MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Bloody Brook (MA34-36)

Within the Towns of Deerfield and Whately, MA

October 2024

Prepared By:

Franklin Regional Council of Governments

12 Olive Street

Greenfield, MA

Prepared For:

MassDEP

Commonwealth of Massachusetts
Department of Environmental Protection

Contents

Executive Summary

Introduction

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans. This WBP was developed by the Franklin Regional Council of Governments (FRCOG) with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was prepared for the Bloody Brook watershed (MA34-36), which is in the town of Deerfield and a portion of northern Whately. The main stem of Bloody Brook is approximately 3.7 miles long, with many more miles of tributaries, and has a watershed area of 3,508 acres. It is a shallow, slow-moving Bloody Brook with multiple large channels that merge in the lower watershed (the channel that runs along North Main Street is considered the main stem but many of the tributaries are of a similar size). The headwaters are found in low-lying agricultural fields and the west side of the Pocumtuck Ridge. Almost immediately after crossing the town line into Whately, the brook drains into the Mill River (watershed HUC-12 code 010802010604), a tributary to the Connecticut River. The Bloody Brook watershed is heavily developed with residential, agricultural, commercial, and light industrial uses.

Impairments and Pollution Sources

Bloody Brook is a Category 5 water on the 2022 Massachusetts Integrated List of Waters (303(d) list) impaired for primary and secondary contact recreation and fish, aquatic life and other wildlife uses due to *E. coli*, total phosphorus (TP), turbidity, and dissolved oxygen from unknown sources.

Goals, Management Measures, and Funding

The long-term goal of this WBP is to reduce *E. coli*, TP, and turbidity, eventually leading to the delisting of the Bloody Brook watershed from the 303(d) list for these three impairments. A dissolved oxygen goal should be set once a background reading is established. It is expected that pollutant load reductions of *E. coli*, TP, and turbidity will result in improvements to other water quality parameters as well, including temperature and dissolved oxygen.

These goals will be accomplished through a) an hydraulic and hydrologic study of the watershed (already funded by a FY25 MVP Action Grant), b) implementation of structural and non-structural Best Management Practices (BMPs) to capture runoff and reduce *E. coli*, TP, and c) sediment loading as well as implementation of watershed education and outreach to achieve additional pollutant load reductions.

This WBP includes an adaptive sequence to establish and track specific water quality goals. A goal has been established to reduce bacteria loading by 64% from the highest geomean recorded in 2008 in the next five years. The 64% bacteria reduction goal corresponds with the target set in the draft *Massachusetts Statewide TMDL for Pathogen-Impaired Inland Freshwater Rivers*. A second goal has been set to reduce TP loading rate by 210 lbs/year in the next three to six years to reach the EPA's standard of 50 µg-P/L. Additional goals may be set for

TP after the initial goal is reached. A third goal has been set to reduce the total suspended solids (TSS) loading rate by 95 tons/year to reduce turbidity to below the standard.

It is expected that funding for management measures will be obtained from a variety of sources including Section 319 grants, Municipal Vulnerability Preparedness (MVP) action grants, Massachusetts Department of Agricultural Resources (MDAR) grants, Natural Resources Conservation Service (NRCS) programs, Town capital funds, and volunteer efforts.

Public Education and Outreach

Education and outreach are needed to educate Deerfield Town staff, students, landowners, residents, business owners, and farmers about the health of the Bloody Brook watershed, including the potential sources of nonpoint source pollution (contaminants released in a wide area rather than from one single source, such as a pipe) and fluvial geomorphic impairments (disturbance to stream channel shape, water flow, and sediment movement in a stream channel). Education and outreach is also needed to help to promote a comprehensive approach to ongoing stormwater management that is currently primarily focused on flooding issues.

Education and engagement on stormwater management and climate-resilient water management are currently being pursued through Town-led public engagement and student projects under MVP and other grants, Franklin Conservation District (FCD) landowner outreach via workshops and property visits funded by the Executive Office of Energy and Environmental Affairs (EEA), and a landowner letter, informational booklet, and survey created and distributed by FRCOG staff under this grant. Further education and outreach can focus on educating Town officials about this WBP's goals in order to help integrate watershed planning and water quality goals into all Town planning arenas. Ongoing engagement would focus also on landowner education, particularly corporate landowners, to cultivate a sense of investment in the WBP goals and identify opportunities for projects. If awarded, the Massachusetts Association of Conservation Districts (MACD) will conduct farmer outreach and support in the watershed under the "Expanded Western Massachusetts Agricultural NPS Program" grant. It is expected that these programs will be evaluated by tracking meetings, event attendance, and other tools applicable to the type of outreach performed.

Implementation Schedule and Evaluation Criteria

The WBP outlines milestones for applying for grants, further assessment, outreach and education, monitoring, BMP development and implementation, and operation and maintenance plans.

This WBP is meant to be a living document, re-evaluated at least once every three years and adjusted as needed based on ongoing efforts (e.g., based on monitoring results, funding, etc.). This WBP recommends conducting a water-quality monitoring project for the Bloody Brook watershed in a few years after all BMP installations still in process have been completed. It also encourages determining the background dissolved oxygen number to better determine a dissolved oxygen target goal. Indirect evaluation metrics are included, such as the number of BMPs installed, hours/miles of road management, and BMP management. The long-term goal of this WBP is to delist Bloody Brook from the Massachusetts Integrated List of Waters 303(d) list.

It is recommended that the Town of Deerfield assign a new or existing working group to the stewardship of this plan, one that can meet regularly to implement and update this WBP and track progress. The Town of Deerfield has demonstrated an excellent capacity to secure grant funding for watershed-based projects and should continue to be supported by regional partners in these efforts. The Franklin Regional Council of Governments (FRCOG) is the regional planning agency for Franklin County and may be aware, through other funded projects, of work that may inform ongoing or planned projects for the Bloody Brook watershed. As part of planning future nonpoint source management work within the watershed, project proponents should contact FRCOG staff for updates and opportunities to leverage funding and coordinate project activities.

Introduction

What is a Watershed-Based Plan?

Purpose and Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to identify past and current water quality conditions and known and likely causes and sources of nonpoint source pollution in your watershed. It will also help interested parties to recognize data gaps, prioritize the NPS problems, identify appropriate best management practices and watershed-based strategies for addressing the problems, and develop proposals to fund the work using 319 nonpoint source competitive grant funds or similar programs. The goal of WBPs and projects aimed at reducing nonpoint source pollution is to restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop WBPs only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

EPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

This WBP includes nine elements (a through i) in accordance with EPA Guidelines:

a) An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this WBP and to achieve any other watershed goals identified in the WBP, as discussed in item (b) immediately below.

b) An **estimate of the load reductions** expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time.

c) A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in this WBP and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United States Department of Agriculture's (USDA's) Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant federal, state, local, and private funds that may be available to assist in implementing this plan.

e) An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g) A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h) A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this WBP needs to be revised or, if a NPS total maximum daily load (TMDL) has been established, whether the TMDL needs to be revised.

i) A **monitoring component** to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under item (h) immediately above.

General Watershed Information

This WBP was prepared for waterbodies located within the Bloody Brook watershed in Deerfield and Whately.

Table 1: General Watershed Information

Watershed Name (Assessment Unit ID):	Bloody Brook (MA34-36)
Major Basin:	Connecticut River
Watershed Area (within MA):	3,508.4 acres or 5.65 square miles
Stream miles	3.7 miles

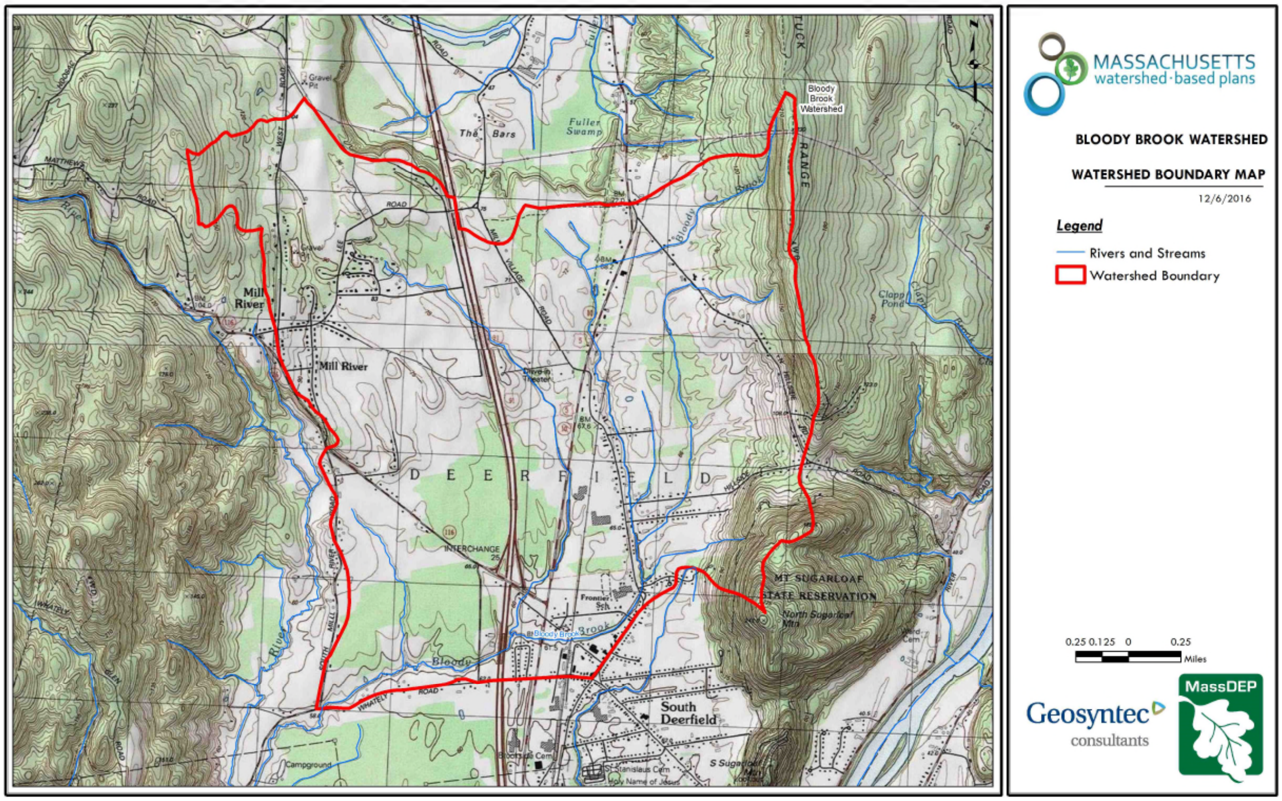


Figure 1: Watershed Boundary Map (MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

The Bloody Brook watershed spans most of the southern half of Deerfield. The Brook's two largest channels flow south and west to join together in through South Deerfield. Bloody Brook is a tributary to the Mill River (watershed HUC-12 code 010802010604), which is a tributary to the Connecticut River. Some of the watershed drains the steep west side of the Pocumtuck Ridge. However, most of the watershed is characterized by small stream channels meandering through wetlands complexes across a broad, flat, lowland. The majority of the watershed is in agricultural or residential development. However, the middle section of the watershed contains the northern half of South Deerfield village, with its dense residential, commercial, and light industrial development. The Interstate 91, a railroad line, and State Routes 5/10 bisect the watershed. Route 5/10 is commercially developed for much of its length.

Bloody Brook joins the Mill River just south of the Deerfield-Whately boundary, about fifteen river miles north of the mouth of the Mill River. The Mill River contains Massachusetts' most diverse community of freshwater mussels, including nine of the Commonwealth's twelve mussel species, four state-listed endangered species and the federally endangered Dwarf Wedge Mussel.[1] Downstream of the Bloody Brook confluence, two public drinking wells for the Town of Whately are located close to the Mill River. Despite ongoing work to stabilize the

[1] Parasiewicz et al. 2003

riverbank to protect the public drinking water source, the wells remain at risk of contamination from inundation flooding and fluvial erosion.[2]

Bloody Brook is a warmwater fishery (WWF) resource and is mapped as BioMap Aquatic Core habitat from where it intersects Jackson Road near North Main Street all the way to the confluence. Massachusetts Department of Fish and Game (DFG) biologists conducted backpack electrofishing in Bloody Brook upstream of the Pleasant Street crossing along North Main Street in Deerfield in July and August 2007 (Sample IDs 2419 & 2140). These samples were both indicative of reasonable conditions for a low gradient stream as they were both dominated by moderately tolerant fluvial specialist and dependent species moderately tolerant to pollution.[3]

The watershed is 40% forested. The watershed also contains BioMap Forest Core habitat on the Pocumtuck Ridge, BioMap Rare Species Core habitat at the intersection of Sandgully Road South and Plain Road (an agricultural area near the Interstate), and an area of both BioMap Wetland Core and Priority Natural Communities Core northeast of the Conway Road/Route 116 Interstate exchange (see Figure 2).

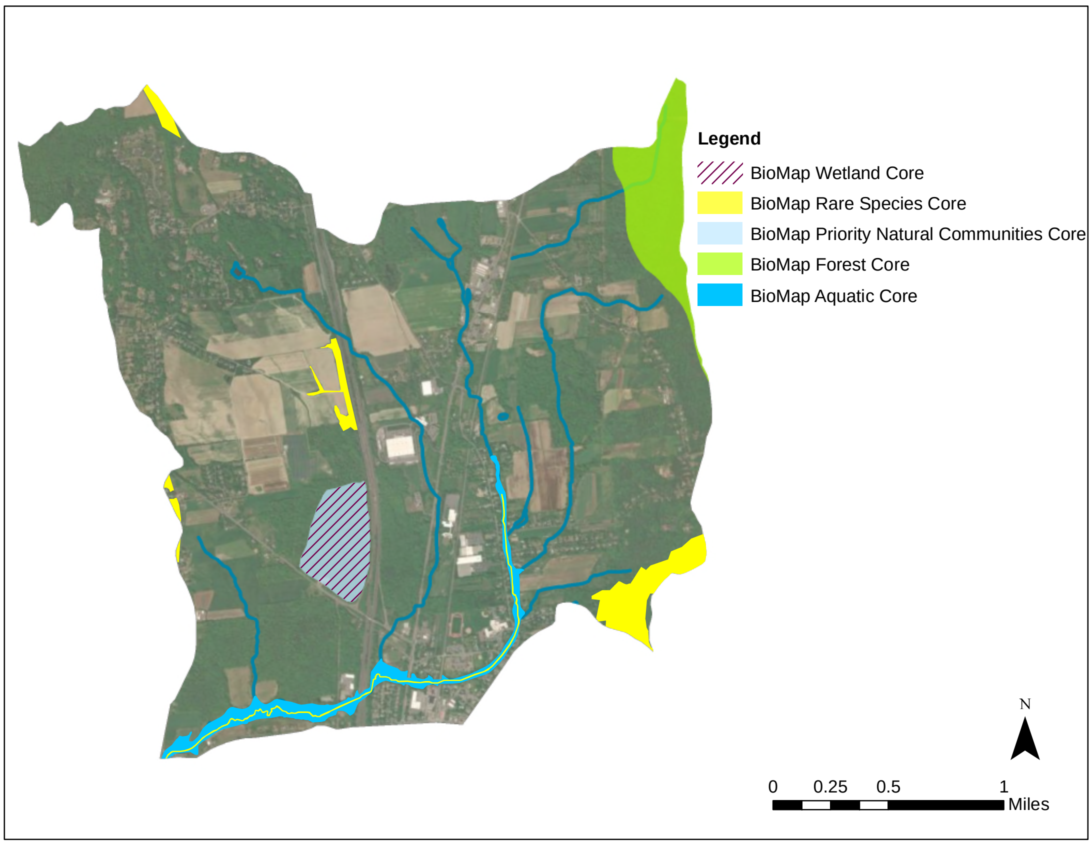


Figure 2: Watershed BioMap Core Habitats (MassGIS 2022)

[2] Town of Whately 2021

[3] *2018 – 2020 Integrated List of Waters* Assessment Appendix 15: Connecticut River Assessment and Listing Decision Summary, November 2021: https://www.mass.gov/doc/20182020-integrated-list-of-waters-appendix-15-connecticut-river-watershed-assessment-and-listing-decision-summary/download

The watershed contains a large amount of prime farmland soils. The *Deerfield Healthy Soils Report*, published in 2022, identifies soils in Deerfield that are important for carbon capture and storage, and includes recommendations for healthy soil protection and regeneration in Deerfield.[4] The Town is developing tools with which to better protect and promote healthy soils. Agricultural activity is primarily commercial corn, hay, and vegetable production, with other smaller-scale specialty cash crops.

