users or function)?
No Impact

Asset: Vine Brook
Asset Type: Wetland Resource Area - Inland
Asset Sub-Type: Riverfront Area
Construction Type: Restoration or enhancement
Construction Year: 2024
Useful Life: 20

Report Comments

N/A

RMAT Climate Resilience Design Standards Tool Project Report

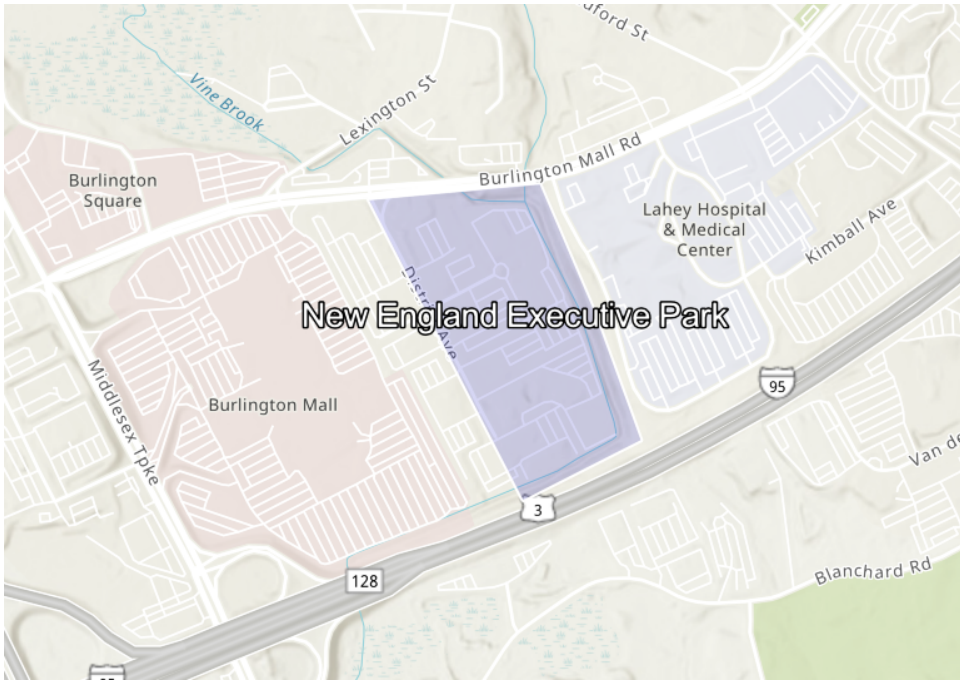
New England Executive Park
Date Created: 5/25/2022 2:09:47 PM Created By: drinaldi@bscgroup.com Download

Project Summary

Link to Project

Estimated Construction Cost: $175000.00
End of Life Year: 2044
Project within mapped Environmental Justice neighborhood: No

Ecosystem Benefits	Scores
Project Score	High
Exposure	**Scores**
Sea Level Rise/Storm Surge	Not Exposed
Extreme Precipitation - Urban Flooding	High Exposure
Extreme Precipitation - Riverine Flooding	High Exposure
Extreme Heat	High Exposure



Asset Summary

Number of Assets: 1

Asset Risk	Sea Level Rise/Storm Surge	Extreme Precipitation - Urban Flooding	Extreme Precipitation - Riverine Flooding	Extreme Heat
Vine Brook	—— Natural Resource project assets do not receive a preliminary climate risk rating. ——			

Project Outputs

	Target Planning Horizon	Intermediate Planning Horizon	Percentile	Return Period	Tier
Sea Level Rise/Storm Surge					
Vine Brook					
Extreme Precipitation					
Vine Brook	2050				Tier 2
Extreme Heat					
Vine Brook	2050		50th		Tier 2

Scoring Rationale - Exposure

Sea Level Rise/Storm Surge

This project received a "Not Exposed" because of the following:

- Not located within the predicted mean high water shoreline by 2030
- No historic coastal flooding at project site
- Not located within the Massachusetts Coast Flood Risk Model (MC-FRM)

Extreme Precipitation - Urban Flooding

This project received a "High Exposure" because of the following:

- Historic flooding at the project site
- Maximum annual daily rainfall exceeds 10 inches within the overall project's useful life
- Existing impervious area of the project site is greater than 50%

- No increase to impervious area

Extreme Precipitation - Riverine Flooding

This project received a "High Exposure" because of the following:

- Project site has a history of riverine flooding
- Part of the project is within a mapped FEMA floodplain, outside of the Massachusetts Coast Flood Risk Model (MC-FRM)
- Part of the project is within 100ft of a waterbody
- Project is potentially susceptible to riverine erosion

Extreme Heat

This project received a "High Exposure" because of the following:

- Not located within 100 ft of existing water body
- Existing impervious area of the project site is greater than 50%
- 10 to 30 day increase in days over 90 deg. F within project's useful life
- No increase to the impervious area of the project site
- No tree removal

Scoring Rationale - Asset Risk Scoring

Asset - Vine Brook
Primary asset criticality factors influencing risk ratings for this asset:

No score available

Project Design Standards Output

Asset: Vine Brook — Natural Resources

Sea Level Rise/Storm Surge

Applicable Design Criteria

Projected Tidal Datums: No
Projected Water Surface Elevation: No
Projected Wave Action Water Elevation: No
Projected Wave Heights: No
Projected Duration of Flooding: No
Projected Design Flood Velocity: No
Projected Scour & Erosion: No

Extreme Precipitation

Target Planning Horizon: 2050

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Total Precipitation Depth & Peak Intensity for 24-hr Design Storms: Yes

Asset Name	Recommended Planning Horizon	Recommended Return Period (Design Storm)	Projected 24-hr Total Precipitation Depth (inches)	Step-by-Step Methodology for Peak Intensity
Vine Brook	2050	25-Year (4%)	8	Downloadable Methodology PDF

Limitations: While precipitation depth is useful for project planning and design, rainfall distribution and peak intensity of the design storm is recommended to also be considered. Lower-intensity, longer-duration storms allow time for infiltration and reduce the load on the infrastructure system over the duration of the storm. Higher-intensity, shorter-duration storms often have higher runoff volumes because the water does not have enough time to infiltrate and infrastructure systems (e.g., catch basins) and may overflow or back up during such storms. In the Northeast, short -duration high intensity rain events are becoming more frequent, and there is often little early warning for these events, making it difficult to plan operationally. These events can result in the rapid inundation of the asset project location. Design should consider both short- and long-duration precipitation events and how they may impact the asset.

The precipitation values provided by this Tool (version 1) are recommended to inform planning and design, but they do not guarantee that the asset will be protected from or be able to withstand an extreme precipitation event. The planning, design, and review guidance accompanying these values is general and projects are encouraged to do their own due diligence to understand the vulnerability of their asset.

Projected Riverine Peak Discharge & Peak Flood Elevation: Yes

Extreme Heat

Target Planning Horizon: 2050
Percentile: 50th Percentile

Applicable Design Criteria

Tiered Methodology: Tier 2

Projected Annual/Summer/Winter Average Temperatures: Yes
Projected Heat Index: No
Projected Growing Degree Days: No
Projected Days Per Year With Max Temp > 95°F, >90°F, <32°F: No
Projected Number of Heat Waves Per Year & Average Heat Wave Duration: No
Projected Cooling Degree Days & Heating Degree Days (base = 65°F): No

Project Inputs

Core Project Information

Name:	New England Executive Park
Given the expected useful life of the project, through what year do you estimate the project to last (i.e. before a major reconstruction/renovation)?	2044
Location of Project:	Burlington
Estimated Capital Cost:	$175,000
Who is the Submitting Entity?	City/Town Burlington John Keeley (jkeeley@burlington.org)
Is this project identified as a priority project in the Municipal Vulnerability Preparedness (MVP) plan or the local or regional Hazard Mitigation Plan (HMP)?	Yes
Is this project being submitted as part of a state grant application?	No
Which grant program?	
What stage are you in your project lifecycle?	Pre-Planning
Is climate resiliency a core objective of this project?	Yes
Is this project being submitted as part of the state capital planning process?	No
Is this project being submitted as part of a regulatory review process or permitting?	No
Brief Project Description:	The proposed project aims to address urban heat island, invasive plant species, and stream restoration. The following Nature Based Solutions are proposed for this area: Perform stream rehabilitation including changing the stream from a straight line to a more natural meandering stream. Create backwater wetlands along the stream that connect to the existing wetland between the Burlington Mall and the Executive Park. Remove adjacent parking area to allow for an expanded green space. Retrofitting the surrounding buildings with green roofs and walls will reduce the heat sink capacity of the Executive Park. Assess parking utilization and scale for additional drainage BMP's high reflective pavements and shade trees.
Project Submission Comments:	

Project Ecosystem Benefits

Factors Influencing Output

✓ This is an ecological restoration project
✓ Project provides flood protection through nature-based solutions
✓ Project reduces storm damage
✓ Project recharges groundwater
✓ Project filters stormwater using green infrastructure
✓ Project improves water quality
✓ Project enables carbon sequestration
✓ Project protects fisheries, wildlife, and plant habitat
✓ Project remediates existing sources of pollution
✓ Project improves air quality
✓ Project provides cultural resources/education

Factors to Improve Output

✓ Protect public water supply by reducing the risk of contamination, pollution, and/or runoff of surface and groundwater sources used for human consumption
✓ Incorporate vegetation that provides pollinator habitat

✓ Provide opportunities for passive and/or active recreation through open space
✓ Increase plants, trees, and/or other vegetation to provide oxygen production

Is the primary purpose of this project ecological restoration?

Yes

Project Benefits

Provides flood protection through nature-based solutions	Yes
Reduces storm damage	Yes
Recharges groundwater	Yes
Protects public water supply	Maybe
Filters stormwater using green infrastructure	Yes
Improves water quality	Yes
Promotes decarbonization	No
Enables carbon sequestration	Yes
Provides oxygen production	Maybe
Improves air quality	Yes
Prevents pollution	No
Remediates existing sources of pollution	Yes
Protects fisheries, wildlife, and plant habitat	Yes
Protects land containing shellfish	No
Provides pollinator habitat	Maybe
Provides recreation	Maybe
Provides cultural resources/education	Yes

Project Climate Exposure

Is the primary purpose of this project ecological restoration?	Yes
Does the project site have a history of coastal flooding?	No
Does the project site have a history of flooding during extreme precipitation events (unrelated to water/sewer damages)?	Yes
Does the project site have a history of riverine flooding?	Yes
Does the project result in a net increase in impervious area of the site?	No
Are existing trees being removed as part of the proposed project?	No

Project Assets

Asset: Vine Brook
Asset Type: Wetland Resource Area - Inland
Asset Sub-Type: Riverfront Area
Construction Type: Restoration or enhancement
Construction Year: 2024
Useful Life: 20

Report Comments

N/A

BSC GROUP

MEMORANDUM

803 SUMMER STREET, BOSTON, MA 02127 - www.bscgroup.com
TEL 617-896-4300

To:	Vine Brook Climate Resilience Project	**Date:**	May 31, 2022
From:	Dominic Rinaldi, PE	**Proj. No.**	28397.01
Re:	RMAT Summary and Technical Memorandum Nature-based Solutions for the Vine Brook Watershed		

As part of the pre-planning work for the Nature-based Solutions (NBS) for the Vine Brook Watershed project, BSC Group (BSC) is utilizing the Climate Resilience Design Standards & Guidelines (the Guidelines) developed for the Resilient Massachusetts Action Team (RMAT). This work includes entering project information for each of six potential NBS sites into the Climate Resilience Design Standards Tool (the Tool), analyzing the Tool's output, and determining the potential impacts and design standards required for each site to meet the Guidelines. The following sites have been analyzed using the Tool:

- Location 1 – Burlington Mall South
- Location 2 – Lord Baron Apartments
- Location 3 – Decommissioned Water Treatment Facility
- Location 4 – 4th Avenue North Development Complex
- Location 5 – Lexington Street Neighborhood South
- Location 6 – New England Executive Park

This memorandum summarizes the results and recommendations for each site and details the impacts the Guidelines will have on future design of the Project.