The catchment area for Bloody Brook is 0 to 3% impacted by groundwater withdrawal, suggesting that low flow resulting from groundwater withdrawal is not driving high pollutant concentrations where they are occurring.[5]

Description of the Problem

The Bloody Brook watershed is more developed than most Franklin County watersheds and the brook is not well buffered through these areas. The watershed is listed as impaired for primary and secondary contact recreation and fish, aquatic life and other wildlife uses due to *Escherichia coli* (*E. coli*), TP, turbidity, and dissolved oxygen. The *E. coli* impairment listing is based on MassDEP 2008 data. Source bracketing in 2010 and 2011 by the Connecticut River Conservancy did not locate any clear source. The TP impairment listing is based on MassDEP 2008 data and the source is unknown, although stormwater and agricultural land use are likely. The turbidity impairment listing is based on MassDEP 2008 data and the source is unknown. Dissolved oxygen is below the Massachusetts Surface Water Quality Standard (SWQS) in this watershed, but low dissolved oxygen may be naturally occurring due to more acidic bedrock and the meandering nature of Bloody Brook. Therefore dissolved oxygen is a low priority impairment compared to the others.

Community Concerns

Deerfield residents have three other concerns for the watershed in addition to nonpoint source pollution. First, residents of Deerfield who reside in the Bloody Brook watershed are very concerned about high water table and recurring inundation flooding of the brook. Though the channel is small and flow is slow under normal conditions, the brook's floodplain is flat and wide, causing floodwaters to span large areas during flood events. And although undersized culverts are contributing to localized flooding, hydraulic and hydrologic (H&H) modeling is needed to better understand the high water table and general flood dynamics.[6]

Second, mosquito monitoring in Deerfield has identified larvae of mosquito species that can carry EEE and West Nile Virus.[7] It is important to residents that water quality and flood mitigation measures also reduce mosquito breeding habitat, or at least do not increase mosquito habitat.

Third, residents are concerned about the presence of invasive species in the watershed, and particularly Japanese knotweed along the brook.

---

[4] Regenerative Design Group, 2022: https://www.deerfieldma.us/DocumentCenter/View/1044/Deerfield-Healthy-Soils-Report

[5] MassDEP Sustainable Water Management Initiative (SWMI) Interactive Map: https://www.arcgis.com/home/item.html?id=7af08a2ed397404ba3691ec5f03c9431

[6] Email correspondence with Nicolas Miller, Fluvial Geomorphologist at Field Geology Services, April 2024. In August 2024, the Town of Deerfield was awarded an MVP Action grant to conduct H&H modeling of the watershed.

[7] Monitoring has found host species, not actual cases of mosquito larvae carrying EEE or West Nile Virus.

Summary of Completed and Ongoing Work

Town Planning

The Town of Deerfield and the FRCOG have a history of successfully planning for and implementing watershed improvements. In the 1990s, the FRCOG's work in the Mill River watershed produced the *Wetlands Functional Deficit Analysis of the Mill River Watershed* study (1999) and *An Assessment of Nonpoint Source Pollution in the Mill River Watershed* land use report and recommendations (1999). In recent years, the Town, with the assistance of the FRCOG, has completed a number of planning projects with stormwater management elements, including the *Deerfield Open Space and Recreation Plan* (2014), the *Deerfield Tree Inventory* (2016), *Town of Deerfield Tree Planting and Maintenance Plan* (2018), *Ecological Resilience in Deerfield: Trees as Living Infrastructure* (2018, with the Conway School of Landscape Design), the *Deerfield Hazard Mitigation Plan* (2020), and the *Sustainable Stormwater Management Plan for Franklin County* and *Stormwater Technical Report for Complete Streets Pilot Communities* (2021). The Town's *Downtown Deerfield Complete Streets and Livability Plan* (2012) and the *Municipal Vulnerability Preparedness Plan for Deerfield Summary of Findings* (2018), has also provided information on stormwater management issues, solutions, and opportunities for co-benefits.

Road Infrastructure Assessment and Upgrades

In 2021, FRCOG conducted an assessment of all non-bridge drainage infrastructure in Deerfield. The *Town of Deerfield Culvert Assessment* (2021) and accompanying ArcOnline map has each culvert and stormwater drain mapped and rated for condition.[8] The dataset does not specify whether storm drains connect to the sewer system or directly to a waterway, but it is assumed that many storm drains discharge directly to the brook (see Figure 3 for an example).

Tributaries in the Bloody Brook Watershed are not as flashy as some of the tributaries in the Deerfield River watershed where residents have seen severe road damage and infrastructure damage in recent years. The Town of Deerfield has an ongoing commitment to improving road-stream crossings and stormwater infrastructure across town, as seen with the Mill Village Road culvert replacement (2020), the Kelleher Drive culvert replacement (2021), culvert and stormwater improvements on Wapping, Pine Nook, and Greenfield Roads (2021 through 2023), the Lower Road culvert replacement (2023), and ongoing mitigation of erosion on River Road.

Figure 3: Stenciled storm drain in Frontier Regional High School parking lot reads "Goes to the Brook!"

[8] FRCOG 2021: https://frcog.maps.arcgis.com/apps/instant/attachmentviewer/index.html?appid=4892ed08f4aa486395c1c25779668e66

Zoning

Nonstructural measures to mitigate stormwater issues in Deerfield include the Deerfield Stormwater Bylaw, whose purpose is to "protect the public health, safety, environment, and general welfare by establishing requirements and procedures for new development and redevelopment to prevent water pollution and maintain groundwater recharge as provided by the Stormwater Bylaw of the Town of Deerfield."[9] The bylaw requires a stormwater management plan demonstrating that a project will meet stormwater performance standards and encourages improved site design and nonstructural controls in the form of Low Impact Development Credits.

In 2021, residents adopted Site Plan Review Green Development Standards (that apply to all uses requiring site plan review in Section 5410). The standards include nonstructural NPS reduction measures such as:

- Limits to site disturbance
- Tree preservation
- Landscaping and water reduction
- Protection and buffering of land in agricultural use
- Storage of hazardous materials
- Construction waste management and topsoil recovery

The Planning Board developed proposed zoning bylaw and subdivision regulation changes that, among other green and climate resilient design elements, includes regulations for landscaping and water reduction and incentives for green roofs and permeable pavement.

Municipal work under MVP Action Grants

The Town of Deerfield was among the first communities in Massachusetts to become certified under the Municipal Vulnerability Preparedness (MVP) program. Deerfield has been actively engaged in planning for climate resiliency and climate action in ways that have vast benefits for water quality. MVP Action grants over several years (FY18, FY19, FY20, FY22, FY23, and FY24) have funded an array of water-quality related work:

Green Infrastructure Policy

- Implementation of the Green Infrastructure Policy via monthly meetings of the Green Infrastructure and Climate Resiliency Committee, a policy implementation action plan, and implementation activities.

Healthy Soils Report

- Public presentations and identifications of public priorities and actions for soil preservation and enhancement following the publication of the Deerfield Healthy Soils Report.

Climate Forum 2020

- A townwide forum on "Climate Resiliency: Deerfield 2030 that included green infrastructure strategies for Deerfield and a "Complete and Green Streets" design charrette.

---

[9] Town of Deerfield, 2011

"Land Conservation Plan for the Deerfield River Floodplain"

- A plan for protecting key land parcels in the Deerfield River floodplain that contribute to the town's resiliency to flood impacts and protection of a water quality buffer.

Green Infrastructure and Nature Based Solutions Projects

- Engineering design, construction, and installation of tree box filters at the following locations:
  - South Main Street
  - Elm Street
  - North Main Street
  - Elementary School
- Creation of rain garden designs for Frontier High School and rain garden installations in the playground area at Deerfield Elementary School.
- Installation of a new front entrance with three rain gardens and additional plantings the Deerfield Elementary School.
- Storm drain stenciling at the major drainage structure for the Frontier High School parking lots.
- Engineering design plans for a new green parking lot at Frontier Regional High School that incorporates porous asphalt in the parking spaces, and rain gardens and infiltration trenches to recharge the remaining stormwater runoff.
- Engineering design plans and construction of a new green municipal parking lot (the Leary Lot at 59 North Main Street). The parking is being designed to an estimated 1.8 – 2 million gallons of water.

Culvert Replacement

- Kelleher Drive culvert

Pollinator Habitat

The Franklin Conservation District is wrapping up a lawn-conversion project in the Bloody Brook watershed in which a pollinator buffer was installed along Bloody Brook where it passes between the Town Hall and the Elementary School. In the fall of 2024, the project will also sponsor property visits and consultation by a river scientist for interested residents in the Bloody Brook watershed.

Funding for Hydraulic and Hydrologic Assessment of the Bloody Brook

The Town of Deerfield was awarded an FY25 MVP Action grant to conduct hydraulic and hydrologic (H&H) modeling of the Bloody Brook watershed. An H&H study model will evaluate drainage and flooding dynamics in the watershed to better understand development and restoration scenarios and support the development of stormwater BMPs, as well as brook or wetland restoration projects.

Watershed-Based Plan Development

Project Partners and Stakeholder Input

This WBP was developed by the Franklin Regional Council of Governments (FRCOG) with input and collaboration from the Town of Deerfield and MassDEP and with technical assistance from Comprehensive Environmental, Inc (CEI). This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using [MassDEP's Watershed-Based Planning Tool.](#) The FRCOG was the recipient of Section 319 funding in Fiscal Year 2020 to serve as the Regional Nonpoint Source Coordinator for Franklin County for the purpose of developing competitive s.319 Nonpoint Source Pollution grant proposals. Core project stakeholders include:

- Town of Deerfield:
  - Kayce Warren, *Town Administrator*
  - Chris Curtis, *MVP Committee*
  - Peter Law, *Conservation Commission*
- Massachusetts Association of Conservation Districts:
  - Michael Leff, *Executive Director*
- Franklin Conservation District
  - Carolyn Shores Ness, *Chair*
  - Meghan Siudzinski, *Grants Administrator and Public Outreach Coordinator*
- Connecticut River Conservancy
  - Andrea Donlon, *Massachusetts River Steward (through 2022)*
- MassDEP
  - Padmini Das, *Nonpoint Source Pollution Section Chief*
  - Malcolm Harper, *s.319 Grant Program Manager*
  - Judith Rondeau, *Nonpoint Source Watershed Specialist and Outreach Coordinator*
  - Meghan Selby, *604b Grant Program Manager*
  - Matthew Reardon, *TMDL Program Manager*

This WBP was developed as part of an iterative process. An initial conversation was held in August 2021 with Selectboard member Carolyn Shores Ness and presentation was given by FRCOG staff to the Deerfield Selectboard in September 2021 seeking approval and support to develop a WBP, which was granted. In October 2021, FRCOG staff conducted a windshield survey (walking and driving) of the watershed and wrote up observations in the *FRCOG Nonpoint Source Field Assessment of the Bloody Brook Watershed*. In February 2022, FRCOG staff presented to the Deerfield Selectboard on work completed so far, with the general findings of the walking and driving tour.

In March 2022, FRCOG staff met with three members of the Conservation Commission to present the findings of the windshield survey and hear their water quality concerns for the watershed. On April 14, 2022, FRCOG staff and two members of the Conservation Commission accompanied a CEI staff engineer on a walking and driving tour of the watershed.

FRCOG staff met with the Franklin Conservation District's (FCD) Meghan Siudzinski in May 2023 to discuss potential synergies between the FRCOG's Bloody Brook watershed-based planning and the FCD's municipal pollinator project focused on the Bloody Brook Watershed. In June 2023, FRCOG staff met with FCD and Conservation Commission representatives about resource concerns and current projects in the watershed. The group proposed the creation of a resource for communicating best practices for stewardship in the Bloody Brook watershed. This project was taken on by FRCOG staff in collaboration with the FCD and review by the Conservation Commission.

The public review draft of the Bloody Brook WBP was posted on the Town website on September 9, 2024 for a two-week review. The public review draft was read by and discussed at an MVP Core Team meeting on October 10,

2024. Revisions were completed in December to reflect Town and community feedback. A final draft plan was submitted to MassDEP in October 2024.

Thanks to a long-standing, robust planning effort and ongoing project development to improve water quality, reduce flooding, and increase climate resilience in Deerfield that was heavy on engagement, it was decided that Town staff were in a position to provide sufficient information about the community's needs and goals.

This WBP is meant to be a living document. It should be reevaluated at least once every three years and adjusted as needed based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). It is recommended that the Town of Deerfield assign a new or existing working group to the stewardship of this plan, one that can meet regularly to implement and update this WBP and track progress. The Town of Deerfield has demonstrated an excellent capacity to secure grant funding for watershed-based projects and should continue to be supported by regional and state partners in these efforts.

Water Quality Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by data from additional studies and a watershed field investigation, including:

- DEP. 2013. *Connecticut River Watershed 2008 DWM Water Quality Monitoring Data*. DWM Control Number CN 322.1.
- DEP. 2021. *Massachusetts Integrated List of Waters for the Clean Water Act 2018/20 Reporting Cycle Appendix 15 Connecticut River Watershed Assessment and Listing Decision Summary*. Draft for Public Comment.
- PVPC. 2011. *Connecticut River Bacteria Monitoring Protect Final Report*. 604b Project #2009-13/AARA 604. Project conducted in partnership with the Connecticut River Watershed Council and Massachusetts Water Resources Center at UMASS Amherst.
- FRCOG. *NPS field investigation of Bloody Brook*. October 6 and 7, 2021
- Rhodes, Amy and Laurie Sanders. 2000. *Report to the Krusos Foundation on the Mill River Watershed Project*. Smith College.
- FRCOG. 1999. *Wetlands Functional Deficit Analysis of the Mill River Watershed*. Produced for the FRCOG.
- UMass Department of Landscape Architecture and Regional Planning. 1999. *Non-Point Source Pollution in the Mill River Watershed: Land Use Assessment and Recommendations*. University of Massachusetts Amherst, produced for the FRCOG.

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

Water Quality Impairments

Waterways or bodies with weakened water quality that do not meet Massachusetts SWQS are considered impaired. In the context of water quality regulation, impaired waters are those listed by MassDEP under Section 303(d) of the Clean Water Act as impaired by a pollutant, such as a pathogen or nutrient, or by other kinds of alterations, such as temperature or low flow conditions. Known water quality impairments, as documented in the MassDEP 2022 Draft Massachusetts Integrated List of Waters,[10] are listed in Table A-1. Impairment categories from the Integrated List are as follows in Table A-2.

Table A-1: 2022 MA Integrated List of Waters Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

[10] MassDEP 2022

Table A-2: Water Quality Impairments (MassDEP 2022)

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA34-36	**Bloody Brook**	**5**	Primary Contact Recreation	Escherichia Coli (*E. coli*)	Source Unknown
MA34-36	**Bloody Brook**	**5**	Fish, other Aquatic Life and Wildlife	Phosphorus, Total	Source Unknown
MA34-36	**Bloody Brook**	**5**	Primary Contact Recreation	Turbidity	Source Unknown
MA34-36	**Bloody Brook**	**5**	Secondary Contact Recreation	Turbidity	Source Unknown
MA34-36	**Bloody Brook**	**5**	Aesthetic	Turbidity	Source Unknown
MA34-36	**Bloody Brook**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown

Water Quality Data

MassDEP Water Quality Assessment Report and TMDL Review

A Water Quality Assessment Report is a detailed report on the condition of a watershed that assesses watershed conditions, perceived problems, and provides recommendations for each MassDEP-defined stream segment of a watershed. The section below summarizes the findings of the Connecticut River Watershed 2003 Water Quality Assessment Report that relate to water quality and water quality impairments. Select excerpts from this document relating to the water quality in the watershed are included below (note: relevant information is included directly from these documents for informational purposes and has not been modified).