RMAT Site Assessments and Results

Location 1 – Burlington Mall South

This proposed project aims to address flooding, urban heat islands, lack of ecological biodiversity, and lack of green community spaces that promote healthy lifestyles. The goal is to encourage public interaction with natural landscapes, while at the same time addressing the ecological challenges outlined by the City of Burlington. The following NBS are proposed for this area:

- Replacement of existing pavement with pervious surfaces including rain gardens, catch basins, and pervious pavement.
- Native plantings and green buffer zones
- Expansion and re-direction of Vine Brook
- Interactive green community space with interpretive features

The Tool was utilized to assess the Project's impact on Vine Brook. The Site received a score of High on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding, Extreme Precipitation – Riverine Flooding, and Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding, high potential maximum daily rainfall, and the large amount of impervious surface at the site. Its High Exposure in Riverine Flooding score results from the site's history of riverine flooding, its partial location within a FEMA floodplain, and its location within 100-feet of a waterbody. The High Exposure for Extreme Heat results from the large amount of impervious surface on site and the expected increase in days exceeding 90F over the project's expected useful life at this Site. Based on the known conditions at the Site, none of these results are unexpected. The Site received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat.

See the Guidelines at
https://eea-nescaum-dataservices-assets-prd.s3.amazonaws.com/cms/GUIDELINES/20210401Section3ClimateResilienceDesignStandardsOverview.pdf
for more details on Target Planning Horizons, Tiers, and Recommended Percentiles.

Location 2 – Lord Baron Apartments

This proposed project aims to address flooding, urban heat islands, and existing degraded green space. The following NBS are proposed for this area:

- Replacement of paved roads and concrete walkways with pervious surfaces including gravel, infiltration trenches, and pervious pavement.
- Amending compacted soils within current green space through rain garden installations.
- Day lighting streams and installation of underground storm water catchment features to enhance hydrologic connectivity.
- Shading enhancement through solar pavilion installations.

The Tool was utilized to assess the Project's impact on both Vine Brook and Sidewalks and Driveways at the Site. The Site received a score of Moderate on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding, Extreme Precipitation – Riverine Flooding, and Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding, high potential maximum daily rainfall, and the large amount of impervious surface at the site. Its High Exposure in Riverine Flooding score results from the site's history of riverine flooding and its partial location within a FEMA floodplain. The High Exposure for Extreme Heat results from the large amount of impervious surface on site and the expected increase in days exceeding 90F over the project's expected useful life at this Site. As this Site includes an asset that is not a natural resource (Sidewalks and Driveways), the Tool also analyzed the risk for this asset. The Site was determined to have a high risk for Urban and Riverine Flooding and Extreme Heat. Based on the known conditions at the Site, none of these results are unexpected. Both the Vine Brook and the Sidewalks and Driveways received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat for both assets.

Location 3 – Decommissioned Water Treatment Facility

The proposed project aims to address flooding and disjointed green space. The following NBS are proposed for this area:

- Create and connect green spaces throughout the development. Adding additional native shrubs and trees to aid with flood storage and canopy coverage.
- Assess daylighting the hydrologic connection located to the east of the intersection of 4th Avenue and the Middlesex Turnpike.
- Assess development for potential Massachusetts Stream Crossing Standards culvert improvement for flood mitigation and ecological connectivity.

The Tool was utilized to assess the Project's impact on Vine Brook. The Site received a score of Moderate on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding and Extreme Precipitation – Riverine Flooding. This Site shows Moderate Exposure for Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding and high potential maximum daily rainfall. Its High Exposure in Riverine Flooding score results from the site's history of riverine flooding, its partial location within a FEMA floodplain, and its location within 500-feet of a waterbody and less than 20-feet above the waterbody. The Moderate Exposure for Extreme Heat results from the site having between 10% and 40% canopy cover and the expected increase in days exceeding 90F over the project's expected useful life at this Site. Based on the known conditions at the Site, none of these results are unexpected. The Site received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat.

Location 4 – 4th Avenue North Development Complex

This proposed project aims to address flooding and existing degraded green space. The following NBS are proposed for this area:

- Replacement of paved roads and concrete walkways with pervious surfaces including gravel, infiltration trenches, and pervious pavement.
- Amending compacted soils within current green space through rain garden installations.

- Shading and habitat enhancement plantings.

The Tool was utilized to assess the Project's impact on Vine Brook. The Site received a score of Moderate on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding and Extreme Precipitation – Riverine Flooding. This Site shows Moderate Exposure for Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding and high potential maximum daily rainfall. Its High Exposure in Riverine Flooding score results from the site's history of riverine flooding, its partial location within a FEMA floodplain, and its location within 500-feet of a waterbody and less than 20-feet above the waterbody. The Moderate Exposure for Extreme Heat results from the site being between 10% and 50% impervious surfaces and the expected increase in days exceeding 90F over the project's expected useful life at this Site. Based on the known conditions at the Site, none of these results are unexpected. The Site received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat.

Location 5 – Lexington Street Neighborhood South

This proposed project aims to address urban flooding, invasive species, and wildlife habitat enhancements. The following are NBS proposed for this area:

- Investment in replacing all culverts with MSCS culverts. Including the removal of artificial banks and slopes at the at the mouths of the culverts to ecologically natural banks and slopes. MSCS culverts will also allow for enhanced wildlife passage.
- Perform an invasive plant species assessment and replace invasive plants with native plants.
- Perform wetland restoration activities where there were historically wetlands through a photo study.
- Invasive species management along banks of Long Meadow Brook.
- Installation of roadside raingardens and bioswales along the public roadways Long Meadow Brook passes under.
- NBS lighting along the street to conserve power and reduce light pollution.

The Tool was utilized to assess the Project's impact on Long Meadow Brook. The Site received a score of Moderate on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding and Extreme Precipitation – Riverine Flooding. This Site shows Moderate Exposure for Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding and high potential maximum daily rainfall. Its High Exposure in Riverine Flooding score results from the site's history of riverine flooding, its partial location within a FEMA floodplain, and its location within 100-feet of a waterbody. The Moderate Exposure for Extreme Heat results from the site being between 10% and 50% impervious surfaces and the expected increase in days exceeding 90F over the project's expected useful life at this Site. Based on the known conditions at the Site, none of these results are unexpected. The Site received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat.

Location 6 – New England Executive Park

The proposed project aims to address urban heat island, invasive plant species, and stream restoration. The following NbS are proposed for this area:

- Perform stream rehabilitation including changing the stream from a straight line to a more natural meandering stream.
- Create backwater wetlands along the stream that connect to the existing wetland between the Burlington Mall and the Executive Park.
- Remove adjacent parking area to allow for an expanded green space. Retrofitting the surrounding buildings with green roofs and walls will reduce the heat sink capacity of the Executive Park.
- Assess parking utilization and scale for additional drainage BMP's high reflective pavements and shade trees.

The Tool was utilized to assess the Project's impact on Vine Brook. The Site received a score of High on the Tool for ecosystem benefits with High Exposures noted in Extreme Precipitation – Urban Flooding, Extreme Precipitation – Riverine Flooding, and Extreme Heat. The High Exposure in Urban Flooding score is a result of the site's history of flooding, high potential maximum daily rainfall, and the large amount of impervious surface at the site. Its High Exposure

in Riverine Flooding score results from the site's history of riverine flooding, its partial location within a FEMA floodplain, and its location within 100-feet of a waterbody. The High Exposure for Extreme Heat results from the large amount of impervious surface on site and the expected increase in days exceeding 90F over the project's expected useful life at this Site. Based on the known conditions at the Site, none of these results are unexpected. The Site received a Target Planning Horizon of 2050 for both Extreme Precipitation and Extreme Heat and a Tier 2 rating for each. The Tool also provided a Recommended 50th Percentile for Extreme Heat.

Considerations for Identified Resilience Actions in the Vine Brook Watershed

The following priority areas, referred to as Resilience Actions, are derived from the Stakeholder Assessment developed as part of the Project.

- Resilience Action 1: Sustainable/Climate Resilient Development
- Resilience Action 2: Public/Open/Recreational Space
- Resilience Action 3: Restoration of Developed Areas
- Resilience Action 4: Community Education to Support Climate Resilience
- Resilience Action 5: Reduce and Avoid Adverse Public Health Impacts
- Resilience Action 6: Protect Residential Properties from Flooding

The following summaries identify how the RMAT Tool analysis and Design Guidelines will impact the Project's ability to meet these Resilience Actions as well as how these Resilience Actions present opportunities to meet the Design Guidelines.

Resilience Action 1: Sustainable/Climate Resilient Development

This Resilience Action is particularly applicable to Locations 1, 4, and 6 as these sites are active commercial areas with significant current and future redevelopment potential. The Target Planning Horizons and Tier ratings for each site should be taken into consideration for implementation of NbS at each site as well as for any future redevelopment at these sites. While each site received a Tier 2 rating, which is a Medium Level of Effort per the Guidelines, the design criteria for both Extreme Precipitation and Extreme Heat still exceed current typical design criteria used in Massachusetts development projects. The larger design storms utilized by the Guidelines for Extreme Precipitation will result in larger stormwater infrastructure while the Guidelines for Extreme Heat will require redevelopment of the sites to perform a more detailed analysis of materials utilized and encourage planting of trees for canopy cover. As these sites are redeveloped and/or expanded to promote economic development in the region, the Guidelines should be utilized to ensure that the vital natural resources adjacent to these sites.

See the Guidelines at
https://eea-nescaum-dataservices-assets-prd.s3.amazonaws.com/cms/GUIDELINES/20210401Section3ClimateResilienceDesignStandardsOverview.pdf
for details on specific design requirements for Target Planning Horizons and Tiers.

Resilience Action 2: Public/Open/Recreational Space

This Resilience Action is directly applicable to all Locations of the Project, and the results of the Tool's analysis should be utilized in planning for implementation of this Action. While the creation of public/open/recreational space will more readily conform to the Guidelines' Design Requirements than other types of development, open space development can assist with the implementation of the Design Requirements for both Extreme Precipitation and Extreme Heat. Open space should be utilized to create NbS for stormwater management from upstream developed areas and to offset heat effects.