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34-36 - Bloody Brook)
AQUATIC LIFE DWM conducted water quality sampling at Whately Road in Deerfield, Station BB01, on this segment of Bloody Brook between April and October 2003 (Appendix B and E). Pre-dawn and early morning dissolved oxygen concentrations were generally low, ranging from 1.6 to 7.9 mg/L. Three of the six measurements were less than 4 mg/L. Total phosphorus concentrations were very high, ranging from 0.058 to 0.16 mg/L. Conductivity measurements also were elevated. Bloody Brook is assessed as impaired for the Aquatic Life Use based on the low dissolved oxygen concentrations and the elevated total phosphorus. **PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS USES**

DWM collected *E. coli* samples from Bloody Brook at Whately Road in Deerfield (Station BB01) between April and November 2003 (Appendix B). The geometric mean of these samples was 251 cfu/100ml.

DWM personnel made field observations at Station BB01 on Bloody Brook during surveys conducted between April and October 2003. Aquatic weeds such as duckweed were recorded as objectionable deposits on one occasion. An oily sheen on the water surface was reported during one visit, and pollen blankets were visible on the water surface on two visits. A musty basement water odor was reported on one occasion. Water clarity was noted as highly turbid at this station on six occasions, with the water being slightly turbid during the other two visits (MassDEP 2003).

The Primary Contact Recreation, Secondary Contact Recreation and Aesthetics uses are assessed as impaired based upon the chronic highly turbid conditions documented during water quality surveys. The Primary Contact Recreational Use is also impaired because of elevated *E. coli* bacteria counts.

Report Recommendations:
Investigate the causes of chronic turbidity, low dissolved oxygen, and elevated total phosphorus concentrations observed in Bloody Brook in 2003, and confirm that these issues are still problematic within this segment. Field reconnaissance is recommended to begin to identify sources of the above-mentioned pollutants that have impaired Bloody Brook.

Evaluate whether this segment is a candidate for bacteria source tracking efforts to identify sources of bacteria contamination in this subwatershed.

The forthcoming *Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Inland Freshwater Rivers* from MassDEP will apply to Bloody Brook. The TMDL calculates the percent reduction needed to meet the Massachusetts SWQS based on the highest calculated *E. coli* geomean (in MassDEP's 2008 sampling). See Element B for more information.

MassDFG Biological Monitoring Summary[11]

MassDFG biologists conducted backpack electrofishing in Bloody Brook upstream of the Pleasant Street crossing along North Main Street in Deerfield in July and August 2007 (Sample IDs 2419 & 2140). These samples were both indicative of reasonable conditions for a low gradient stream as they were both dominated by moderately tolerant fluvial specialist and dependent species moderately tolerant to pollution.

MassDEP Water Quality Monitoring Data, 2008[12]

MassDEP staff conducted water quality monitoring in Bloody Brook at Whately Road in Deerfield (W1063) during the summer of 2008. During the five-day unattended continuous probe deployments for dissolved oxygen (DO) and temperature in May, June and July a minimum DO of 0.2mg/L was recorded (mean minimum DOs were low ranging from 0.20 to 2.8mg/L), the maximum DO saturation was 65%, and the maximum temperature was 21.2°C. The attended probe data can be summarized as follows: pH ranged from 6.0-6.4SU; maximum temperature 20.2°C; minimum DO 0.3mg/L, maximum saturation 61%.

The geometric mean of the 2008 *E. coli* data was 231.2 CFU/100 ml. The seasonal average total phosphorus concentration was 0.089mg/L (maximum 0.12mg/L). No observations of dense/very dense filamentous algae

[11] DEP 2021
[12] DEP 2012

were noted. Flows were described as stagnant during three of the five surveys. At the time, the Aquatic Life Use for Bloody Brook was again assessed as Not Supporting with the dissolved oxygen and total phosphorus impairments being carried forward.

Table A-3: DEP Monitoring 2008

Location: Whately Road, Deerfield (BB01)

Station ID	Start Date	Water Clarity	Total D.O. (mg/L)	Ammonia (mg/L)	*E. coli* (CFU/100 mL)	Suspended Solids (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	True Color (PCU)	Turbidity (NTU)
BB01	5/06/08	Slightly turbid	--	0.08	92	2.3	0.68	0.038	16	1.7
BB01	5/30/08	Mod. Turbid	2.9	--	--	--	--	--	--	--
BB01	6/03/08 6/04/08	Highly Turbid	2.5	0.20	108	5.0	0.85	0.093	31	8.2
BB01	6/27/08	Highly Turbid	3.0	--	--	--	--	--	--	--
BB01	7/01/08	Highly Turbid	5.4	0.18	230	6.2	0.81	0.094	43	9.8
BB01	7/25/08	Highly Turbid	5.50	--	--	--	--	--	--	--
BB01	7/29/08 7/30/08	Mod. Turbid	0.3	0.10	410	3.3	0.88	0.098	34	4.9
BB01	9/03/08	Highly Turbid	--	--	170	--	--	--	--	--
BB01	9/09/08	Highly Turbid	--	0.13	960	3.6	0.95	0.12	45	5.4

PVPC Connecticut River Bacteria Monitoring Project

In September 2009, MassDEP collected several bacteria samples on Whately Road (BBD1) and got a reading of 960 CFU/100mL. In 2010 and 2011, the Pioneer Valley Planning Commission and the Connecticut River Conservancy sampled fourteen sites in the Bloody Brook watershed as part of the Connecticut River Bacteria Monitoring Project (604b Project #2009-13/ARRA 604).[13] The sampling data attempted to further identify source locations for the *E. coli* impairment identified by the DEP, but the variable sample data did not confidently identify particular source locations. According to the Deerfield Health Agent, the original high readings by MassDEP at BBD1 were likely attributable to two failed septic systems that were later repaired. The Health Agent also

[13] PVPC 2011

suspected high levels at BBD3, BBD3.1, BBD4, and BBD4.1 were caused by sewer exfiltration.[14] The geometric mean of the 2010-2011 data was 286.9 CFU/100mL.

Table A-4: Connecticut River Conservancy Monitoring
Bloody Brook Bacteria Results 2010 - 2011

Results are shown as E. coli MPN/100 mL
Tier 2 sites = selected for initial screening
Tier 3 = monitored because Tier 2 sites suggested contamination in the vicinity

Site ID	Tier	Location	8/4/10	9/1/10	9/21/10	10/20/10	6/28/11	Geometric Mean
BBD1	2	Whately Rd. along N-S-running road segment upstream side of bridge	71.70	152.00	67.00		816.40	156.25
BBD2	2	Northern trib @ upstream side of Conway Street	2419.60*	2419.60*	1203.30		193.50	1422.6
BBD2.1	3	Northern trib, upstream of Rte 116				139.60		--
BBD2.2	3	Northern trib, east side of Rtes 5/10				235.90		--
BBD3	2	Routes 5 & 10	727.00	547.50	206.40		365.40	416.24
BBD3.1	3	BB behind library, upstream of culvert to school				866.40	365.40	562.65
BBD4	2	Pleasant St. near North Main St.	579.40	488.40	461.10		410.60	481.10
BBD4.1	3	BB, just downstream of Kelleher Drive				517.20	387.30	447.56
BBD4.2	3	Capt. Lathrop Dr. downstream walk thru backyard					122.30	--
BBD5	2	Capt. Lathrop Dr., downstream side		275.50	248.10		146.70	261.44
BBD6	2	Hillside Rd., upstream side					150.00	--
BBD6.1	3	Outfall at Hillside Rd., river right					32.70	--
BBD7	2	Eastern trib on Hillside Rd., downstream side					816.40	--
BBD7.1	3	Outfall on E branch of Hillside Rd.					178.90	--

* 8-4 and 9-1 sample exceeds 2419.6; 10 ml dilution = 7,269.9

[14] PVPC 2011, p. 26

2000 Report to the Krusos Foundation on the Mill River Watershed Project[15]

The 2000 *Report to the Krusos Foundation on the Mill River Watershed Project* contributes additional information about pollutants. This information is summarized here to help inform the selection of appropriate BMPs:

- High level of chloride, likely resulting from road salt mixing with soil and running off into the river
- High concentration of sulfates
- High concentration of nitrates

The reports also highlight that low dissolved oxygen levels may be partly naturally occurring due to the meandering, shallow, and exposed nature of Bloody Brook. The bedrock under Bloody Brook is naturally less alkaline and therefore less able to buffer, raising the acidity level. Together, high concentration of coliform, nitrates, and chloride combined with low alkalinity and dissolved oxygen levels makes aquatic life unable to survive.

Data Gaps

The most recent available data for TP, turbidity, DO, and *E. coli* in Bloody Brook are old (2008). Moreover, this data collection targeted the brook's main stem in the lower watershed. Because there are so many branches of the Bloody Brook, source location cannot be assessed from existing data. Additional monitoring would have to be conducted to determine a focus area for phosphorus and turbidity treatments. However, given the widespread nature of agricultural activity in the watershed, it may be advisable to treat all agricultural areas as potential sources of nutrients and sediment.

E. coli data was collected by the Pioneer Valley Planning Commission and Connecticut River Conservancy in 2010 and 2011, a few years after the *E. coli* impairment was determined by the DEP in 2008. A robust bracketing effort did not find any reliable source locations. Because *E. coli* source assessment is often difficult, and efforts in this watershed have not generated clear results, it is recommended that water quality monitoring efforts after BMP implementation be used to further evaluate the *E. coli* impairment and possible source areas.

The water quality standard for DO stipulates that where natural background conditions are lower, DO shall not be less than natural background conditions. The background DO rate is unknown, but the possibility that low dissolved oxygen levels may be partly naturally occurring due to the meandering nature of Bloody Brook indicates that DO in Bloody Brook may be naturally lower.[16]

Land Use and Impervious Cover Information

Land use information and impervious cover is presented in the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).

[15] Rhodes and Sanders 2000

[16] Rhodes and Sanders 2000

Watershed Land Uses

Table A-5: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Agriculture	1182.67	33.7%
Commercial	84.25	2.4%
Forest	1403.8	40%
High Density Residential	112.47	3.2%
Highway	91.03	2.6%
Industrial	105.52	3%
Low Density Residential	415.87	11.9%
Medium Density Residential	27.03	0.8%
Open Land	83.31	2.4%
Water	2.5	0.1%

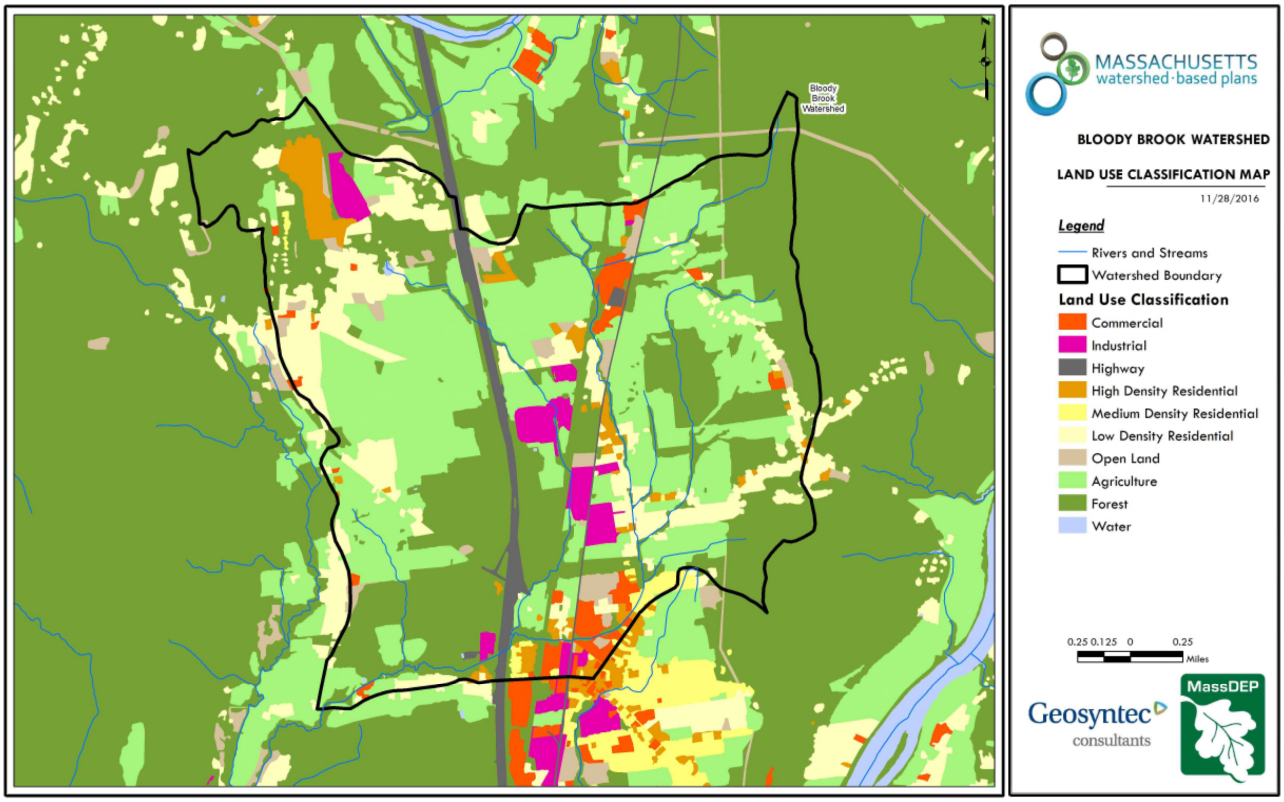


Figure A-1: Watershed Land Use Map (MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc.

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with greater efficiency than disconnected impervious cover areas that are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. USEPA provides guidance on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the **total impervious area (TIA)** of a watershed.[17] Within

[17] USEPA 2010

each subwatershed, the total area of each land use were summed and used to calculate the percent TIA (Table A-6).

Table A-6: TIA and DCIA Values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
Bloody Brook	8.3	6.1

The relationship between TIA and water quality can generally be categorized as shown in Table A-7:[18]

Table A-7: Relationship between Total Impervious Area (TIA) and water quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0-10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of "urban drainage", with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

[18] Schueler et al. 2009

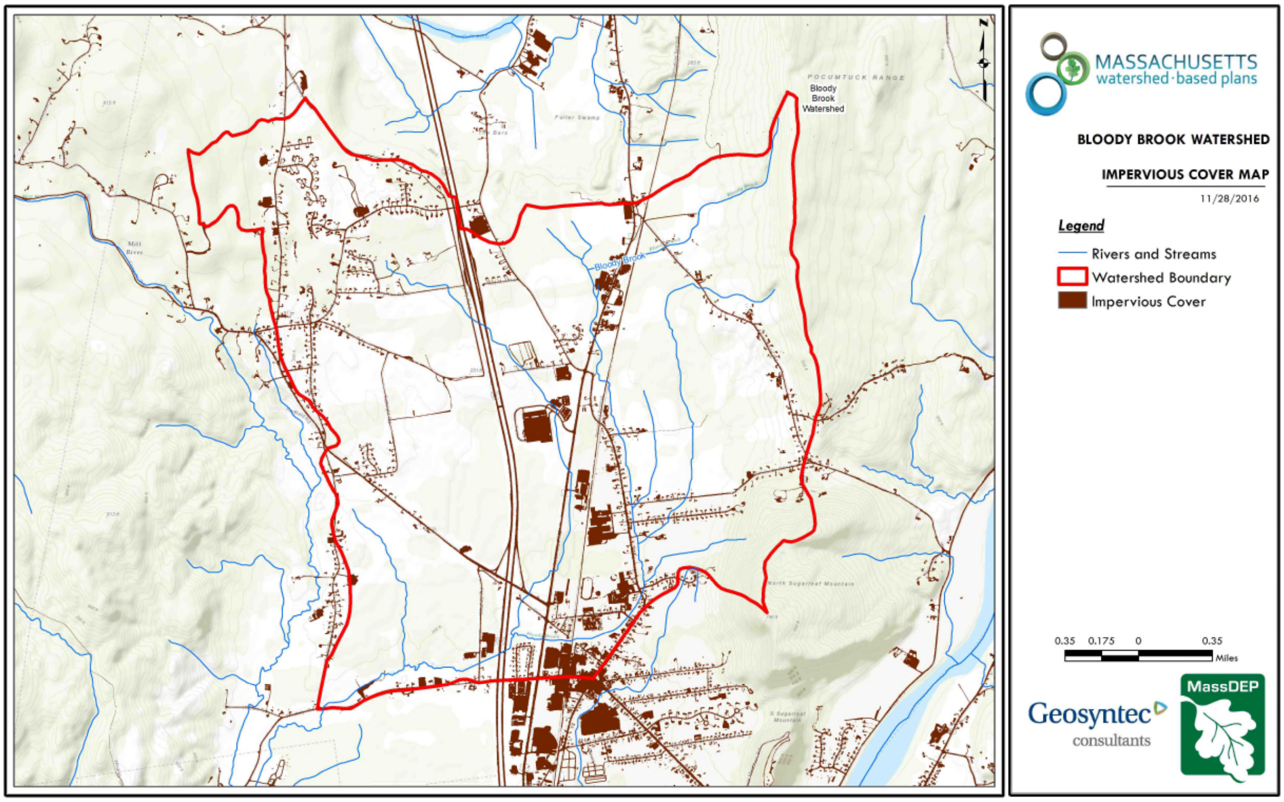


Figure A-2: Watershed Impervious Surface Map (MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Ctrl + Click on the map to view a full sized image in your web browser

Pollution Sources

Bloody Brook is thought to have a widely disbursed sources of pollution, the major sources being stormwater runoff from developed areas with high impervious surface, landscaping practices, and agriculture.

Agriculture

There are roughly 120 acres of land in active agriculture (hay or crops) within the 200-foot buffer in the watershed.[19] There is no livestock evident in the buffer in agricultural fields.[20] A few farm operations are based in the Bloody Brook watershed, with numerous others using fields in the watershed for corn, hay, or other commercial crops. There are no dairy operations in the watershed. Small-scale livestock operations were observed in the watershed, including one residence where waterfowl was fenced into a small pond close to the mainstem. The use of manure as fertilizer in the watershed is a possible contributor of bacteria loading. Synthetic fertilizers in the watershed are a likely contributor of phosphorus. Some soil erosion in the form of rilling was observed on an uncropped field during FRCOG's October 2021 NPS field investigation of Bloody

[19] Desktop analysis using GoogleEarth (2020 imagery); the analysis did not differentiate between hay and crops
[20] FRCOG 2021 (*NPS field investigation of Bloody Brook)*

Brook, suggesting that agricultural soil erosion could be a source of turbidity, as well as nutrient and bacteria transport.

Forest and Forestry

Forest represents only 40% of the watershed. The forested areas are found mostly at the brook's headwaters along the Pocumtuck Range and in the northwest corner of the watershed, and in the lower watershed around Whately Road. It is unknown but unlikely that any large-scale logging has occurred in recent years in the watershed, given how few larger areas there are with single ownership.

Groundwater Withdrawal

The MassDEP Sustainable Water Management Initiative Interactive (SWMI) Map ranks HUC-12 watershed subbasins to show levels of impact on stream flow from groundwater withdrawal, based on percent of August median flow represented by August groundwater withdrawals. When groundwater withdrawal significantly impacts streamflow rates, pollutants appear more concentrated than under normal flow conditions.

In the Bloody Brook watershed, groundwater is withdrawn for private wells only. Based on data last updated in 2013, the catchment area for Bloody Brook is listed as 0 to 3% impacted. This demonstrates that the Bloody Brook generally maintains the level of flow expected for a watershed its size, and suggests that low flow resulting from groundwater withdrawal is not driving high pollutant concentrations where they are occurring.

Hydromodification

The Bloody Brook stream channel has been straightened and channelized throughout the upper and middle watershed. Historical heavy channel management facilitated residential, commercial, and civic development alongside the brook, some of which is within the 100-foot buffer zone and the 200-foot Riverfront Area. As a low-gradient stream, Bloody Brook is not experiencing a large amount of erosion, but hydromodification is likely leading to increased flooding, leading to further NPS contamination as floodwaters sweep up NPS and return it to the stream system. For example, in the late 1990s Bloody Brook was ditched/channelized along Mill Village, Hillside, and North Hillside Roads to reduce localized flooding, which prevents the brook from accessing its floodplain at that location.[21]

Landscaping

A riparian stream buffer is absent along much of Bloody Brook; many residential, commercial, and agricultural landowners mow or farm to the edge of Bloody Brook. There are approximately 11,000 linear feet of brook with less than a 10-foot buffer from an adjacent residential, commercial, or agricultural land use.[22]

Excess nitrogen and phosphorus from lawn fertilizers are possibly a significant contributor of pollutant loading to the Bloody Brook, as industrial and commercial operations, as well as some residences, maintain large lawns.

---

[21] FRCOG 1999

[22] Desktop analysis using GoogleEarth (2020 imagery)

According to the 2018 *Deerfield Hazard Mitigation Plan*, Deerfield residents that live along the Bloody Brook commonly dump yard waste (leaves, grass clippings, etc.) into or near the edge of the brook.[23]

Mining

There are no gravel or other mining operations present in the Bloody Brook watershed.

Roads

Paved roads dominate in the watershed. There are 2 miles of unpaved roads, predominantly used for agricultural purposes in flat areas, so are therefore less prone to erosion.

There are a large number of road crossings where there is little buffer between the road and the brook.

Road Drainage Infrastructure

Most stormwater drains to catch basins that are located intermittently along roads. Failing culverts and full catch basins are potential sources of nonpoint source pollution because stormwater can subvert these drainage structures instead sediment settling out of them or stormwater being properly conveyed by them, potentially resulting in erosion and sedimentation during high flows. The FRCOG conducted a culvert assessment for the Town of Deerfield in 2021, finding approximately 30 drainage structures in poor or critical condition within the watershed.[24] Critically failing drainage structures found in 2021 were more likely to be along Hillside Road, one of the steepest roads in the watershed.

These structures offer an opportunity for pre-treatment and/or infiltration of stormwater instead of collection and conveyance of stormwater directly to the brook. Ultimately, capturing and infiltrating stormwater before it reaches a stormwater drain is best practice. But upgrading or replacing these structures with deep sump catch basins, leaching catch basins, infiltration trenches, or sediment traps/settling basins at outfalls can also be an important part of a BMP strategy for reducing sediment and other pollutant loading to the brook.

According to the 2020 Hazard Mitigation Plan, there are beaver dams located on the brook in three areas in the lower watershed, where the brook parallels Whately Road. It is possible the DEP's 2008 monitoring site (W1063) located on Whately Road may have been influenced by the presence of beavers.

Septic and Sewer

Though the Board of Health reports that there have been no problem areas recently, a few areas in the watershed have historically had septic/sewer issues due to having been built on soils listed as having severe limitations for septic tank effluent disposal. Issues noted back in the late 1990s were located at:[25]

- Houses in Mill Village Road area during periods of flooding/high water table
- Houses on Hillside and North Hillside Roads

[23] Town of Deerfield 2018
[24] FRCOG 2021 Town of Deerfield Storm Water Drainage Assessments
[25] FRCOG 1999

A 2021 I&I report finds that there are no sanitary sewer overflows (SSOs) throughout the Deerfield municipal sewer system.[26]

Stormwater Runoff from Development

Stormwater runoff from developed areas is likely a major source of the bacteria, phosphorus, and turbidity in the Bloody Brook. Stormwater runoff can transport bacteria, sediment, and nutrients to water resources from all land surfaces, but the concentrations from pollutants increase dramatically in developed areas where there is a greater presence of impervious surface. South Deerfield Village, in the middle watershed, contains residential, commercial, and civic development and a large portion of the connected impervious surface (DCIA) in the watershed. These types of development and associated roads can carry bacteria and nutrients from pet waste, nutrients from lawn fertilizers, road salt/sand, and sediment from landscaping or construction projects, among other pollutants. In the upper watershed, there is also a concentration of commercial land uses along State Routes 5/10, south of the North Hillside Road intersection.

Hazardous Waste Materials

There are potential sources of toxic hazardous waste materials throughout the watershed, particularly associated with vehicle and equipment storage, but likely also agricultural products. These source areas include commercial parcels in South Deerfield Village and farm parcels in the upper watershed.

Businesses such as Pelican Products and Yankee Candle handle larger quantities of hazardous chemicals, but these hazardous materials are seen as being at low risk of uncontrolled release. [27]

There are five underground storage tanks in the watershed at 126 Whately Road, the Verizon facility on Conway Street, 176 North Main Street, 183 North Main Street, and 236 Greenfield Road.[28]

Analysis of Land Use as a Source of Impairments

Despite having an estimated total impervious surface area below 10%, the Bloody Brook watershed is not demonstrating the high-quality structural and biological characteristics typical of a watershed in that range. One contributing factor may be that despite having low percentage, the two largest channels of Bloody Brook flow through South Deerfield Village, the area of town with the highest concentration of impervious cover.

Residential, agricultural, and commercial land use are all suspected sources of nonpoint source pollution in Bloody Brook. Based on the 2021 NPS field investigation of Bloody Brook and desktop analysis using GoogleEarth 2020 imagery, FRCOG staff determined that the upper and lower reaches of the Bloody Brook watershed are dominated by residential and agricultural uses. With a few important exceptions, the brook and its tributaries are well buffered from residential uses in these areas. Agricultural uses may be the dominant concern in these areas.

The greatest impact to the Bloody Brook likely occurs in the middle of the watershed. Here, the branches of Bloody Brook cross the State Routes 5/10 corridor, where numerous commercial and industrial sites have large

---

[26] DPC Engineering 2021
[27] Town of Deerfield 2018
[28] MassDEP Underground Storage Tank Facility Search database, accessed 2/9/2022

areas of impervious surface, lawn, and limited buffer. In the medium-density South Deerfield Village, residential, commercial, and institutional properties have maintained only a minimal buffer between the brook and buildings, driveways, and parking lots. This area contains large amounts of directly connected impervious surface, landscaping, and some hazardous waste storage and agriculture.

As described in the Agriculture, Landscaping, and Roads sections, many areas are lacking a critical riparian stream buffer (Figure A-3 a-b) and (Figure A-4 a-f).

Figure A-3a: Residential driveway, middle watershed

Figure A-4b: Roads, middle watershed

Figure A-3 a–b: Road Crossings over Bloody Brook with No Vegetative Buffer

Figure A-4: General Characterization of Sources of Nonpoint Source Pollution

Figure A-4a: Residential lawn in upper watershed

Figure A-4b: Residential lawn middle watershed

Figure A-4c: Residential lawn middle watershed

Figure A-4d: Residential lawn middle watershed

Figure A-4e: Residential lawn lower watershed

Figure A-4f: Commercial lawn middle watershed

Figure A-4 a – f: Areas of Bloody Brook Edge with No Vegetative Buffer

Water Quality Goals

A water quality goal is a quantitative or qualitative target pollution level in a water body. Water quality goals may be established for a variety of purposes, including the following:

a.) For **water bodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the United States Environmental Protection Agency (USEPA) as the maximum amount of the target pollutant that the waterbody can receive and still safely meet water quality standards. If the waterbody has a TMDL for total phosphorus (TP) or total nitrogen (TN), or total suspended solids (TSS), that information is provided below and included as a water quality goal.

b.) For **water bodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (USEPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 µg/L in any stream at the point where it enters any lake or reservoir, nor 25 µg/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 µg/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2021) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. The Bloody Brook watershed is a Class 'B' waterbody (see Table A-8). Class B is assigned to waters designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06 (of the MSWQS), they shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value (MassDEP, 2021).

Table A-8: Surface Water Quality Classification by Assessment Unit

Assessment Unit ID	Waterbody	Class
MA34-36	Bloody Brook	B

d.) **Other water quality goals set by the community** (e.g., protection of high-quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Table A-9: Water Quality Goals

Pollutant	Goal	Source
Bacteria	**Class B Standards** Concentrations of bacteria in Inland Waters, subject to the reduced interval requirements set forth in 314 CMR 4.05(5)(f)3. as applicable, and except as otherwise provided in the seasonal exception set forth in 314 CMR 4.05(5)(f)4. as applicable, shall, on a year-round basis, satisfy 314 CMR 4.05(5)(f)1.a. for E. coli: i. concentrations shall not exceed 126 colony-forming units (cfu) per 100 mL, calculated as the geometric mean of all samples collected within any 90-day or smaller interval; and ii. no more than 10% of all such samples shall exceed 410 cfu per 100 mL (a statistical threshold value).	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2021)
Total Phosphorus (TP)	Total phosphorus should not exceed 50 ug/L in any stream.	Quality Criteria for Water (USEPA, 1986)
Total Suspended Solids (TSS)	**Class B Standard** These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair anyuse assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota, or degrade the chemical composition of the bottom.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)
Turbidity	Waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2021)
Dissolved Oxygen (DO)	Dissolved oxygen shall not be less than 5.0 mg/L in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2021)

Note: *There may be more than one water quality goal for bacteria due to different Massachusetts Surface Water Quality Standards Classes for different Assessment Units within the watershed.*

Estimated Pollutant Loading

A Geographic Information Systems (GIS) was used for the pollutant loading analysis for TP, TN, and TSS. MassGIS 2005 land use data (MassGIS, 2009b) was intersected with impervious cover data[29] and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data[30] to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

Directly connected impervious area was estimated using the Sutherland equation. Any reduction in impervious area due to disconnection—the area difference between total impervious area (TIA) and DCIA—was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr);

A_n = area of land use/cover type n (acres);

P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (see values provided in Appendix A).[31] Table A-10 lists estimated pollutant loads for the primary nonpoint source (NPS) pollutants total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS) in the watershed.

[29] MassGIS 2009a

[30] USDA NRCS and MassGIS 2012

[31] USEPA 2020; UNHSC 2018, Tetra Tech 2015

Table A-10: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Agriculture	554	3,279	29.85
Forest	198	1,022	40.49
Low Density Residential	90	889	12.25
Industrial	83	734	9.18
Commercial	80	690	8.63
High Density Residential	59	406	5.96
Highway	58	495	23.64
Open Land	21	202	3.99
Medium Density Residential	12	104	1.44
TOTAL	1,155	7,822	135.42

[1]These estimates do not consider loads from point sources or septic systems.

Analysis of Phosphorus Loading

The estimated land use-based phosphorus to receiving waters within the watershed areas is 1,155 pounds per year, as presented by Table A-10. The largest contributor of the land-use based nutrient (phosphorus and nitrogen) load originates from areas designated as agricultural (48 percent of the TP load and 42 percent of the TN load). Agricultural areas provide excellent opportunities for nutrient load reductions through agricultural BMPs.

Forested areas constitute the second largest contributor of phosphorus and nitrogen (17 percent of the TP load and 13 percent of the TN load). Phosphorus generated from forested areas is a result of natural processes such as decomposition of leaf litter and other organic material; the forested portions of the watershed therefore are unlikely to provide opportunities for nutrient load reductions through BMPs.

Low-density residential development, commercial, and industrial land uses accounts for around 10% of TP loading each. Each of these land uses can provide good opportunities for nutrient load reductions through conservation landscaping and water management practices, and stormwater BMPs on public roads, public lands, and private properties.

Estimated *E. coli* Loading

Fecal coliform is more difficult to characterize than other pollutants. Data are extremely variable, even during repeated sampling at a single location. Because of this variability, it is difficult to establish different concentrations for each land use.

Using the Simple Method and the residential roads concentration value from the National Median Concentration for Chemical Constituents in Stormwater for *E. coli*,[32] *E. coli* loading in Bloody Brook is estimated to be 399 CFU/year. This method uses one of the higher concentration rates for urbanized areas (residential roads). Vegetated urban areas and forest will likely have lower bacteria concentrations than represented here, and landscaping areas, pasture, and hayfield with manure application will likely have dramatically higher concentrations.

The simple method for urban stormwater bacterial load calculation:

$$L = 1.03 * 10^{-3} * R * C * A$$

Where: L = Annual load (Billion Colonies)
R = Annual runoff (inches)
C = Bacteria concentration (#/100 ml)
A = Area (acres)
$1.03 * 10^{-3}$ = Unit conversion factor

[32] Schueler 1999

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:
Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for TP (1,155 lbs/year), TN (7,822 lbs/year), and TSS (135.42 lbs/year) were previously presented in Table A-10 of this WBP. Bacteria loading estimates vary widely depending on the modeling method. The *E. coli* loading estimate for Bloody Brook is 399 CFU/year, based on the Simple Method.