Resilience Action 3: Restoration of Developed Areas

Each Project Location includes some element of restoration of developed areas, which will aid in meeting the Design Requirements of the Guidelines. Removal of impervious surfaces, installation of NbS stormwater management, and restoration of wetlands and other green spaces will significantly improve each Site's ability to meet the Design Requirements for Extreme Precipitation and help mitigate flood impacts from existing developments. Many of these same

NbS will help the Project meet the Extreme Heat Design Requirements. NbS utilized in the restoration of developed areas should be designed to help the existing developments meet the Design Requirements.

Resilience Action 4: Community Education to Support Climate Resilience

While the RMAT Tool analysis does not directly impact this Resilience Action, community awareness, support, and participation are critical to successfully implementing the Design Requirements of the Guidelines. The community must understand and support the goals of the Project, the existing risks on the Sites, and how the Project will reduce and/or mitigate these risks. Public awareness and support will aid in the long-term protection and maintenance of the NbS implemented, allowing the Project to successfully meet the Design Requirements throughout its expected lifespan.

Resilience Action 5: Reduce and Avoid Adverse Public Health Impacts

Implementation of the Design Guidelines for Extreme Precipitation and Extreme Heat will help meet this Resilience Action through a variety of ways. Reducing and/or mitigating flooding on and downstream of the Sites will protect against structural damage as well as the increase in pollutants and infectious diseases that floodwaters can carry. Pollutant removal from stormwater runoff and pollutant reduction from removal of impervious surfaces will improve the quality of downstream and subsurface water supplies. Meeting the Design Requirements for Extreme Heat can help reduce incidences of heat stress conditions such as heat stroke and improve air quality to lessen respiratory issues. Lower area temperatures also lessen the need for air conditioning and the likelihood of power grid issues that impact the safety and health of the region's populace. The restoration of open space and increased tree plantings will further help improve regional air quality.

Resilience Action 6: Protect Residential Properties from Flooding

Implementation of the Design Guidelines for Extreme Precipitation and Extreme Heat will help meet this Resilience Action directly. The reduction of impervious surfaces and increased tree planting that will help meet the Extreme Heat requirements will also reduce stormwater runoff to help protect against Site and downstream flooding. By utilizing NBS to meet the Extreme Precipitation Design Requirements, Sites and downstream areas will be better protected from flooding. The restoration of open space and improvements to both Vine Brook and Long Meadow Brook can also be utilized to create expanded floodplain in areas away from residential properties to lessen the impacts that flooding has on these residential areas.

Conclusions

Each of the Project Locations includes similar risk assessments and Design Requirements as determined by the RMAT Tool analysis. Based on the types of sites and proposed Project elements, these results are not unexpected. Utilizing these Design Requirements in the implementation of NBS within the Vine Brook Watershed will allow the Project to meet the six Resilience Actions derived from the Stakeholder Assessment.

cc:

Appendix E: Vine Brook Nature-based Solutions Ecological Restorataion and Resilience Opportunities

NATURE-BASED SOLUTIONS ECOLOGICAL RESTORATION AND RESILIENCY OPPORTUNITIES TABLE

Value	GOOD	BETTER	BEST
Feasibility *	low	mid	high

* Feasibility is based on property ownership or technical access

Number = sitemap location, **A** = multiple locations or entire area

This table is intended for use in conjunction with the Project Location maps attachment # And Storymap case study sites illustrated. (site map references in green)

Vine Brook Watershed Study Area

#	RESTORATION/RESILIENCY OPPORTUNITY												
	Site Map Reference & Individual Site Map #s	Woods Corner	Burlington Mall - South	New England Executive Park - South	New England Executive Park - North	Lexington Street - Neighborhood South	Burlington High School	Lexington Street - Neighborhood North	4th Avenue - North	Terrace Hall Ave (Lord Baron Apartments)	4th Avenue - South	4th Avenue-South (Water Treatment Facility)	
	Ownership	Commericial/Infrastructure	Commericial/infrastrcuture	Commericial/Infrastructure	Commericial/Infrastructure	Residential/Infrastructure	municipal	Residential/Infrastructure	Commericial/Infrastructure	Residential/Infrastructure	Commericial/Infrastructure		
	`	Map 1	Map 2	Map 3	Map 4	Map 5	Map 6	Map 7	Map 8	Map 9	Map 10	Map 11	
	Nature Based Solutions (NBS)												
1	Invasive species management	mid	mid	mid	mid	high	mid	mid	mid	high	high	high	
2	River / pond bank revegetation	low	mid	mid	low	high			low				
3	Grassland meadow management restoration		low				mid	low		mid	mid	mid	
4	Forest / shrubland heath management or restoration		mid	mid	mid	high	mid	low	mid	low	low	high	
5	Wetland management restoration	low	low	low	low	high	mid	low	low	low	low	mid	
6	Habitat enhancements	high	low	low	high	high	mid	low	high	mid	low	high	
7	New wetland or floodplain construction / expansion	low	low	low	low	low	mid		low	low	low	mid	
8	Pond creation / alteration		low	low	low	low			low	low	mid	mid	
9	Stream flow alteration	low	low	low	low	low			low	mid	low	low	
10	Species monitoring protocol					mid	high						
11	Pollinator hedgerow buffer		low	mid	mid	low	mid	mid	mid	mid	high	high	
12	Pocket forest		mid	low		low				low	mid	high	
13	Back-water wetland	low	mid	mid	low	mid	low	mid		low	mid	mid	
	Built Environment Best Management Practice (BMP)												
14	Stormwater treatment wetlands		low	mid		high		low		mid	mid	mid	
15	Daylighting of streams												
16	Upstream BMPs rain-garden, bio-swale, etc.	mid	mid	mid	mid	high		high	mid	mid	mid	high	
17	Shade-habitat/ Infiltration tree plantings	mid	mid	low	mid	mid	high	high	mid	mid	high	high	
18	MSCS culvert improvement	low			low	mid		mid	low	low			
19	Dam modification / controls		low	low		low				low	low	low	
20	Roof Top Gardens/Green Walls		low	low		low	low		low	low	low	mid	
21	Vertical Parking		low	low		low				low	low	low	
22	Pervious parking walking areas		high	low	mid	low	mid		mid	mid	low	low	
23	Aquatic algae / invasive treatment												
24	Lighting modifications / upgrades	mid	high	low		mid	mid	mid		mid	mid	mid	
25	Species crossing protections	low	low	mid	low	high			low	low	mid	high	
26	Beaver deceiver / promoter												

#	RESTORATION/RESILIENCY OPPORTUNITY Site Map Reference & Individual Site Map #s	Woods Corner	Burlington Mall - South	New England Executive Park - South	New England Executive Park - North	Lexington Street - Neighborhood South	Burlington High School	Lexington Street - Neighborhood North	4th Avenue - North	Terrace Hall Ave (Lord Baron Apartments)	4th Avenue - South	4th Avenue- South (Water Treatment Facility)	
	Ownership	Commericial/Infrastructure	Commericial/infrastrcuture	Commericial/Infrastructure	Commericial/Infrastructure	Residential/Infrastructure	municipal	Residential/Infrastructure	Commericial/Infrastructure	Residential/Infrastructure	Commericial/Infrastructure		
	`	Map 1	Map 2	Map 3	Map 4	Map 5	Map 6	Map 7	Map 8	Map 9	Map 10	Map 11	Map 12
	Ecological Awareness & Access Projects												
27	Educational interpretation		high	high		high	high			mid	mid	high	
28	Furnishings / gathering space		high	low		mid	high			mid			
29	Soft trail		high	mid		mid	high			mid			
30	Paved pervious trail		high	mid	high	mid	low			mid	mid	mid	
	Related Regulatory Actions												
31	Conservation purchase / restriction		low	low		mid				low	low	high	
32	Public - private partnership	low	low	low		low		low		low	low	high	
33	Land swap / land bank		low	low		low		low		low	low	high	
34	Zoning overlay / other regulations		low	low	low	low		low	low	mid	low	mid	
35	Resilient redevelopment incentive	low	low	low	low	low		low	low	low	low	mid	
	Related Architectural Projects to Consider												
36	Green architectural enhancements		low	low	mid	low	mid	low	mid	low	low	high	
37	Green energy features		low	low	mid	mid	mid	low	mid	mid	mid	high	

15	16	17	17	18	19	20	21	22	23	24	25

Good Value= Improves the habitat value, or resiliency of a site or feature
Better Value = Makes significant improvements to resiliency with long lasting effect
Best Value = An improvement to a resource that provides significant lasting resiliency and strengthens or serves related resources
Data viewer
https://bscgroup.maps.arcgis.com/apps/webappviewer/index.html?id=57228d298b06498c84767d15f1ff9c96&extent=-8000160.7153%2C5220006.5663%2C-7941457.0775%2C5246071.5929%2C102100

Appendix F: Potential Nature-based Solutions Maps

Vine Brook Watershed and Urban Heat Island Assessment

OVERVIEW NOTES & LEGEND:

The goal of this section of the report is to locate sites for potential Nature Based Solutions. As you examine the sites think of what opportunities for improvement could be applied that affect local and regional ecological outcomes.

Categories of NBS approaches to consider:

Ecosystem restoration approaches
- Ecological restoration
- Ecological Engineering
- Forest landscape restoration

Issue-specific ecosystem-related approaches
- Ecosystem-based adaptation
- Ecosystem-based mitigation
- Climate adaptation services
- Ecosystem-based disaster risk reduction

Infrastructure-related approaches
- Natural infrastructure
- Green infrastructure

Ecosystem-based management approaches
- Integrated coastal zone management
- Integrated water resources management

Ecosystem protection approaches
- Area-based conservation approaches, including protected area management
-

Visit IUCN.org for more detailed descriptions and further resources

The following are a list of Nature Based Solution types (NBS) that may be applicable to the locations, or parts there of, identified in the public outreach and analysis.
For a comparison of value and feasibility see the NBS matrix.
For detailed descriptions of these project types see the NBS projects section of the report.

Ecosystem Enhancement/ Restoration
- Invasive species managment (Identification, removal and replacement of harmful species)
- River/ pond bank revegetation (creation of slopes features and preferred vegetation)
- Grassland/meadow management restoration (introduction and maintenance practices)
- Forest Shrubland heath management restoration (Species additions and removals)
- Wetland management restoration (Erosion control microdamming and connectivity)
- Hedge row pollinator Strip (buffering open areas with high value trees or forbes)
- Habitat enhancements (nesting foraging and hunting features)
- New wetland or flood plain construction/ expansion (micro damming and chaneling)
- Pond creation/ alteration (creation expansion or shaping of ponds)
- River flow alteration (adding sinuosity, erosion control, planting and aeration features)
- Species monitoring protocol (Staffing and technical support for inventory and monitoring)

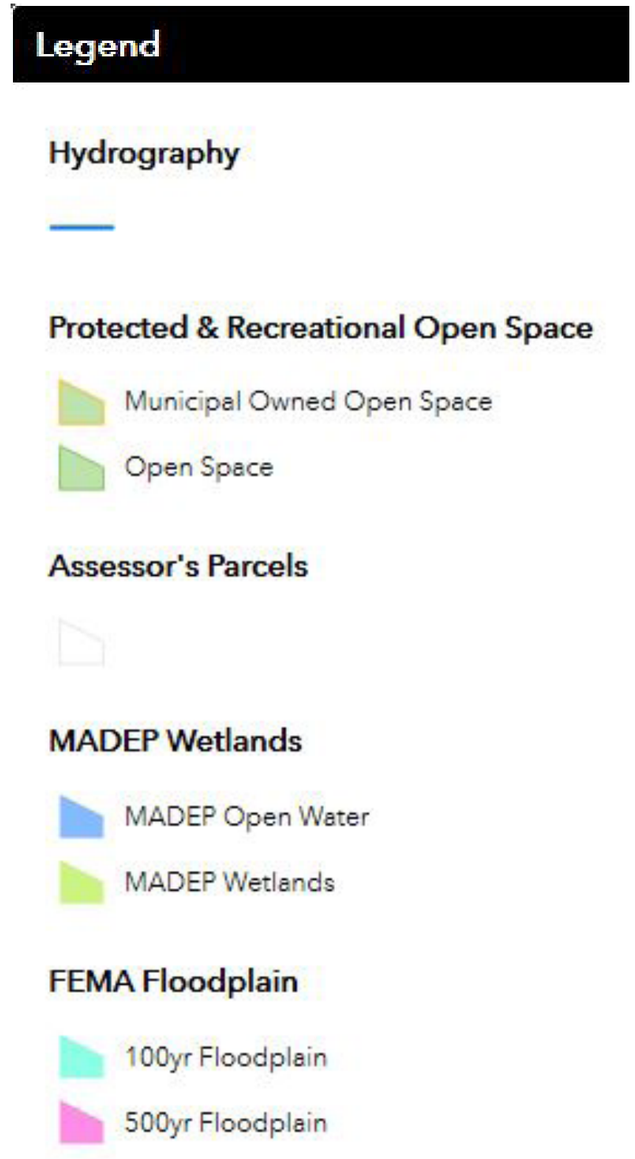
Built Environment Best Management Practice (BMP)
- Stormwater treatment wetlands (temporary impoundment and treatment of storm water)
- Upstream BMPs (Rain garden, bio-swale vegetated buffer, swale, etc.)
- Shade-habitat/ Infiltration tree plantings (Canopy shade trees over lawn and pavement)
- MSCS culvert improvement (Higher wider culverts with passable banks and chanel)
- Dam weir smart controls (Channel modifications for gradual passage of water)
- Pervious parking walking areas (Stabilized pervious access and activity surfaces)
- Algae/ aquatic invasive species treatment (Chemical, cultural, mechanical solutions)
- Species crossing protections (Signage, light, fences, audible surfacing)
- Beaver Deceiver/ Promoter (structures to prevent flood damage or improve flood plain)

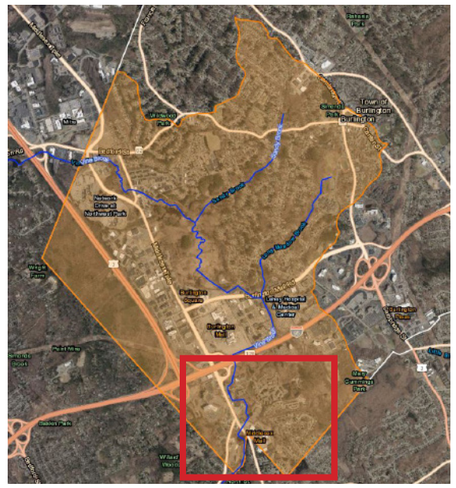
Ecological Awareness & Access Projects
- Educational interpretation (Signage, events, digital media, arts and other ecological info)
  Furnishings/ gathering space (Public gathering spaces for environmental appreciation)
- Soft trail (Stabilized natural surface and terrain trails)
- Paved Trail (Durable universal access surface trails or other access)

Related Regulatory Actions
- Conservation Purchase/ restiction (Conservation trust, direct purchase)
- Public - private partnership (Sponsored managed private plantings)
- Land swap/ land bank (Development rights transfer Use deferral)
- Zoning overlay/ other regulations (Development limits, activity limits)
- Resilient redevelopment incentive (Loans, grants, technical support, regulatory support)

Related Architectural Projects to Consider
- Green architectural enhancements (green wall, green roof, white roof, water harvesting etc.)
- Green energy features (Solar, Wind, Hydroelectric, Biomass, Geo/Hydrothermal)

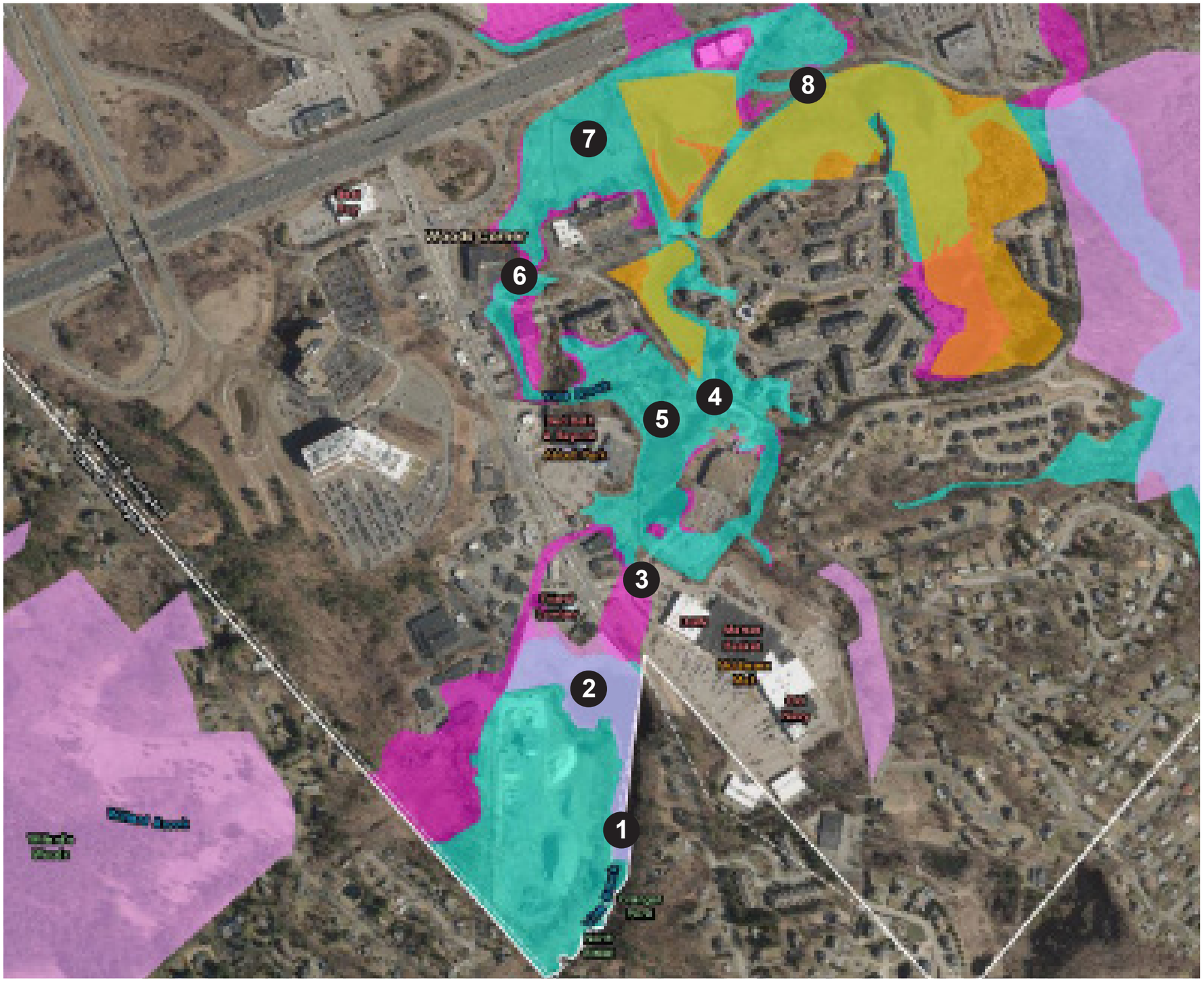
The following Data layers are shown on the area maps included here to identify physical and political boundaries. Please use the (Data Viewer) for more detail.