Water Quality Goals

Based on the impairments and water quality data identified in Element A, the long-term water quality goal in the Bloody Brook is to reduce bacteria, TP, and TSS loading to the Bloody Brook so that it meets its designated uses for fish, other aquatic life, and wildlife; and primary contact recreation (Table A-2). This plan will focus on TSS loading reductions as a primary method for reducing and meeting the turbidity goal.

- The water quality goal for *E. coli* is based on the MSWQS (MassDEP, 2021), which prescribes the minimum water quality criteria required to sustain a waterbody's designated uses. To meet the standard established in the forthcoming MassDEP *TMDL for Pathogen-Impaired Inland Freshwater Rivers*, bacteria load must be reduced 64% below the highest *E. coli* geomean recorded in 2008 (352 CFU/100 mL).
- The water quality goal for TP is based on EPA criteria of 50 µg-P/L used by MassDEP. The State of Vermont has established combined phosphorus criteria for aquatic biota, wildlife, and aesthetics uses; for example, the assigned criteria for aquatic biota and wildlife in a warm water moderate gradient stream is 21 µg-P/L.[33] This example serves as a possible reference for setting a more ambitious long-term TP goal later in the process.

[33] VT DEC Watershed Management Division 2022: https://dec.vermont.gov/sites/dec/files/documents/2022-Vermont-Water-Quality-Standards.pdf

- A sediment load reduction goal was calculated using the pre-development land cover (100% forested watershed) load as a target. TSS load reduction is expected to aid with bacteria and nutrient load reduction.

It is recommended that background conditions for dissolved oxygen be established through continuous DO monitoring in order to get a more complete picture of daily variations in areas identified as low DO and establish a dissolved oxygen goal, if needed. It is possible that BMPs that reduce sediment, phosphorus, and temperature loading may indirectly increase dissolved oxygen because a) phosphorus can a stimulate excess growth of algae, which leads to low dissolved oxygen levels, b) high concentrations of suspended particles can block sunlight, hindering photosynthesis by aquatic plants and ultimately reducing the amount of oxygen produced, and c) cold water can hold more dissolved oxygen.

It is expected that progress made toward achieving the water quality goals will also result in reductions in nitrogen discharges to the Connecticut River stemming from the Bloody Brook. For nitrogen, the EPA currently recommends a limit of 0.34 mg-N/L for waters entering Long Island Sound based on literature values.[34]

A description of criteria for each water quality goal is described by Table B-1.

[34] O'Donnell 2019

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus	1,155 lbs/yr	946 lbs/yr	210 lbs/yr
Bacteria	*MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading.* The 90-day *E. coli* rolling geomean recorded in 2008 was 352 CFU/100 ml. The pollutant loading estimate for the watershed derived from the simple method is 399 CFU/year per year.	**<u>Class B Standards</u>** Concentrations of bacteria in Inland Waters, subject to the reduced interval requirements set forth in 314 CMR 4.05(5)(f)3. as applicable, and except as otherwise provided in the seasonal exception set forth in 314 CMR 4.05(5)(f)4. as applicable, shall, on a year-round basis, satisfy 314 CMR 4.05(5)(f)1.a. for E. coli: i. concentrations shall not exceed 126 colony-forming units (cfu) per 100 mL, calculated as the geometric mean of all samples collected within any 90-day or smaller interval; and ii. no more than 10% of all such samples shall exceed 410 cfu per 100 mL (a statistical threshold value).	64% reduction
Total Suspended Solids	199 ton/yr	Estimated pre-development loading rate is 103.5 tons/year.	95 tons/yr

TMDL Pollutant Load Criteria

A draft TMDL for Pathogen-Impaired Inland Freshwater Rivers has been prepared by MassDEP. According to the Appendix pages for Bloody Brook, the draft TMDL criteria for Bloody Brook is a 64% reduction of the highest *E. coli* geomean in 2008 (352 CFU/100 mL), which would result in a maximum 90-day rolling geomean of 126 CFU/mL.[35]

[35] Provided to the FRCOG by Matthew Reardon, MassDEP, on April 7, 2022. The surface water quality standard (SWQS) was applied to the rolling geomean for all sample days in the given year within a 90-day window from the first sample event. The statistical threshold value criterion was applied to the single sample results because less than 10 samples were collected within the calendar year at the site. The highest maximum 90-day rolling geomean of the sites was used to calculate the percent load reduction required to meet SWQS.

Element C: Describe management measures that will be implemented to achieve water quality goals

Element C: A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

The following section begins with a general plan for reducing NPS pollution and building flood resilience based on general watershed characteristics in three watershed sections: upper, middle, and lower (Table C-1). Proposed management measures are organized by the categories of structural BMPs, nonstructural BMPs, and agricultural BMPs. *Structural BMPs* are designed to remove pollutants from stormwater runoff or reduce the volume of stormwater runoff. *Nonstructural BMPs* are focused on pollutant reduction, management of pollutants, and preservation of natural features. *Agricultural BMPs*, which could be structural or nonstructural BMPs used in an agricultural setting, are called out separately because of these initiatives are likely best pursued by agricultural liaisons such as MACD.

General Watershed Characteristics, Critical Areas, and Management Strategies

The Pollution Sources section of Element A describes the unique potential NPS pollution sources coming from the upper, middle, and lower watershed sections of the Bloody Brook watershed. Table C-1 lists the general potential sources of NPS pollution, critical areas for treatment, and broad solutions for reducing NPS pollution in each of the watershed sections.

Table C-1: Summary of Potential NPS Pollution Sources and Broad Solutions

Watershed Section	Potential NPS Sources	Critical Areas for Management Measures	Broad Solutions
Upper Watershed Contributing areas north of North Main Street and east and west of the I-91, Routes 5/10, and North Main Street corridors	• Agricultural practices • Residential landscaping • Unpaved roads	• Area of concentrated impervious surface: commercial development along Routes 5/10 south of North Hillside Road intersection. • Agricultural areas in mapped Core Habitat northwest of Route 116 and I-91 and Sandgully Road.	• Increase buffer width • Wetlands restoration • Agricultural BMPs • Landscaping BMPs • Road BMPs

Watershed Section	Potential NPS Sources	Critical Areas for Management Measures	Broad Solutions
		• Sloped agricultural areas in the vicinity of Mill Village Road.	
Middle Watershed I-91, Routes 5/10, and North Main Street corridors	• Impervious surfaces from roads residential, commercial, industrial, institutional development • Residential and other development landscaping	• Areas of concentrated impervious surface: Yankee Candle Corporate offices, Treehouse Brewery, Pelican Products, schools, and Town campus. • Areas of denser residential development and minimal riparian stream buffer in South Deerfield village, particularly along North Main Street.	• Increase buffer width • Stormwater BMPs • Landscaping BMPs • Road BMPs
Lower Watershed Contributing areas southwest of the I-91, Routes 5/10, and North Main Street corridors	• Agricultural practices • Residential landscaping	• Select properties along Whately Road with minimal riparian stream buffer.	• Increase buffer width • Agricultural BMPs • Road BMPs

Structural BMPs

Stormwater BMPs

Structural stormwater BMPs generally fall into the categories of conveyance, pretreatment, and treatment. Treatment BMPs filter pollutants, typically using soils (often engineered) and vegetation (often native). Pretreatment techniques keep a treatment BMP from being overloaded by slowing the flow and settling out sediment and other solids before stormwater reaches a treatment BMP. Pretreatment can be especially helpful when phosphorus pollution is a result of sedimentation. Pretreatment BMPs can include deep sump catch basins, vegetative filter strips, oil/grit separators, and sediment forebays. A treatment train is a sequence of stormwater BMPs that include both pretreatment and treatment. These types of stormwater BMPs can be installed anywhere there is sufficient space, including in road right-of-ways and at public properties, businesses, and residences.

Volume 2 of the Massachusetts Stormwater Handbook provides a wealth of information on structural BMPs both pretreatment, treatment, and conveyance. Outlined here are a few of the most effective BMPs for removing phosphorus:

Rain Gardens

Rain gardens are depressions in the ground filled with sand, soil media, and mulch intended to filter runoff that's directed into it. Rain gardens can remove up to 90% of phosphorus when designed large enough and/or paired with pretreatment systems. These structures can be lined and piped to prevent infiltration in high pollutant areas or left unlined to allow for exfiltration and groundwater recharge (MassDEP, 2016b). Co-benefits of rain gardens is the opportunity to install pollinator friendly plant species and provide native habitat. These systems are especially effective at treating the "first flush" aka initial runoff of stormwater, which contains the most amount of nutrient pollution.[36]

Infiltration Basins

Infiltration basins are impounded sections that catch stormwater runoff, usually by way of a pretreatment basin. As the name suggests, these systems allow stormwater to infiltrate and are sometimes constructed with more than one chamber to catch varying amounts of volume. Infiltration basins are estimated to remove 60%-70% of phosphorus if constructed properly. It should be noted that infiltration basins should be sited some distance away from steep gradients (15% or more) in order to properly capture and retain stormwater.

Bioswales aka Water Quality Swales

Bioswales are shallow linear depressions that collect, slow down, and absorb stormwater from nearby areas. Bioswales can be landscaped with native plants, or simply seeded with grass to reduce maintenance need. At times, rock veins or rip rap are installed along the bioswale to reduce stormwater velocity, allowing more of the water to infiltrate and alleviate flashy flow conditions. Bioswales can be one of the most effective ways to remove phosphorus with an estimated removal rate similar to rain gardens and bioretention basins (20% - 90%). They are excellent ways to capture water along roadsides and driveways with curb cutting or sheet flow directed into them.

Infiltration Trenches

In situations where space is limited, an infiltration trench can remove significant phosphorus (40% - 70%). Infiltration trenches are typically linear rectangular trenches filled with sand, gravel, and stone substrate that runoff is directed into and allowed to exfiltrate through the bottom into the subsoil.

Media Filters (Sand, Organic or Proprietary Media Mix)

For a less visible BMP, media filters provide filtration of stormwater underground in a two-chamber concrete system filled with media tailored to remove phosphorous. This media could be a mix of sand, loam, peat, mulch or other removal material such as steel wool.

In order to properly design and prioritize structural measures, it is recommended to reference the planned H&H model for future flow rates in the Bloody Brook watershed (funded by a FY25 MVP Action Grant). BMPs can be designed for future storm sizes. In 2020, the MassDEP Stormwater Advisory Committee presented recommendations for updating the MassDEP Wetlands Regulations and Stormwater Handbook that included

[36] Zeng 2019

replacing the use of the Rainfall Frequency Atlas (TP40) with NOAA Atlas 14 and calculating stormwater estimates based on 90% of the upper bound of the 90th percentile confidence interval (a method referred to as NOAA14+).[37] Some communities are practicing NOAA14++ and basing stormwater estimates on the upper bound of the 90th percentile confidence interval. Using the New Salem, MA weather station, the NOAA14+ method estimates the following rainfall amounts for 24-hour storms:

100-year interval/24-hour storm:	10.8 inches
10-year interval/24-hour storm:	5.57 inches
2-year interval/24-hour storm:	3.47 inches

The depth to the water table and appropriate soils (not clay or soils with a high percentage of fines) are important for infiltration BMPs to function properly. There must be adequate separation between the seasonal high water table and permeable soils to retain and/or infiltrate surface runoff. The water table is very shallow in parts of South Deerfield, so screening for adequate soils and depth to the water table early in the BMP selection and siting process is key. There are engineering options for addressing challenging site conditions, including the use of amended soils and piping stormwater that has been filtered (cleaned) through a bioretention area in to an existing storm drainage system.

Proposed Management Measures

The FRCOG performed a field investigation in the Bloody Brook watershed on October 6 and 7, 2021 to identify potential nonpoint pollution sources and potential structural BMPs that may be implemented to reduce pollutant loads to Bloody Brook. All developed portions of the watershed within 200 – 400 feet of the brook or its tributaries were visited. The parcels with hotspot scores over 60 (see Appendix C: Hotspot Analysis and Map) were affirmed as potential sites for BMPs, based on ownership and site conditions. The following locations in bold were identified by CEI in their *Stormwater Improvement Opportunities* Technical Memorandum as viable locations for retrofits.

- **Frontier Regional High School (public)**

  The Frontier Regional School parcel has a single large school building, extensive parking and access roadways, tennis courts, and other pervious ball fields located to the northwest. This parcel includes approximately 8.2 acres of impervious area, the third highest in the watershed. Stormwater from the parking lots that flow to catch basins located on or near the site likely flow untreated directly to Bloody Brook, as indicated by the storm drain stencil in Figure 3. Potential additional stormwater retrofits at Frontier Regional include:

  - Allocate more parking lot space on the outer edge to retrofit as bioretention, water quality swales, or other infiltration features;
  - A vacant grassed area approximately 100-feet by 60-feet is located at the far southern side of the site adjacent to Pleasant Street. This parcel could be used to treat runoff from a portion of the parking lot with likely an extended detention basin or gravel wetland, depending on field conditions assessed as part of a future project. Before finalizing BMP type, onsite soil

[37] MassDEP Stormwater Advisory Committee 2020

investigations should be completed to determine expected infiltration rates and depth to groundwater. Due to the close proximity to Bloody Brook, groundwater is expected to be high in this area and thus infiltration may be infeasible; and

- Explore the feasibility of diverting stormwater from at least a portion of the Pleasant Street stormwater drainage system to the above parcel for treatment with the above recommended BMPs.

Map all stormwater existing infrastructure and determine if additional stormwater BMPs can be constructed at the site.

- **Deerfield Elementary School (public)**

  The Deerfield Elementary School parcel consists of a large building, large parking lot located across Pleasant Street, and numerous smaller impervious areas associated with access roads/paths, parking/drop off areas, and a playground. An existing stormwater BMP (appears to consist of a narrow detention or infiltration system that overflows towards the rear of the site via an overflow structure) is located at the west side of the building and appears to capture parts of the basketball court, nearby access roads, and portion of the roof. Entrance area raingardens are currently under construction. Parking lot to the north of the site has a small stormwater BMP (appears to be a bioretention area) at the rear of the site that appears to capture stormwater runoff from a small portion of the parking area before discharging to a wetland complex to the north. Potential additional stormwater retrofits in north parking lot include:

  - Allocate more space within the parking lot to additional islands;
  - Allocate more parking lot space on the outer edge to retrofit as bioretention, water quality swales, or other infiltration features;
  - Establish a more comprehensive vegetated buffer at the rear of the site along Bloody Brook;
  - Convert the raised islands to depressed islands; and
  - Explore the feasibility of retrofitting the existing narrow detention or infiltration system BMP in the parking lot to increase water quality treatment capacity.

  Map all stormwater existing infrastructure and determine if additional stormwater BMPs can be constructed at the site.

- **Municipal parcel at North Main Street and Route 5** (a.k.a. the nursery parcel)
  A vacant municipally owned parcel, measuring approximately 400-feet by 180 feet, is located at the intersection of North Main Street and Route 5. Catch basins were observed in the surrounding area and discharge to an unknown location. At least a portion of runoff from Route 5 appears to discharge into a swale running along the west side of the roadway. The parcel is generally located below Route 5 but above North Main Street.
  - It may be possible to collect stormwater from much of the intersection and pipe it to a new stormwater infiltration basin on this parcel depending on field conditions assessed as part of a future project. Map all stormwater existing infrastructure. Before finalizing BMP type, onsite soil investigations should be completed to determine expected infiltration rates and depth to

groundwater. Due to the upland location of the parcel, groundwater is expected to be relatively low in this area and infiltration may be feasible depending on soil types.

Map all stormwater existing infrastructure and determine if additional stormwater BMPs can be constructed at the site.