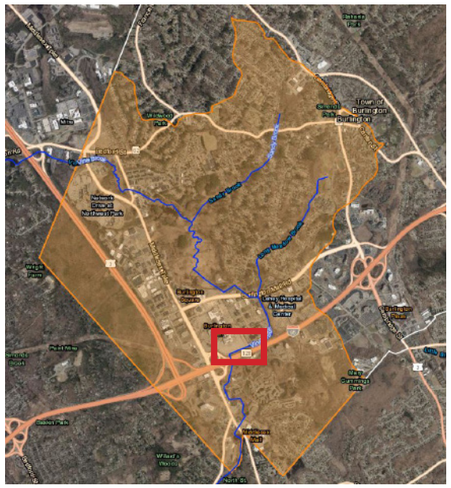




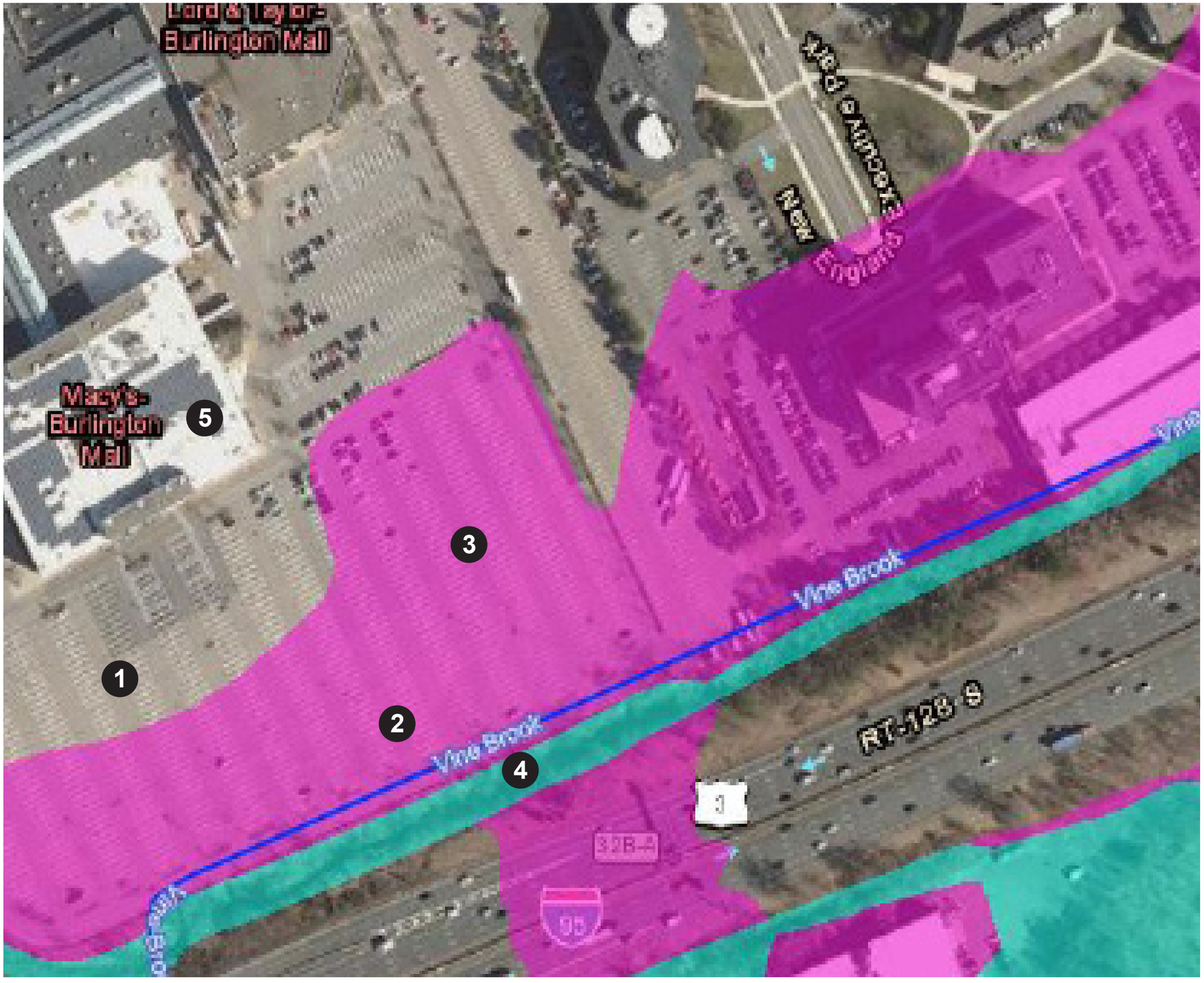
Map 1:
Woods Corner
<u>NBS approaches at desinated areas:</u>

1. Stream flow alteration, Upstream BMPs rain-garden, bio-swale, etc. (at 75 Middlesex Turnpike)
2. Invasive species management
3. MSCS culvert improvement (where Vine Brook passes under Old Concord Rd. 45 Middlesex Trnpke)
4. MSCS culvert improvement (at Littles Brook at Old Concord Rd.)
5. Invasive species management
6. MSCS culvert improvement (at Wheeler Rd. crossing)
7. Invasive species management
8. Habitat Enhancements, New wetland or floodplain construction / expansion (at Mary Cummings Park & Blanchard Rd.)



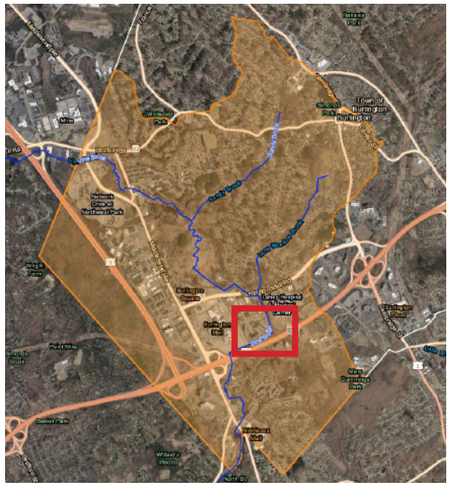


Map 2:
Burlington Mall-South



<u>NBS approaches at desinated areas:</u>

1. Shade-habitat/ Infiltration tree plantings
2. New wetland or floodplain construction / expansion Forest / shrubland heath management or restoration Pervious parking walking areas, Upstream BMPs rain-garden, bio-swale, etc, Lighting modifications / upgrades,
3. Stream flow alteration, Pond creation / alteration, Back-water wetland, Wetland management restoration
4. Roof Top Gardens/Green Walls

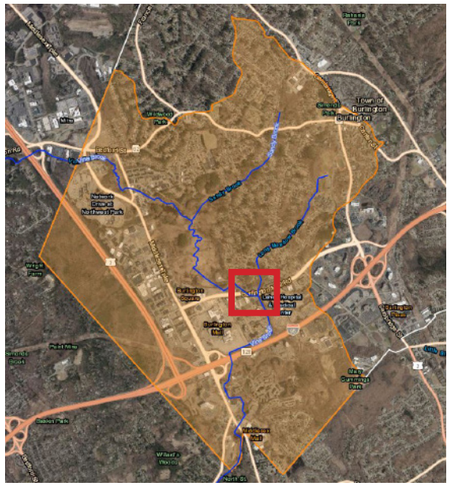


Map 3:

New England Executive Park - South

<u>NBS approaches at desinated areas:</u>

1. Shade-habitat/ Infiltration tree plantings
2. Vertical parking
3. Green architectural enhancements
4. Stream flow alteration
5. Upstream BMPs rain-garden, bio-swale, etc.
6. Pervious parking walking areas

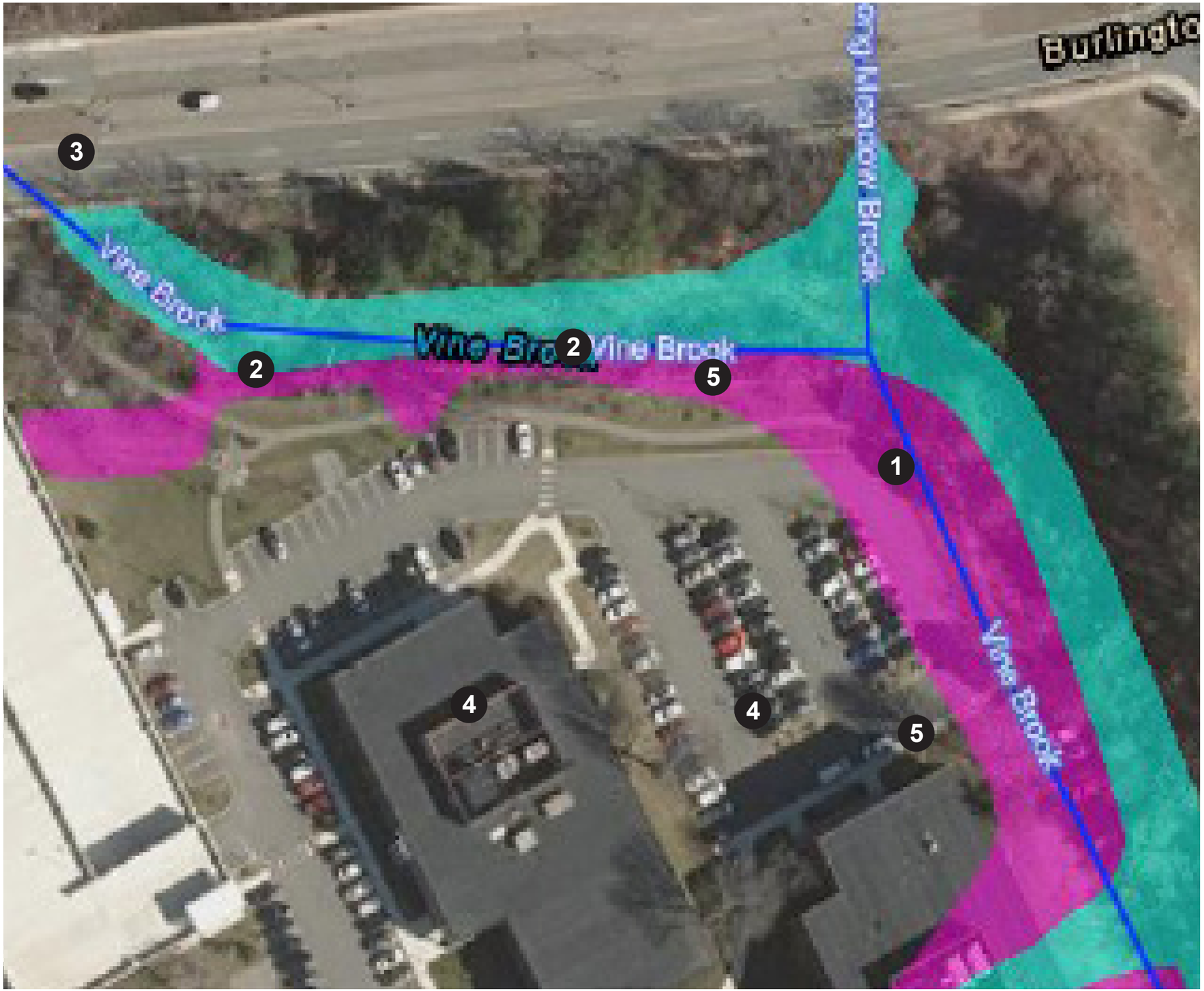


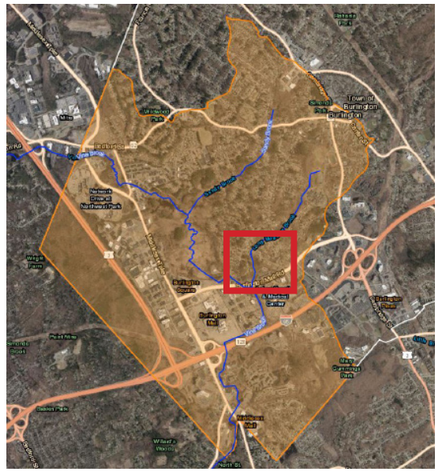
Map 4:

New England Executive Park-North

<u>NBS approaches at desinated areas:</u>

1. Stream flow alteration
2. Upstream BMPs rain-garden, bio-swale, etc.
3. MSCS culvert improvement
4. Roof Top Gardens/Green Walls
5. Pervious parking walking areas, New wetland or floodplain construction / expansion





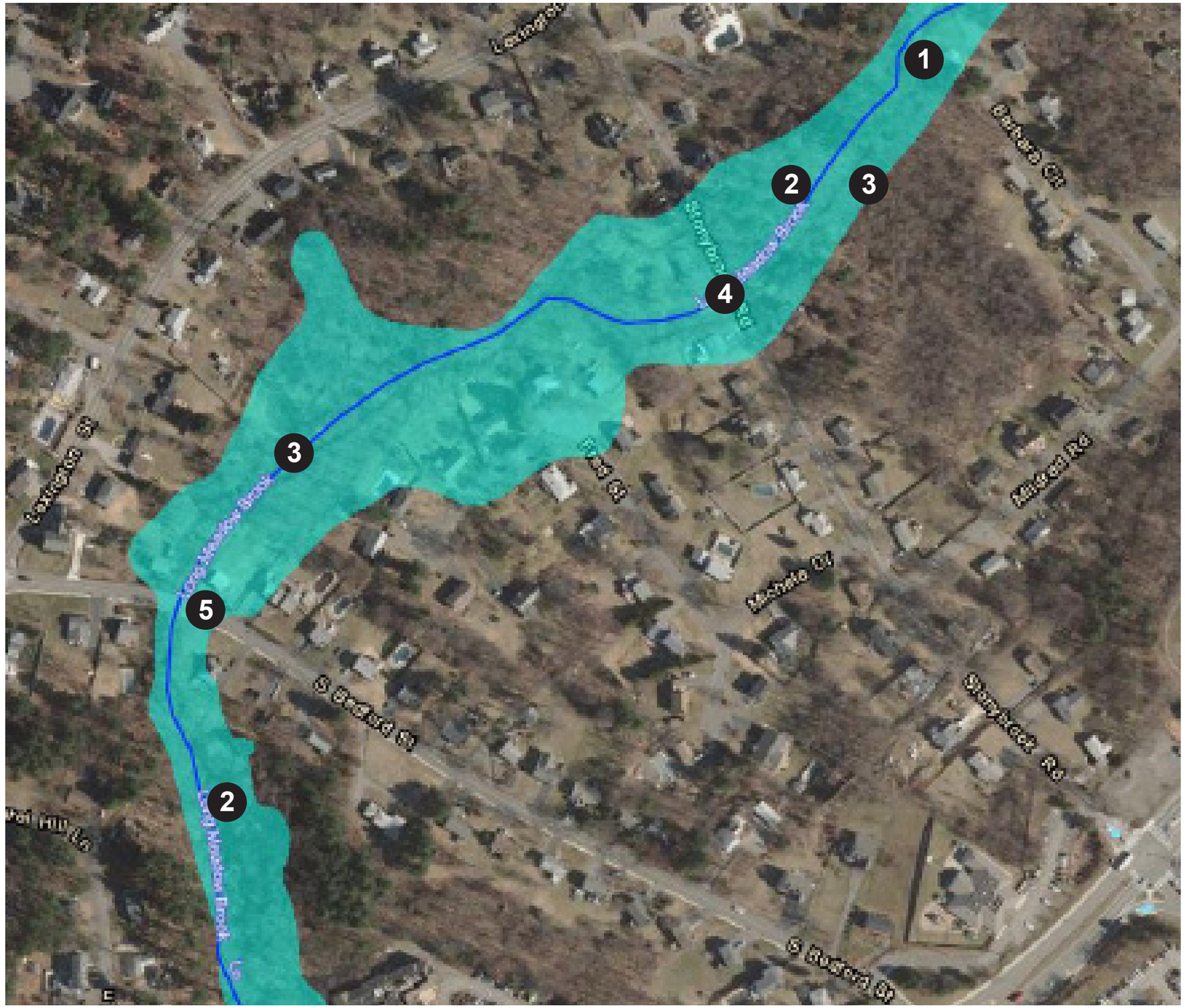
Map 5:

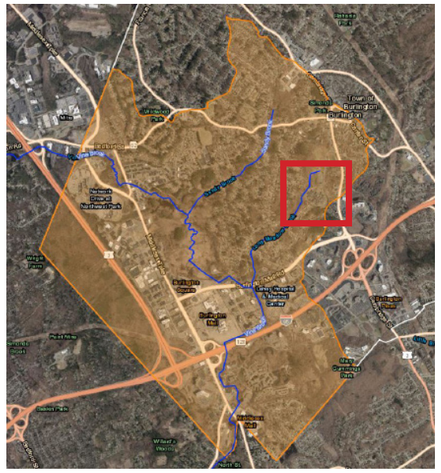
Lexington St. Neighborhood South

<u>NBS approaches at desinated areas:</u>

1. MSCS culvert improvement (at Barbara Cir.)
2. Invasive species management
3. Habitat enhancements
4. MSCS culvert improvement (at Sony Brook Rd.
5. MSC culvert at South Bedford St.

Systemic initiatives include:
Residential Awareness: Permeability Asphalt, Habitat, SRI, Lawn, and Wetland carbon and flood control awareness
Residential Incentives:
Raingarden, and Water harvesting incentives
Public works standards:
Infiltration catchbasin upgrades
Pavement reduction



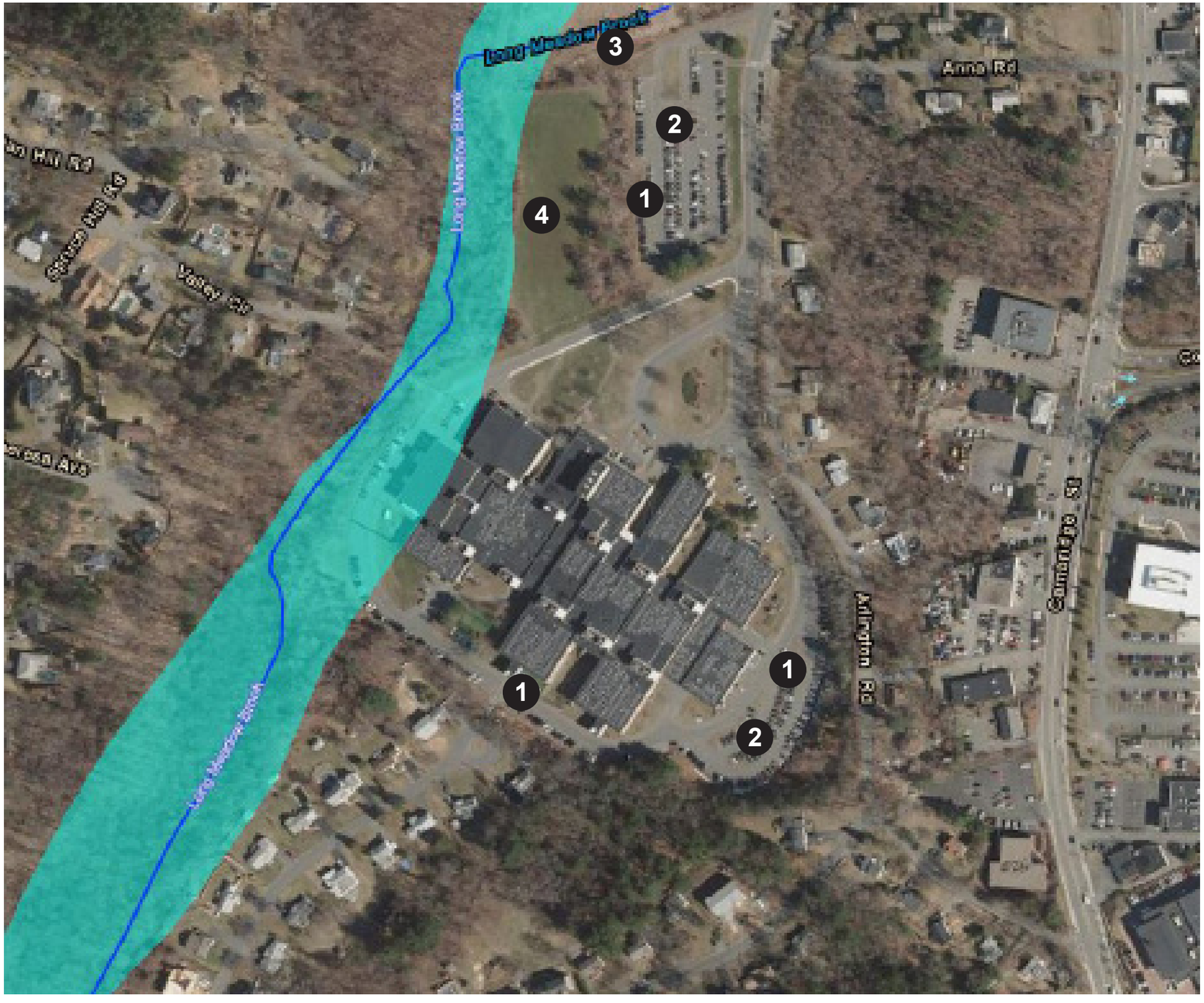


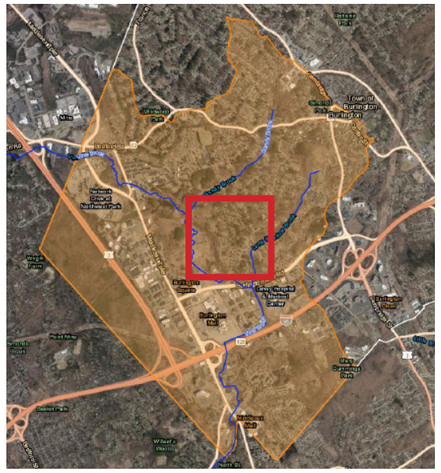
Map 6:

Burlington High School

<u>NBS approaches at desinated areas:</u>

1. Bpstream BMPs rain-garden, bio-swale, etc.
2. Pervious parking walking areas
3. Invasive species management
4. Grassland meadow management restoration (alternatives to turf lawn for non active use landscapes)