- **Yankee Candle Corporate Offices (private)**
  The Yankee Candle parcel consists of an administration building, large distribution center, and extensive parking and access roadways. Impervious area totals approximately 18.8 acres, the most in the watershed. Drainage infrastructure such as catch basins were observed throughout the property and appear to discharge to the unnamed perennial tributary to Bloody Brook and a large retention pond at the intersection with Yankee Candle Way and Route 5. The property was observed to be in generally good condition with new landscaping throughout. Due to available space and site characteristics, this location may have the potential for a public-private partnership project to address stormwater discharges from the site. Potential stormwater projects at the Yankee Candle Corporate Offices site could include:
    - Retrofit the existing retention pond to provide additional stormwater treatment.
    - Additional stormwater infiltration and treatment BMPs constructed on the property or within close proximity to the stream channel.

Map all existing stormwater infrastructure. The actual BMP type and location is to be determined pending site constraints such as depth to groundwater and soils type.

- **Treehouse Brewing (private)**
  The Treehouse Brewing parcel is located just downstream (south) from Yankee Candle along the unnamed perennial tributary. This parcel includes a single large manufacturing, office, and sales facility with a large parking lot and several access roads. Impervious area totals approximately 5.2 acres. Runoff from much of the site appears to sheet flow to a low spot at the tributary before flowing untreated to the stream channel. Due to available space, presence of an untreated stormwater discharge, and stream channel characteristics, this location may have the potential for a public-private partnership project to address stormwater discharges from the site, as well as provide additional treatment of the stream tributary by naturalizing the stream channel. Potential stormwater projects at the Treehouse site could include:
    - A stormwater BMP within and/or adjacent to the stream channel to treat parking lot runoff before it enters the stream. The actual BMP type and location is to be determined pending site constraints such as depth to groundwater and soils type, however, would likely consist of a constructed wetlands or similar structure.
    - Increased vegetation in the stream channel and a larger vegetated buffer around the stream channel.
    - Addition minor regrading or similar work may be also be performed to allow for additional flood storage within the stream channel.

Before finalizing BMP type, permitting constraints should be evaluated, as well as additional site constraints as noted above.

These additional locations were identified as places for potential stormwater BMP retrofits but were not highlighted in CEI's *Stormwater Improvement Opportunities* Technical Memorandum:

- Tilton Library (public)
- South Deerfield Congregational Church (private)
- Deerfield Police Department and South County EMS (public)
- Pelican Products (private)
- Atlas Farm and Farm Store (private)

Table C-2 presents the proposed management measures as well as the estimated pollutant load reductions and costs.[38]

---

[38] The planning level cost estimates and pollutant load reduction estimates and estimates of BMP footprint were based off information obtained in the following sources and were also adjusted to 2016 values using the Consumer Price Index (CPI) (United States Bureau of Labor Statistics, 2016): Geosyntec Consultants, Inc. (2014); Geosyntec Consultants, Inc. (2015); King and Hagen (2011); King and Hagen (2011); Leisenring, et al. (2014); King and Hagen (2011); MassDEP (2016a); MassDEP (2016b); University of Massachusetts, Amherst (2004); Voorhees (2015); Voorhees (2016a); Voorhees (2016b)

Table C-2: Proposed Management Measures, Estimated Pollutant Load Reductions and Costs

BMP Type(s)	Drainage Area (acres)	BMP Size (storm depth; inches)	TN Pollutant Load Reduction (lbs/yr)	TP Pollutant Load Reduction (lbs/yr)	TSS Pollutant Load Reduction (lbs/yr)	Estimated Footprint (s.f.)	Planning Level (Construction Only) Capital Cost
BIORETENTION AND RAIN GARDENS	5	1.5	47.17625	7.93753	1785.25346	12,100	$245,919
GRASSED CHANNEL/ WATER QUALITY SWALE	5	1.5	1.10184	0.16818	128.07253	Variable	$119,103
EXTENDED DRY DETENTION BASIN W/ SEDIMENT FOREBAY	5	1.5	10.93367	10.93367	10.93367	4,356	$297,852
INFILTRATION BASIN W/ SEDIMENT FOREBAY	5	1.5	56.39474	56.39474	56.39474	7,260	$55,053
INFILTRATION TRENCH	5	1.5	33.83684	33.83684	33.83684	3,630	$45,823
TOTAL			**149.44**	**109.27**	**2,014.49**	**27,346**	**763,750**

Note: Proposed management measures are conceptual examples; catchment mapping, proper siting, and construction design by a licensed engineer is required before installation.

Nonstructural BMPs

Increase Buffer Width

A healthy riparian stream buffer includes a diverse mix of vegetation, including trees, shrubs, grasses, and herbaceous plants, not just mown grass. Diverse vegetation enhances habitat and increases resilience to climate change. Every bit of buffer helps, but the Massachusetts Riverfront Protection Area recognizes the benefit of a buffer within 200 feet of a perennial stream. Ceasing mowing is a passive method for creating a buffer. Various funding sources can be explored for purchasing trees for planting a riparian stream buffer.

Upland Wetlands Restoration

Wetlands restoration in the upper watershed is likely to reduce flooding and nonpoint source pollution in Bloody Brook. Wetlands act as natural sponges, absorbing and slowly releasing water or allowing it to percolate into the groundwater. Wetlands are located in the upper watershed help reduce the volume and speed of runoff, mitigating downstream flooding during heavy rain events or snowmelt. Wetlands also filter pollutants, sediments, and nutrients out before the water flows downstream or enters the groundwater.

For the purpose of riparian stream buffer enhancement and upland wetland restoration, it is recommended to map the agricultural drainage ditches throughout the watershed, particularly at critical junctions such as where ditches meet stream tributaries and/or roadways. This project could identify features such as locations of minimal or no vegetated buffer, areas where water could be impounded to alleviate downstream flooding impacts, areas where water could be treated such as through implementation of native vegetation, and other best practices. Work would be focused on privately owned agricultural areas. At the conclusion of the project, private property owners could be contacted to see if they would be interested in installing a demonstration project on their property.

According to the 1999 *Wetlands Functional Deficit Analysis of the Mill River Watershed*, there is a relative lack of emergent wetland habitat in the Mill River watershed (the larger watershed that Bloody Brook falls within).[39] The report cites the following ditched agricultural land along Bloody Brook as possible locations for wetland restoration:

1) Mill Village
2) Hillside Road
3) North Hillside Road
4) Tributaries of Bloody Brook between Route 116 and South Mill River and Whately Roads area
5) West of North Street along the Deerfield/Whately border

---

[39] FRCOG. 1999. *Wetlands Functional Deficit Analysis of the Mill River Watershed*. Produced for the FRCOG.

Landscaping BMPs

Landscaping BMPs tend to be low-cost measures that residents, businesses, and public property managers such as the DPW can easily implement. Landowners can find help from landscape designers and landscape construction professionals for landscaping BMPs that are more intensive to install, such as changing out impervious surface materials or installing structural BMPs such as rain gardens and bioswales. If widely adopted, landscaping BMPs can have a large impact on NPS pollution loading to the Bloody Brook.

- Install a rain barrel to capture roof runoff
- Redesign the roof gutter system to outlet to a landscape feature (e.g., infiltration trench, rain garden, vegetated swale, drywell)
- Reduce the size of parking lot or driveway
- Install permeable materials for driveway, walkway, or outdoor stairway
- Replace traditional lawn with vegetation that infiltrates rainwater more easily (e.g., gardens, clover lawn)
- Aerate a traditional lawn
- Allow a section of lawn to grow tall
- Plant more trees or native pollinator plants
- Increase the vegetated buffer around a wetland, stream, or Bloody Brook
- Dump grass clippings and leaves away from a wetland, stream, or Bloody Brook
- Clean leaves and debris away from storm drains on street
- Cover crop garden when not planted with vegetables
- Pick up pet waste
- Follow fertilizer application best practices or do not use lawn fertilizers

Paved and Unpaved Road BMPs

It is recommended, if it has not already been done, that nonstructural BMPs currently implemented in the Town of Deerfield including street sweeping and catch basin cleaning, be evaluated and potentially optimized for removal of *E. coli,* TP, and sediment. First, it is recommended that potential pollutant load removals from ongoing activities be calculated in accordance with **Elements H and I** of this document. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions, such as increased frequency or improved technology.

Unpaved Roads are more prone to erosion from saturation or moderate-to-heavy rains. FRCOG's forthcoming Unpaved Roads Stormwater Management Toolkit includes recommendations for essential design, management, and maintenance practices for unpaved roads, such as proper roads structure, appropriate grading, removal of grader berms so stormwater can quickly leave the road, compaction, construction of formal ditches, disconnected ditches from waterbodies, and sufficient use of turnouts and stormwater drainage culverts.

Other Nonstructural BMPs

Other recommended BMPs include (but are not limited to):

- Septic system maintenance
- Municipal sewer system inspection and maintenance
- Protection and conservation of open space, riparian stream buffers, wetlands and stream corridors
- Impervious cover reduction

- Public education and outreach (see Element E)

Agricultural BMPs

A number of farms operating in the Bloody Brook watershed have been identified for outreach and possible implementation of agricultural BMPs under the "Expanded Western Massachusetts Agricultural NPS Program," if awarded. Typical agricultural BMPs that may be implemented are described below. This lists focuses on BMPs related to crop production, as there were no livestock operations in the watershed as of the writing of this plan. The estimated pollutant load reduction (TP and *E. coli*) that may be achieved from implementing these BMPs is site-specific, can be calculated once BMPs are closer to completion, and may be updated in future iterations of this WBP.

1. **Riparian Stream Buffers:** A riparian (or stream) buffer is the area of trees, shrubs and grasses adjacent to a river that can intercept pollutants from both surface and shallow groundwater before reaching a river or stream. This practice involves the protection, maintenance, and restoration of riparian forest areas. The ability of a buffer to remove pollutants is dependent on the width of the buffer, the type of vegetation, the manner in which runoff traverses the vegetated areas, the slope and the soil composition within the riparian area. Buffers also provide habitat for wildlife and enhance fish habitat by reducing water temperature.

2. **Afforestation of Hay and Cropland:** Using a small portion of hay and pasture land for tree planting. This converts pasture that is not well suited for haying or cropping due to slope and other characteristics, optimizes the use of suitable fields in the watershed, and prevents runoff and soil loss from marginal fields.

3. **Cropland Management Practices:** Cropland management practices include, among others, continuous no till, cover crops, and fertilizer management. Continuous no till is used to encourage procedures to convert fields under some degree of tillage to a system of minimal soil disturbance that will maintain a minimum a 60% rain drop intercepting residue cover. Cover crops keep cover on fields during times of year when they would otherwise be left barren in order to minimize runoff and erosion from the soil surface and also decrease leaching of nitrogen through the soil.

4. **Fertilizer Management Practices:** Farmers can implement fertilizer management practices to help maintain high yields and save money on fertilizers while reducing nonpoint source pollution. A Crop Nutrient Management Plan; is a tool that farmers can use to achieve these goals. [40]

MACD references guidance from USDA when planning and implementing BMPs with farm owners. The Massachusetts "Field Office Technical Guide" provides detailed information on agricultural BMPs that may be

[40] See here for ten key components to include in a crop nutrient management plan: megamanual.geosyntec.com/npsmanual/cropnutrient.aspx

implemented at farms in the watershed.[41] Appendix D includes a list of potential agricultural BMPs that may be implemented in the watershed.

WBP Implementation and Management Capacity

As stated in the introduction, this WBP is meant to be a living document. It should be reevaluated at least once every three years and adjusted as needed based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). It is recommended that the Town of Deerfield assign a new or existing working group to the stewardship of this plan, one that can meet regularly to implement and update this WBP and track progress. The Town of Deerfield has demonstrated an excellent capacity to secure grant funding for watershed-based projects and should continue to be supported by regional partners in these efforts. As the regional planning agency for Franklin County, FRCOG staff may also be aware of other funded projects that may inform ongoing or planned projects for the Bloody Brook watershed, and project proponents can contact FRCOG staff for updates and opportunities to leverage funding and coordinate project activities.

[41] The Massachusetts "Field Office Technical Guide" can be accessed at: https://efotg.sc.egov.usda.gov/#/state/MA/documents/section=4&folder=-3 ; the list of BMPs, as well as detailed information on each, is found under "Section 4 - Practice Standards and Supporting Documents" > "Conservation Practice Standards & Support Documents".

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Table D-1 presents the funding needed to implement the management measures presented in this watershed plan. The table includes costs for structural and non-structural BMPs, operation and maintenance activities, information/education measures, and monitoring/evaluation activities.

Table D-1: Summary of Funding Needed to Implement the Watershed Plan

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Structural and Non-Structural BMPs (from Element C)						
Engineering study of potential stormwater BMPs	Not applicable	Not applicable	Town of Deerfield	Engineering consultant	To be determined	Studies could be combined into single study for cost savings.
Installation of new structural stormwater BMPs (see recommended BMP types in Table C-2)	Frontier High School; Deerfield Elementary; municipal lot on North Main; willing large commercial properties	To be determined	Town of Deerfield	Engineering consultant, Contractor	To be determined	Stormwater BMPs and costs for design and installation will be determined by future studies.
Agricultural Management Measures	Not applicable	Not applicable	MACD	MACD	To be determined	Estimated costs of these projects are currently unknown but can be updated in future version of this WBP.
Deerfield Highway Department best practices: street sweeping, catch basin cleaning, reduced salt application.	Potentially, if equipment is needed	To be determined	Town of Deerfield	Engineering consultant	To be determined	An engineering consultant could develop an O&M plan for Town roads.

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Information/Education (see Element E)						
Project updates (website and social media posts)	Not applicable	To be determined	Town of Deerfield	None	Not applicable	
Outreach to large commercial property owners for partnership on project	Not applicable	Not applicable	Town of Deerfield	Consultant, FRCOG	$5,000	
Ongoing outreach to residents and business owners	$1,500	To be determined	Town of Deerfield	Consultant, FRCOG, FCD, MACD	$1,500	As part of funded MVP projects, FCD projects, MACD's grant, and/or as standalone project for a consultant
Monitoring and Evaluation (see Element H/I)						
Sampling QAPP	Not applicable	Not applicable	Connecticut River Conservancy; Town of Deerfield	$5,000	$5,000	Estimated cost; will vary widely depending on level of detail
Annual water quality sampling	Not applicable	Not applicable	Connecticut River Conservancy; Town of Deerfield	$5,000	$5,000	Extent of sampling program TBD, this is placeholder estimate
BMP monitoring	Not applicable unless specific equipment was needed as recommended in the O&M Plan	To be determined. Estimates of annual costs would be provided in the O&M Plan.	Town of Deerfield	Training of volunteers might be needed. Town staff might need training on BMPs for stormwater and road maintenance	$2,500 for annual training and printing of outreach materials	Funding for the O&M Plan implementation could come from the Town's Chapter 90 Program funding
				Total Funding Needed	**To be determined**	

Potential Funding Sources:

- 604b Water Quality Management Planning Grant Program
- Section 319 Nonpoint Source Competitive Grant Program
- Municipal Vulnerability Preparedness (MVP) Action Grant Program
- Long Island Sound Futures Fund (LISFF) through the National Fish and Wildlife Foundation (NFWF)
- Town Ch. 90 funds
- Town Capital Funds

<table>
<tr><th>Management Measures</th><th>Capital Costs</th><th>Operation & Maintenance Costs</th><th>Relevant Authorities</th><th>Technical Assistance Needed</th><th>Funding Needed</th><th>Notes</th></tr>
<tr><td colspan="7">• Town Wetland Funds (i.e., filing fees to enforce Massachusetts Wetlands Protection Act)
• Massachusetts Environmental Trust
• FEMA Hazard Mitigation Grant
• Volunteer time for public outreach and monitoring</td></tr>
</table>

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Education and outreach are needed to educate Deerfield Town staff, students, residents, business owners, and farmers about the health of the Bloody Brook watershed, including the potential sources of nonpoint source pollution (contaminants released in a wide area rather than from one single source, such as a pipe) and fluvial geomorphic impairments (disturbance to stream channel shape, water flow, and sediment movement in a stream channel). Education and outreach is also needed to help to promote a comprehensive approach to ongoing stormwater management that is currently primarily focused on flooding issues.