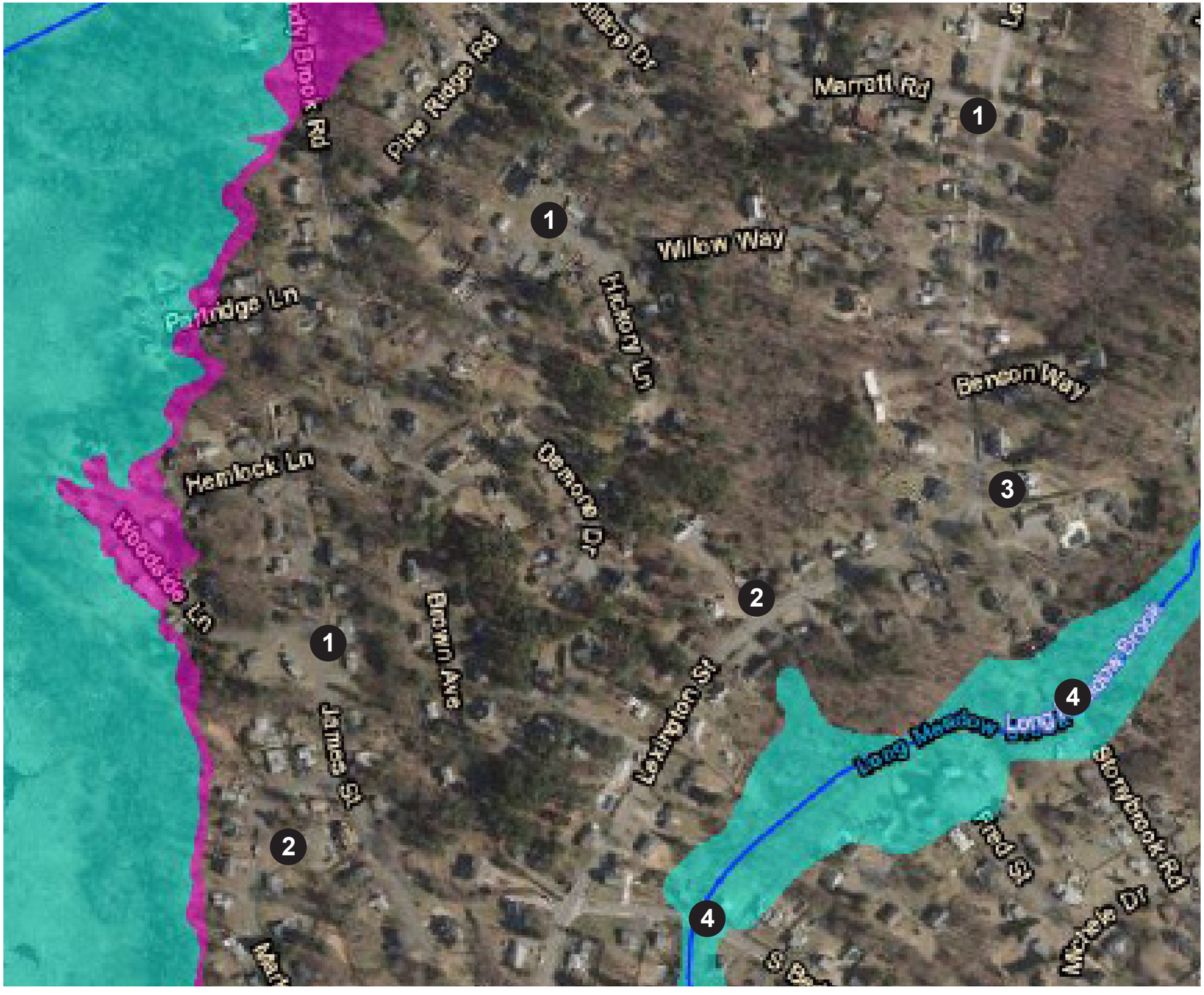


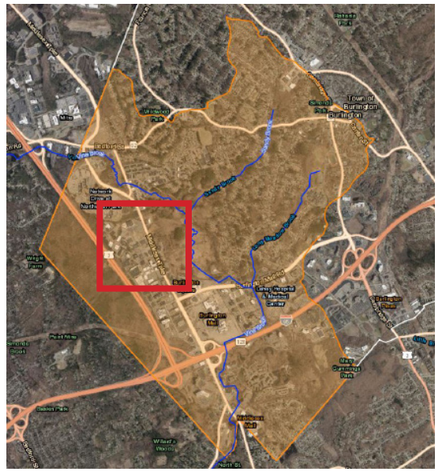
Map 7:

Lexington St. Neighborhood North

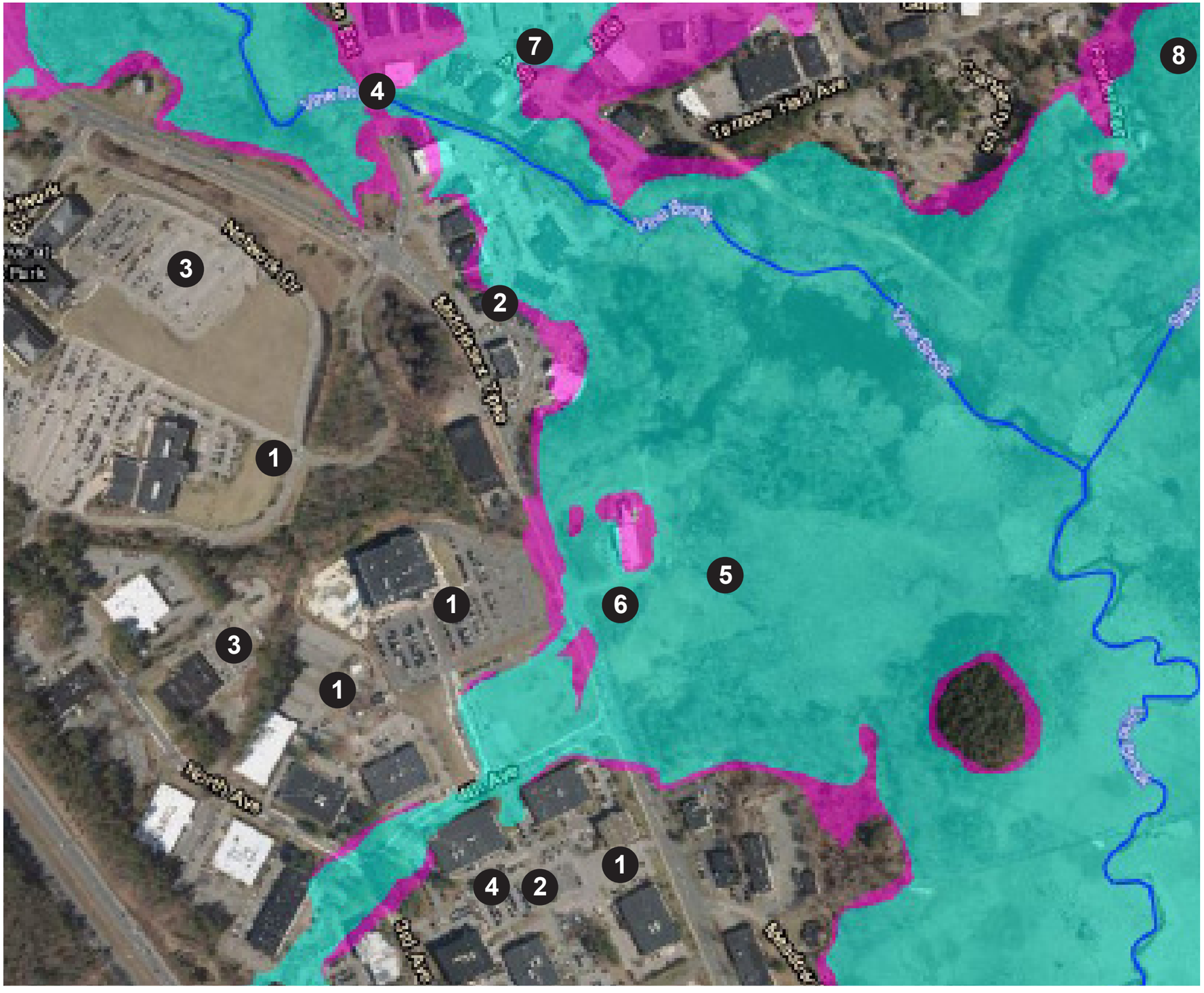
<u>NBS approaches at desinated areas:</u>

1. Pervious parking walking areas
2. Upstream BMPs rain-garden, bio-swale, etc.
3. Upstream BMPs rain-garden, bio-swale, etc. (within public rights of way)
4. MSCS culvert improvement



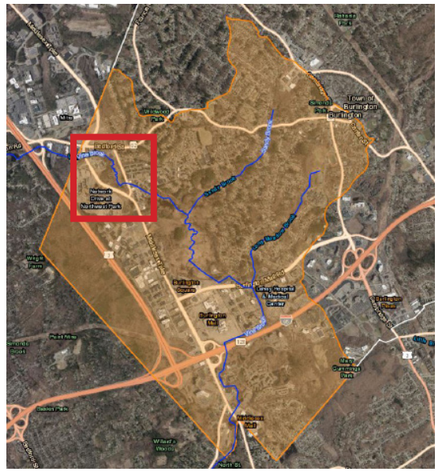


Map 8:
4th Avenue-North

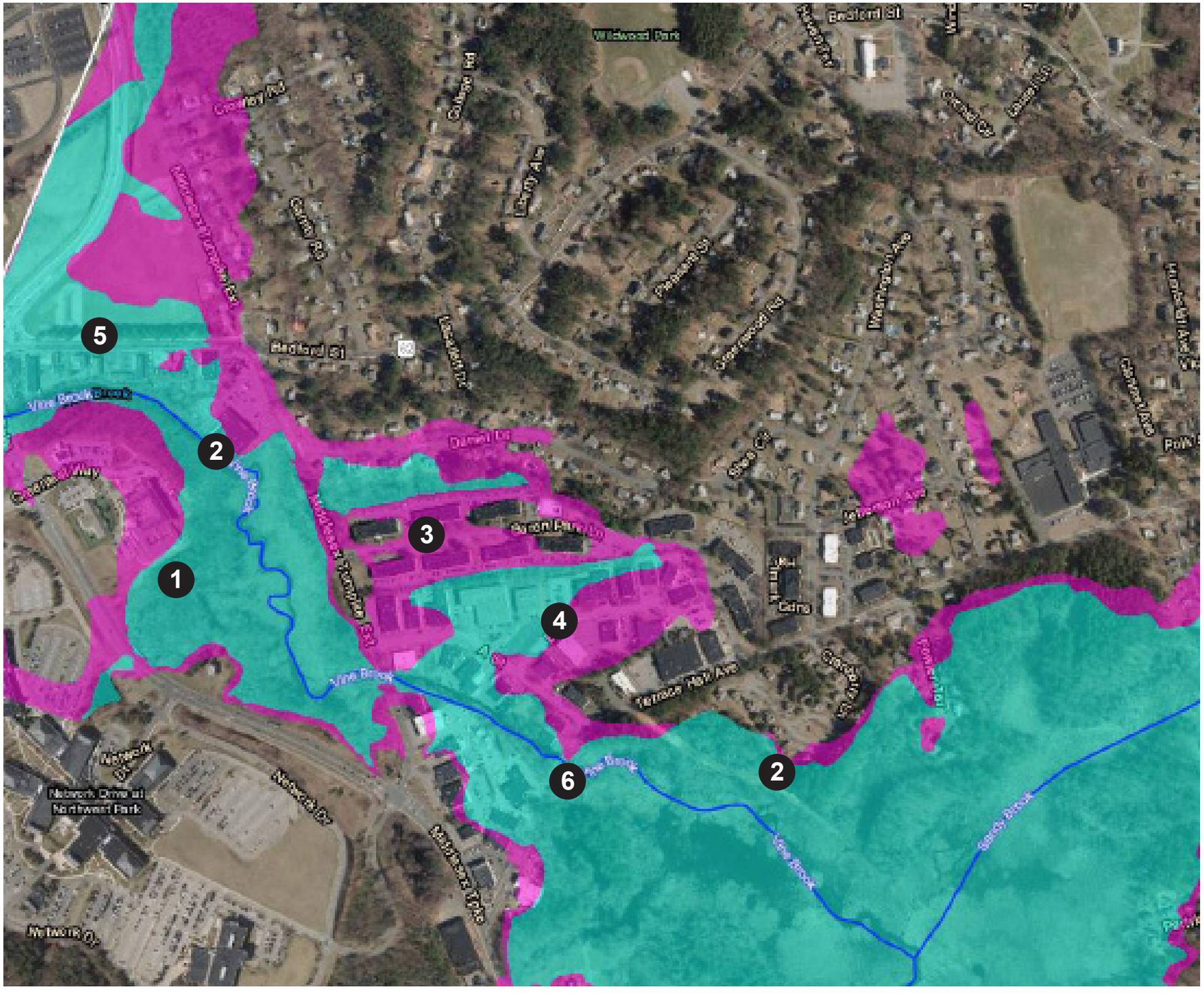


<u>NBS approaches at desinated areas:</u>

1. Pervious parking walking areas within overflow parking
2. Upstream BMPs rain-garden, bio-swale, etc. (within public rights of way)
3. Vertical parking
4. MSCS culvert improvement at Middlesex Trnpke Ext.(Town Suggested)
5. Invasive species management
6. New wetland or floodplain construction / expansion at 171 Middlesex Trnpke (Town Suggested)
7. New wetland or floodplain construction / expansion (industrial area off Terrace Hall Ave.)
8. Sandy Brook crossing Hilltop Dr.