Education and engagement on stormwater management and climate-resilient water management are currently being pursued through Town-led public engagement and student projects under MVP Action grants, Franklin Conservation District (FCD) landowner outreach via workshops and property visits funded by the Executive Office of Energy and Environmental Affairs (EEA), and a landowner letter, informational booklet, and survey created and distributed by FRCOG staff under this grant. The Town of Deerfield is slated to develop a list of possible interventions that the Town and individual property owners can use to address impacts from excess stormwater and stream flooding that acknowledges the high water table in this part of the Connecticut River Valley.

Immediate education and outreach can focus on educating Town officials about this WBP's goals in order to help integrate watershed planning and water quality goals into all Town planning arenas. Long-range engagement could focus also on landowner education, particularly corporate landowners, to cultivate a sense of investment in the WBP goals and identify opportunities for projects. If awarded, the Massachusetts Association of Conservation Districts (MACD) will conduct farmer outreach and support in the watershed under the "Expanded Western Massachusetts Agricultural NPS Program" grant. It is expected that these programs will be evaluated by tracking meetings, event attendance, and other tools applicable to the type of outreach performed.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Gain a better understanding of the perceptions of Bloody Brook as a watershed system to better inform outreach efforts.

2. Educate Town staff, students, residents, business owners, and farmers about the location and water quality of Bloody Brook, and the sources of nonpoint source pollution and geomorphic impairments.
3. Provide information to homeowners and business owners about specific stormwater improvements, landscaping practices, proper septic design and maintenance, and the water quality benefits.
4. Work with some of the large commercial/industrial private landowners to identify potential NPS projects on their lands that could be eligible for s.319 funding.
5. Increase the use of conservation practices in the watershed agricultural community.
6. Improve the literacy of Town staff in watershed stewardship for water quality; focus on educating Town officials about this WBP's goals in order to help integrate watershed planning and water quality goals into all Town planning arena.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. Town of Deerfield Staff and volunteer board and committee members.
2. Schools within the watershed: Frontier High School and Deerfield Elementary School.
3. All watershed landowners and residents, especially those owning property within 200 feet of Bloody Brook and its tributaries.
4. Businesses within the watershed, including the corporate business owners.
5. Farmers within the watershed.

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Continue to work with the "Deerfield's Bloody Brook: A Resident and Business Owner's Guide to Understanding and Stewarding the Bloody Brook Watershed" informational booklet—making it available to Town staff and the general public.
2. Continue resident outreach informed by the resident survey conducted as part of the mailing of "Deerfield's Bloody Brook", tailoring educational materials to the interests of watershed landowners.
3. Promote the forthcoming tool funded under an FY25 MVP grant demonstrating BMPs that individual property owners can use to address impacts from excess stormwater and stream flooding that acknowledges the high water table

4. Consider using the new *Property Owner Guide to Managing Stormwater* published by the SNEP Network that is geared toward large commercial/industrial property owners when conducting outreach to large commercial landowners in the watershed.[42]
5. Include nonpoint source pollution and stormwater and agricultural BMPs as a topic at future Climate Resilience Forums in Deerfield or other MVP-funded outreach events for farmers, residents, and landowners.
6. MACD representatives will conduct one-on-one meetings with farmers and support the development of farm conservation plans.
7. MACD will conduct outreach and education activities, including farm tours highlighting agricultural BMPs.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of surveys returned.
2. Track the number of educational materials handed out to targeted residents, farmers, and businesses.
3. Track the number of farm tours and the attendance at each.
4. Track the number of farmers participating in outreach and education efforts, conservation plans, and implementation of BMPs.

Additional outreach products will be determined depending on the results of initial surveys. This section of the WBP will be updated when the plan is re-evaluated in 2027 in accordance with Element F&G.

[42] https://snepnetwork.org/wp-content/uploads/2024/09/SNEP_PropertyOwnerGuide_final.pdf

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2027, or as needed, based on ongoing monitoring results and other ongoing efforts. New projects will be identified through future data analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones[43]

Category	Action	Year(s)
Establish authority over WBP	The Town of Deerfield will determine the Town body responsible for stewarding the WBP	2024
Monitoring	Perform water quality sampling at key locations in the Bloody Brook watershed as part of the existing water quality monitoring per Element H&I	2025 and annually
Agricultural Nonpoint Source Regional Coordinators	Conduct outreach to build relationships and scope potential implementation sites for agricultural BMPs.	2025 - 2028
	Support the development of conservation plans outlining BMPs to reduce pollutant and nutrient runoff. Implement agricultural BMPs at farms in the watershed (contingent on available funding)	2025 - 2028
Structural BMPs	Identify locations, develop and rank structural BMP concepts	To be determined
Non-structural BMPs	Document potential pollutant removals from nonstructural BMPs (i.e., street sweeping, catch basin cleaning). The methodology is included in the 2016 Massachusetts Small MS4 Permit and in Elements H&I of this WBP.	Annually
	Evaluate ongoing nonstructural BMPs and determine if modifications can be made to optimize pollutant removals (e.g., increase frequency).	Annually
	Routinely implement optimized nonstructural BMPs.	Annually

[43] Note that goals and milestones of this WBP are intended to be adaptable and flexible. Stakeholders will perform tasks contingent on available resources and funding.

Category	Action	Year(s)
Public Education and Outreach *(See Element E)*	Outreach and education to Town staff, students, residents, business owners about the location and water quality of Bloody Brook, the sources of nonpoint source pollution and geomorphic impairments, and information on specific stormwater improvements, landscaping practices, and proper septic design and maintenance.	2025 - 2028
	Outreach to large commercial landowners about the potential for a public-private partnership project	2025 - 2026
	Project updates (website and social media posts)	Annually
Adaptive Management and Plan Updates	Town of Deerfield determine the Town body responsible for stewarding the WBP	2024
	Reevaluate WBP at least once every three years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). – Next update, August 2027	2027
	Use monitoring results to reevaluate BMP effectiveness at reducing *E. coli.* TP, turbidity and/or other indicator parameters in the Bloody Brook watershed and establish additional long-term reduction goal(s), if needed.	2034
	Delist all segments within the Bloody Brook watershed from the 303(d) list.	2039

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The water quality target concentration(s) are presented under Element A of this plan. To achieve these target concentrations, the annual loading must be reduced to the amount described in Element B. Element C of this plan describes the various management measures that will be implemented to achieve this targeted load reduction. The evaluation criteria and monitoring program described below will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of Bloody Brook.

Direct Measurements

Direct measurements are generally expected to be performed as described below. Prior to implementing a direct measurement program, an abbreviated quality assurance project plan (QAPP) and/or Standard Operating Procedures (SOPs) will be established to flesh out details of the program and establish best practices for sample collection and analysis. Water quality monitoring may be performed by the Connecticut River Conservancy with additional funding.

Brook Sampling

Establish regular sampling of priority pollutants bacteria, total phosphorus, total suspended solids, and turbidity in Bloody Brook; potentially include analysis of other common NPS pollutants total nitrogen. Additional parameters such as temperature, conductivity, biochemical oxygen demand, salinity, dissolved oxygen, pH, and chlorine could provide additional data for consideration. Monitoring locations will be selected to build upon existing water quality data. It is also recommended that samples be taken May through November during notable storm events with a goal to capture up to four events per year. Total suspended solids and discharge measurements can later be converted to estimates of loading and will aid in better characterizing base loading to Bloody Brook. Additional monitoring locations may be selected based on accessibility and representativeness and shall be appropriate to quantify water quality improvements in the watershed.[44]

Dissolved Oxygen Background Reading

A dissolved oxygen goal could be set once a background reading is established. Continuous DO monitoring as part of regular brook sampling should be used to obtain a more complete picture of daily DO variations and establish a background value.

BMP, TSS, and Flow Monitoring

As feasible and dependent on available funding and Town staff capacity, the effectiveness of existing and proposed structural BMPs will be evaluated by routine inspection during and after storm events to measure amounts of sediment collected (i.e., sediment traps, catch basins, etc.). As feasible and dependent on funding for laboratory testing and availability of volunteers, TSS and discharge will also be periodically measured at the mouth of Bloody during notable storm events with a goal to capture up to four events per year. TSS and discharge measurements can later be converted to estimates of annual loading.

Indirect Indicators of Load Reduction

Nonstructural BMPs

Potential load reductions from non-structural BMPs (i.e., street sweeping and catch basin cleaning) can be estimated from indirect indicators, such as the number of miles swept, or the number of catch basins cleaned. As summarized by Figure HI-1 and Figure HI-2, Appendix F of the 2016 Massachusetts Small MS4 General Permit provides specific guidance for calculating TP removal from these practices. As indicated by Element C, it is recommended that potential TP removal from these ongoing actives be estimated. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

[44] Additional guidance is provided at: https://www.epa.gov/sites/production/files/2015-06/documents/stream.pdf and https://www.mass.gov/guides/water-quality-monitoring-for-volunteers#2

$\text{Credit}_{sweeping} = IA_{swept} \times PLE_{IC\text{-}land\ use} \times PRF_{sweeping} \times AF$ **(Equation 2-1)**

Where:

$\text{Credit}_{sweeping}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)

IA_{swept} = Area of impervious surface that is swept under the enhanced sweeping program (acres)

$PLE_{IC\text{-}land\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

$PRF_{sweeping}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-3).

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Table 2-3: Phosphorus reduction efficiency factors ($PRF_{sweeping}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	$PRF_{sweeping}$
2/year (spring and fall)[2]	Mechanical Broom	0.01
2/year (spring and fall)[2]	Vacuum Assisted	0.02
2/year (spring and fall)[2]	High-Efficiency Regenerative Air-Vacuum	0.02
Monthly	Mechanical Broom	0.03
Monthly	Vacuum Assisted	0.04
Monthly	High Efficiency Regenerative Air-Vacuum	0.08
Weekly	Mechanical Broom	0.05
Weekly	Vacuum Assisted	0.08
Weekly	High Efficiency Regenerative Air-Vacuum	0.10

Figure HI-1. Street Sweeping Calculation Methodology

$\text{Credit}_{CB} = IA_{CB} \times PLE_{IC\text{-}land\ use} \times PRF_{CB}$ **(Equation 2-2)**

Where:

Credit_{CB} = Amount of phosphorus load removed by catch basin cleaning (lb/year)

IA_{CB} = Impervious drainage area to catch basins (acres)

$PLE_{IC\text{-}and\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

PRF_{CB} = Phosphorus Reduction Factor for catch basin cleaning (see Table 2-4)

Table 2-4: Phosphorus reduction efficiency factor (PRF_{CB}) for semi-annual catch basin cleaning

Frequency	Practice	PRF_{CB}
Semi-annual	Catch Basin Cleaning	0.02

Figure HI-2. Catch Basin Cleaning Calculation Methodology

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates

Anticipated pollutant load reductions from existing (i.e., under construction), ongoing, and future BMPs will be tracked as BMPs are installed; this information should be included in future iterations of this WBP.

Geomorphic Indicators

Project-specific indicators of projects focused on bank stability and reduction of TSS loading could include the number of projects installed, estimates of sediment load reductions, estimate of flow velocity reductions, number of linear feet of bank stabilized, and number of acres of floodplain reconnected.

TMDL Criteria

Bloody Brook (MA34-36) will be included in the forthcoming *Massachusetts Statewide TMDL for Pathogen-Impaired Inland Freshwater Rivers* currently in draft stage.

Adaptive Management

As discussed by Element B, the baseline monitoring program will be used to evaluate if Element C management measures have been effective at addressing listed water quality impairments or water quality goals for other indicator parameters established by Table A-9 of this WBP. Monitoring results can further be used to periodically inform or adjust load reduction goals presented in Table B-1. Based on monitoring data, additional long-term reduction goal(s) may be established, if needed, to lead to delisting of Bloody Brook from the 303(d) list over the next 15 years. It is recommended that this evaluation be conducted at least once every three years.

If monitoring results and indirect indicators do not show improvement to the *E. coli,* TP, or turbidity levels and other indicators measured within the watershed, the management measures and loading reduction analysis (Elements A through D) should be revisited and modified accordingly.

References

314 CMR 4.00. 2013. *Division of Water Pollution Control, Massachusetts Surface Water Quality Standards*

ArcGIS. 2020a. *USA Soils Hydrologic Group* Imagery Layer

ArcGIS. 2020b. *USA Soils Water Table Depth* Imagery Layer

Cohen, A. J.; Randall, A.D. 1998. *Mean annual runoff, precipitation, and evapotranspiration in the glaciated northeastern United States, 1951-80.* Prepared for United States Geological Survey, Reston VA.

Downtown Deerfield Complete Streets and Livability Plan. 2013. Prepared by Nelson/Nygaard, The Cecil Group, and Doucet and Associates.

DPC Engineering, LLC. 2019. Town of Deerfield, Massachusetts Wastewater System Asset Management Plan Final Report. Prepared for the Town of Deerfield.

FRCOG (Franklin Regional Council of Governments). 1999. Wetlands Functional Deficit Analysis of the Mill River Watershed. Prepared for the Pioneer Valley Planning Commission.

FRCOG (Franklin Regional Council of Governments). 2016. Deerfield Public Tree Inventory. Prepared for the Town of Deerfield and Deerfield Highway Department.

FRCOG (Franklin Regional Council of Governments). 2018. *Town of Deerfield Tree Planting and Maintenance Plan*. Prepared for the Town of Deerfield and Deerfield Highway Department.

FRCOG (Franklin Regional Council of Governments). 2021a. *Deerfield Culvert Assessment Summary*.

FRCOG (Franklin Regional Council of Governments). 2021b. *Sustainable Stormwater Management Plan for Franklin County, Stormwater Technical Report for Complete Streets Pilot Communities*.

Geosyntec Consultants, Inc. 2014. *Least Cost Mix of BMPs Analysis, Evaluation of Stormwater Standards Contract No. EP-C-08-002, Task Order 2010-12.* Prepared for Jesse W. Pritts, Task Order Manager, U.S. Environmental Protection Agency

Geosyntec Consultants, Inc. 2015. *Appendix B: Pollutant Load Modeling Report, Water Integration for the Squamscott-Exeter WISE River Watershed.*

King, D. and Hagan, P. 2011. *Costs of Stormwater Management Practices in Maryland Counties.* University of Maryland Center for Environmental Science Chesapeake Biological Laboratory. October 11, 2011.

Leisenring, M., Clary, J., and Hobson, P. 2014. *International Stormwater Best Management Practices BMP Database Pollutant Category Statistical Summary Report: Solids, Bacteria, Nutrients and Metals.* Geosyntec Consultants, Inc. and Wright Water Engineers, Inc. December 2014.

MA Department of Revenue Division of Local Services 2016. *Property Type Classification Codes, Non-arm's Length Codes and Sales Report Spreadsheet Specifications* June 2016

MassDEP 2012. *Massachusetts Year 2012 Integrated List of Waters Final Listing of Massachusetts' Waters Pursuant to Sections 305b, 314 and 303d of the Clean Water Act*

MassDEP 2016a. *Massachusetts Clean Water Toolkit*

MassDEP 2016b. *Massachusetts Stormwater Handbook, Vol. 2, Ch. 2, Stormwater Best Management Practices*

MassDEP 2019. *Massachusetts Year 2016 Integrated List of Waters Final Listing of Massachusetts' Waters Pursuant to Sections 305b, 314 and 303d of the Clean Water Act* December 2019.

MassGIS 1999. *Networked Hydro Centerlines* Shapefile

MassGIS 2001. *USGS Topographic Quadrangle Images* Image

MassGIS 2005. *Elevation Topographic Data 2005* Digital Elevation Model

MassGIS 2007. *Drainage Sub-basins* Shapefile

MassGIS 2009a. *Impervious Surface* Image

MassGIS 2009b. *Land Use 2005* Shapefile

MassGIS 2012. *2010 U.S. Census Environmental Justice Populations* Shapefile

MassGIS 2013. *MassDEP 2012 Integrated List of Waters 305b/303d* Shapefile

MassGIS 2015a. *Fire Stations* Shapefile

MassGIS 2015b. *Police Stations* Shapefile

MassGIS 2017a. *Town and City Halls* Layer

MassGIS 2017b. *Libraries* Layer

MassGIS 2020. *Massachusetts Schools Pre-K through High School* Datalayer

MassGIS 2021. *Standardized Assessors' Parcels* Mapping Data Set

Paraziewicz, Piotr, Holli Kitson, Lisa Snopkoski. 2003. Instream Flow Requirements of the Mill River – Hatfield, MA. Report for Massachusetts Department of Environmental Management.