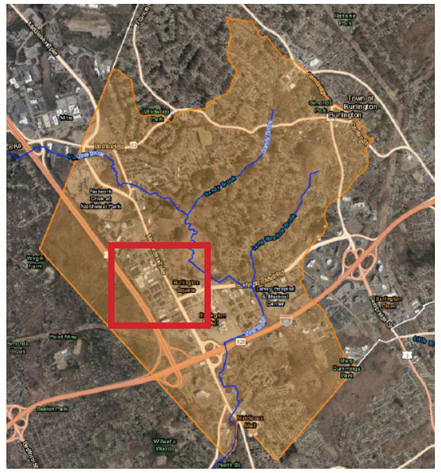


Map 9:
Terrace Hall Ave.



<u>NBS approaches at desinated areas:</u>

1. River / pond bank revegetation
2. Invasive species management
3. Pollinator hedgerow buffer
4. Upstream BMPs rain-garden, bio-swale, etc., Green energy features,
5. Bedford St. at Mitre Field (Town Suggested)
6. Habitat enhancements

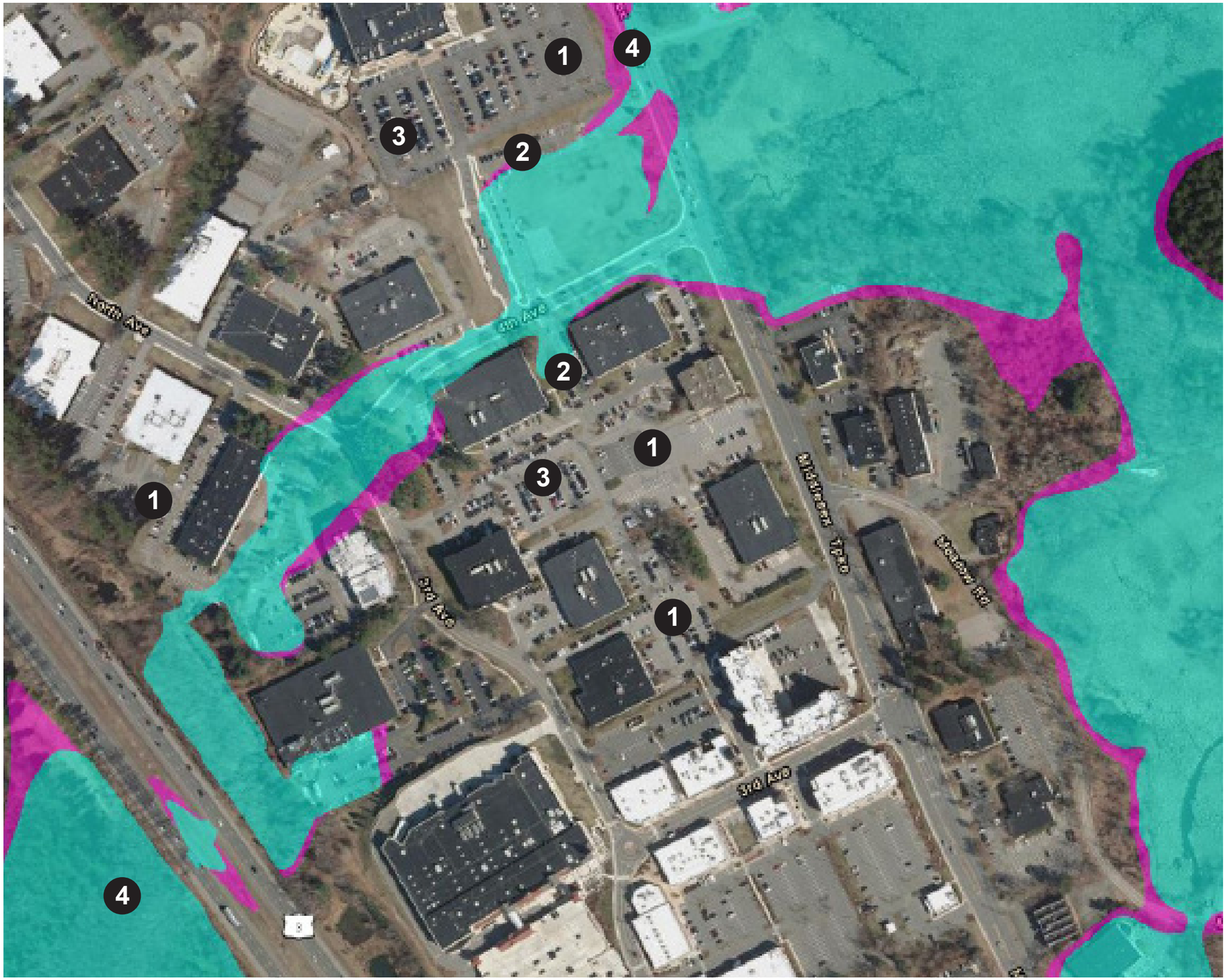


Map 10:

4th Avenue - South

<u>NBS approaches at desinated areas:</u>

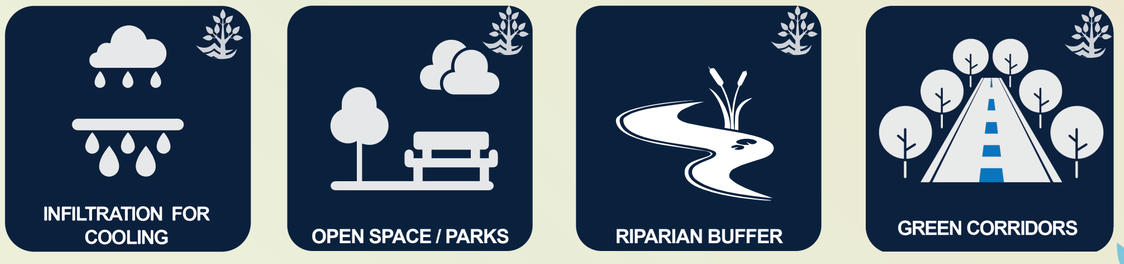
1. Pervious parking walking areas Upstream BMPs rain-garden, bio-swale, etc.
2. New wetland or floodplain construction / expansion
3. Shade-habitat/ Infiltration tree plantings
4. Wetland management restoration



Appendix G: Project Infographics

VINE BROOK WATERSHED INLAND FLOOD AND URBAN HEAT ISLAND ASSESSMENT

INLAND FLOODING



NATURE - BASED SOLUTIONS

Areas where dense commercial development interface with naturalized areas require flood mitigation strategies that involve protection, restoration, and management of natural resources. Solutions to mitigate for flood impacts based on natural approaches can minimize risk to people and property, shorten flood retention times, improve the ecological resilience of surrounding natural resources, and provide more enjoyable open spaces for recreation.

Drawing upon inspiration from nature is the basis for Nature-based Solutions to create more climate resilient communities. Nature-based solutions may be applied in any landscape and provide co-benefits to the community.

Where residential neighborhoods border densely developed areas, there is opportunity to manage the land to mitigate the effects of flood impacts. Conservation measures are particularly important where commercial infrastructure and residential infrastructure are shared.

Densely developed areas where pavement and buildings exist, create stormwater runoff where infiltration is limited. Flooding damages properties, disrupts business activity and presents safety issues. As flood water recedes it transports pollutants and sediment to surrounding natural environments reducing natural flood mitigation for future storm events.

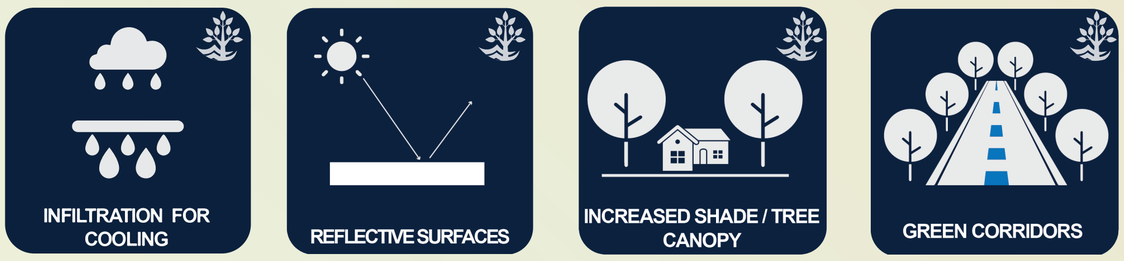
Climate data projections predict higher total annual precipitation as well as more intense precipitation events in the coming decades. Most of this rainfall increase is expected to occur as extreme precipitation and during the winter and spring seasons.

MVP Municipal Vulnerability Preparedness

BSC GROUP

VINE BROOK WATERSHED INLAND FLOOD AND URBAN HEAT ISLAND ASSESSMENT

URBAN HEAT ISLAND EFFECTS



NATURE - BASED SOLUTIONS

Areas where dense commercial development interface with naturalized areas are important for urban heat island mitigation. Solutions to mitigate for urban heat island effect based on natural approaches can reduce cooling costs, GHG emissions, prevent heat related illness and create more enjoyable open spaces for recreation.

Mimicking open space in developed areas provides urban heat island mitigation similar to the effects of naturalized areas.

OPEN SPACE

Drawing upon inspiration from nature is the basis for Nature-based Solutions to create more climate resilient communities. Nature-based solutions may be applied in any landscape and provide co-benefits to the community.

COMMERCIAL

Densely developed areas where pavement and buildings exist can be many degrees hotter than surrounding areas during an extreme heat event. Finding places to incorporate measures to cool highly developed areas through greening of the landscape can have local and regional benefits.

Where residential neighborhoods border densely developed areas, there is opportunity to manage the land to mitigate the effects of urban heat island. Conservation measures are particularly important where commercial infrastructure and residential infrastructure are shared.

RESIDENTIAL

URBAN HEAT ISLAND effect occurs in areas where EXTREME TEMPERATURES are made worse by the presence of IMPERVIOUS SURFACE rather than vegetated ground cover.

MVP Municipal Vulnerability Preparedness

BSC GROUP

Appendix H: Additional Resources

Appendix H: Additional Resources

PROJECT WEBSITE

https://climateresilientburlington.wordpress.com/

The project website is used as a repository of project information and a source of community education on key project concepts. It includes:

- A summary of **flood and urban heat island climate vulnerability** in Burlington, intended as a community educational resource
- An overview of **Nature-based Solutions** and how they are used to increase community resilience
- An **ArcGIS interactive viewer** that allows visitors to explore maps about the project area
- Records of project community engagement activities, technical resources, and the final project report

PROJECT STORYMAP

https://storymaps.arcgis.com/stories/776750d898c24f9680657ebaeb646c8e

The project StoryMap provides a visual summary of the project assessment and recommended Nature-based Solutions at each of the six priority project sites.