Regenerative Design Group. 2022. *Deerfield Healthy Soils Report: MVP Implementation Project 2022*.

Sanders, Laurie. Est. n.d est. 1999. A Riparian Buffer Survey in the Mill River Watershed Hampshire & Franklin Counties, Massachusetts.

Schueler, T.R., Fraley-McNeal, L, and K. Cappiella. 2009. *Is impervious cover still important? Review of recent research* Journal of Hydrologic Engineering 14 4: 309-315.

Slaff, Johnny, Sam Freedman, and David Grist. 2018. Ecological Resilience in Greenfield: Trees as Living Infrastructure. Prepared for the FRCOG by the Conway School.

Town of Deerfield. 2014. *Deerfield Open Space and Recreation Plan*. Prepared with the assistance of the FRCOG.

Town of Deerfield. 2018. *Summary of Findings for the Town of Deerfield MVP Project*. Prepared with the Assistance of Conservation Works.

Town of Deerfield. 2020. Press release: Deerfield enacts green infrastructure policy. https://www.recorder.com/Deerfield-enacts-green-infrastructure-policy-34188617

Town of Deerfield. 2011. Stormwater Regulations for the Town of Deerfield. https://www.deerfieldma.us/sites/g/files/vyhlif3001/f/uploads/deerfield_stormwater_regulations.pdf

Town of Deerfield. 2020. *Town of Deerfield Multi-Hazard Mitigation Plan*.

Town of Whately. 2021. *Town of Whately Open Space and Recreation Plan*.

United States Bureau of Labor Statistics 2016. *Consumer Price Index*

United States Geological Survey 2016. *National Hydrography Dataset, High Resolution Shapefile*

University of Massachusetts, Amherst 2004. *Stormwater Technologies Clearinghouse*

USDA NRCS and MassGIS 2012. *NRCS SSURGO-Certified Soils* Shapefile

USEPA 1986. *Quality Criteria for Water Gold Book* EPA 440/5-86-001. Office of Water, Regulations and Standards. Washington, D.C.

USEPA. 2010. *EPA's Methodology to Calculate Baseline Estimates of Impervious Area IA and Directly Connected Impervious Area DCIA for Massachusetts Communities.*

Voorhees, Mark, USEPA. 2015. *FW: Description of additional modelling work for Opti-Tool Project* Message to Chad Yaindl, Geosyntec Consultants. 23 April 2015. E-mail.

Voorhees, Mark, USEPA. 2016a. *FW: EPA Region 1 SW BMP performance equations* Message to Chad Yaindl, Geosyntec Consultants. 25 January 2016. E-mail.

Voorhees, Mark, USEPA. 2016b. *FW: Description of additional modelling work for Opti-Tool Project* Message to Chad Yaindl, Geosyntec Consultants. 23 April 2015. E-mail

.

Water Quality Assessment Reports

"*Connecticut River Watershed 2003 Water Quality Assessment Report*"

Appendices

Appendix A – FRCOG 2021 NPS Field Investigation of Bloody Brook

Bloody Brook Windshield Survey Results

						Residential			Agricultural				Commercial/Civic/Industrial		
Waypoint ID	Latitude	Longitude	Address	Public/ private	Stream buffer width and character	Evidence of permanent irrigation	Evidence of trash or junk	Evidence of pet waste	Agriculture type	Livestock access to streams	Manure handling/ storage	Tillage practices/ evidence of erosion	Business type	Vehicle operations	Outdoor materials
0			North Street Whately	private	Campground; 200' unmowed; campers 350'	no							campground	campers, septics	pool, disposal
1	42.47435454	-72.63741041	Whately Road		partly forested, vegetated										
2	42.47499816	-72.6334647	Whately Road	private	mowed to w/in few feet of stream both sides E & W										
3	42.47518989	-72.6333991	Whately Road	private	mowed to w/in few feet W side				home garden on bank	no	no				
4	42.47602425	-72.62975095	Whately Road	private	20'-40'								lanscaping/excavating	2 semis plus 4 tank trailers	fueling station
5	42.47699795	-72.62005334	Whately Road	private	ranges from 130-300'	no		yes							
6	42.47853175	-72.61939495	Whately Road	private	narrow, mowed to 100'								food manufacturer	4 docks; no vehicles	pallets
7	42.47843611	-72.61898006	Whately Road												
8	42.47923949	-72.61813736	Whately Road	private	narrow buffer to impervious driveway to storage								storage units	yes, many docks	2 propane tanks
10	42.48983773	-72.63245501	S Mill River Road	private	narrow-maybe 10' surrounded by ag fields				corn and hay	none	none				
9	42.48615804	-72.62052783	Conway Road	private	not in buffer area									excavating equipment	stored soils and gravel; finer gravel/sand is covered
11	42.50300858	-72.63306434	Lee Road	private	none										
12	42.50508805	-72.62776664	Meadow wood Drive	private	10' buffer	none	none	none							
13	42.51307023	-72.63056121	Sandgully Road	private	N/A				tree farm	no	no				
14	42.49869121	-72.61096834	Plain Road E	private	not adjacent								corporate office	docks, trailers	?
15	42.50127384	-72.61001526	Evans Lane	private	yard w/in 200'; forested buffer est. 100/150'	no	no								
16	42.50081749	-72.60855727	Route 5/10	private	road, parking lots, buildings w/in 200'				greenhouses; field crops	no	no	no	farm and farm stand; office	tractors	limited
17	42.50385427	-72.60884495	Route 5/10	private	limited to none; some forest, some landscaping								auto body, propane	repair	tanks, vehicles, plows
18	42.50325543	-72.6063627	Route 5/10	public	N/A								highway maintenance	lots of vehicles; repair	scraps, plastics, metal, gravel
19	42.50473631	-72.60671351	Route 5/10	private	N/A									none	none
20	42.50737706	-72.60213923	North Hillside	private	variable				corn/hay	none	none	evidence of slumpage			
none - viewed in GoogleMap	42.5068748444	-72.60084635	North Hillside	private	N/A										
21	42.49795265	-72.5910348	North Hillside	private	N/A								farm and autobody		vehicles, tractors, farm equipment
22	42.49010343	-72.60002623	Hillside Road	private	mowing up to stream @ road/res		none	none							
23	42.48954103	-72.60503561	Hillside Road	private	50' veg buffer on N side of road		none	none							
24	42.49071631	-72.60514339	North Main Street	private	no buffer; homemade bridge		none	none							
25	42.49424403	-72.60625704	Jackson Road	private	variable: none to 200'				hay	none	none				
26	42.49453854	-72.60300751	Jackson Road	private	straightened channel 20' buffer				crop	none	none				
27	42.49570409	-72.60740375	Boynton & Sandgully Road	private	wide				hemp	none	none				
27	42.50482733	-72.62207848	North Main Street	private	40-50' on NW side; mown on S/E side		none	none							
28	42.48318014	-72.60391267	North Main Street	private	100' buffer		none	none							
29	42.48248998	-72.60516979	North Main Street	private	15' veg buffer then lawn both sides										
30	42.49102971	-72.60587881	North Main Street	private	15' veg buffer then lawn both sides										
31	42.48875184	-72.60539442	Captain Lathrop Drive	private	20-30'		no	yes	chickens and ducks	yes	no	no			
32	42.48832864	-72.60474156	Captain Lathrop Drive	private											
33	42.48724419	-72.60459596	North Main Street	private	no buffer--mown to edge		no	no	vegetable farm	no	no	?			
34	42.4856528	-72.60470744	North Main Street	private	some buffer--small trib has no buffer										
35	42.48458847	-72.60387059	North Main private driveway	private	wide										
36	42.48369764	-72.60383296	North Main Street/Kelleher		no buffer south side of Kelleher culvert; all mown										
37	42.48169332	-72.60504498	Pleasant Street		7' forested		no	no							
38	42.48101707	-72.60521111	North Main Street	private	10' forested								auto supply	2 loading docks	none
39	42.48025134		Pleasant Street	public	20' forested										
40	42.47972662	-72.61121773	long driveway off Elm Street	private	75' forested								metal fabrication	yes	yes
41	42.47943595	-72.61219022	long driveway off Elm Street	private	150' forested										
42	42.47909828	-72.61543435	Elm Circle	private	100' forested at shortest distance		none	none							
44	42.49069108	-72.61066647	Route 5/10	private	limited/none								manufacturing	loading docks	no

Bloody Brook Windshield Survey Results

Waypoint ID	Latitude	Longitude	Address	Public/ private	Stream buffer width and character	Evidence of permanent irrigation	Evidence of trash or junk	Evidence of pet waste	Agriculture type	Livestock access to streams	Manure handling/ storage	Tillage practices/ evidence of erosion	Business type	Vehicle operations	Outdoor materials
46	42.49578414	-72.61327383	Yankee Candle Way	private	variable; 5' in some places								manufacturing; commercial	yes-dozens of trucks	no
47	42.49928443	-72.61573287	Plain Road	private	20' vegetated buffer				crops	none	none	none seen but it's likely due to the slope			
48	42.49206244	-72.6062213	North Main Street	private	N/A										
49	42.48903071	-72.60791243	North Main Street	private	N/A								plastics manufacturer	yes	yes
45	42.48977897	-72.61254074	Route 5/10	private	50' forested								veterinarian	no	?
43	42.48355383	-72.61296987	Conway Road at interstate entrance	private	N/A				greenhouses and hay	no	no	no			

Appendix B – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27
INDUSTRIAL, HSG B	0.12	29.4	1.16
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			

Appendix C – Hotspot Analysis and Map

The following GIS-based analysis was performed by the MassDEP/Geosyntec Consultants Watershed-Based Planning Tool within the watershed to identify high priority parcels for best management practice (BMP) (also referred to as management measure) implementation:

- Each parcel within the watershed was evaluated based on ten different criteria accounting for the parcel ownership, social value, and implementation feasibility (See **Table C-1** for more detail below);
- Each criterion was then given a score from 0 to 5 to represent the priority for BMP implementation based on a metric corresponding to the criterion (e.g., a score of 0 would represent lowest priority for BMP implementation whereas a score of 5 would represent highest priority for BMP implementation);
- A multiplier was also assigned to each criterion, which reflected the weighted importance of the criterion (e.g., a criterion with a multiplier of 3 had greater weight on the overall prioritization of the parcel than a criterion with a multiplier of 1); and
- The weighted scores for all the criteria were then summed for each parcel to calculate a total BMP priority score.

Table C-1 presents the criteria, indicator type, metrics, scores, and multipliers that were used for this analysis. Parcels with total scores above 60 are recommended for further investigation for BMP implementation suitability. **Figure C-1** presents the resulting BMP Hotspot Map for the watershed. It should be noted that the majority of parcels identified by hotspot analysis are privately owned. The following link includes a Microsoft Excel file with information for all parcels that have a score above 60: hotspot spreadsheet.

This analysis solely evaluated individual parcels for BMP implementation suitability and likelihood for the measures to perform effectively within the parcel's features. This analysis does not quantify the pollutant loading to these parcels from the parcel's upstream catchment. When further evaluating a parcel's BMP implementation suitability and cost-effectiveness of BMP implementation, the existing pollutant loading from the parcel's upstream catchment and potential pollutant load reduction from BMP implementation should be evaluated.

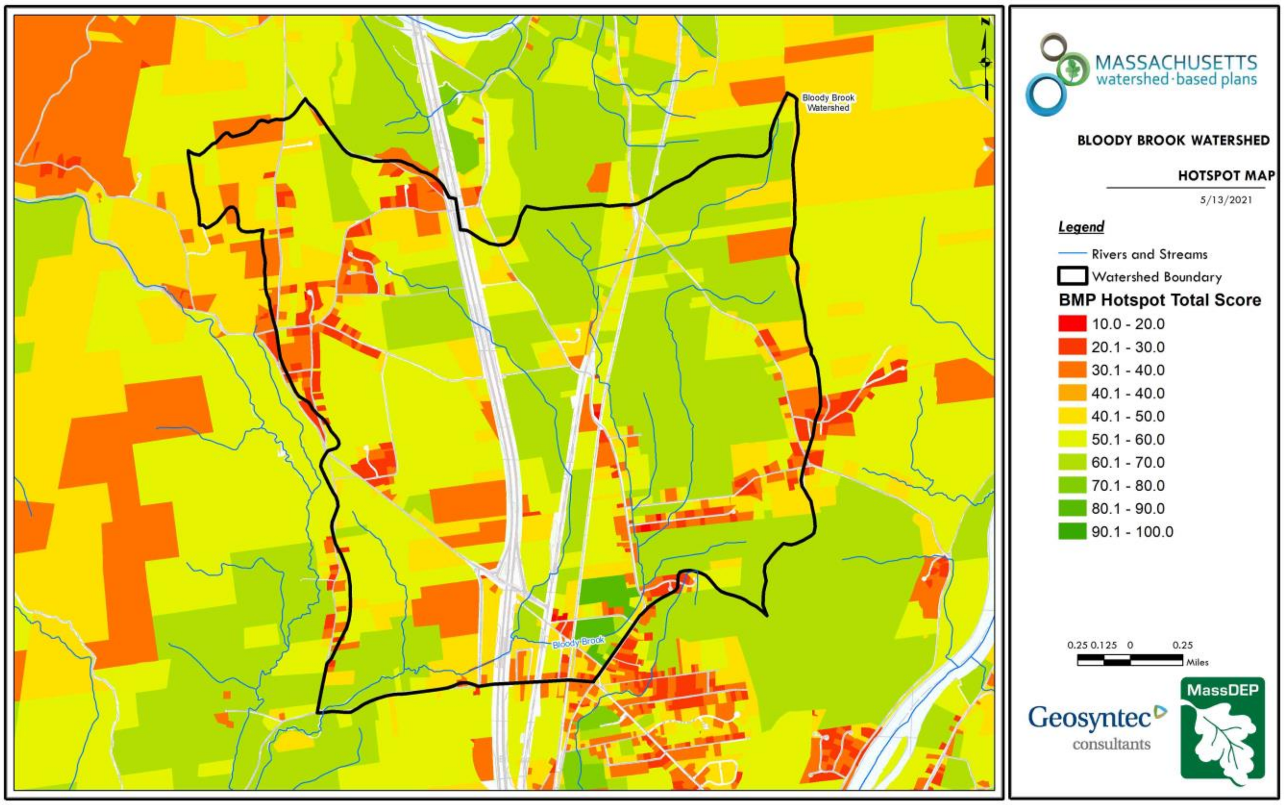
GIS data used for the BMP Hotspot Map analysis included:

- MassGIS (2015a);
- MassGIS (2015b);
- MassGIS (2017a);
- MassGIS (2017b);
- MassGIS (2020);
- MA Department of Revenue Division of Local Services (2016);
- MassGIS (2005);
- ArcGIS (2020);
- MassGIS (2009b);
- MassGIS (2012); and
- ArcGIS (2020b).

Matrix for BMP Hotspot Map GIS-based Analysis

Criteria	Indicator Type	METRICS: Yes or No?		Hydrologic Soil Group				Land Use Type									Water Table Depth				Parcel Area			Parcel Average Slope					Multiplier	Maximum Potential Score
		Yes	No	A or A/D	B or B/D	C or C/D	D	Low and Medium Density Residential	High Density Residential	Commercial	Industrial	Highway	Agriculture	Forest	Open Land	Water	101-200 cm	62-100 cm	31-61 cm	0-30 cm	Greater than 2 acres	Between 1-2 acres	Less than 1 acre	Less than 2%	Between 2% and 15%	Greater than 15%	Less than 50%	Between 51% and 100%		
Is the parcel a school, fire station, police station, town hall or library?	Ownership	5	0																										2	10
Is the parcel's use code in the 900 series (i.e. public property or university)?	Ownership	5	0																										2	10
Is parcel fully or partially in an Environmental Justice Area?	Social	5	0																										2	10
Most favorable Hydrologic Soil Group within Parcel	Implementation Feasibility			5	3	0	0																						2	10
Most favorable Land Use in Parcel	Implementation Feasibility							1	2	4	2	4	5	1	4	**X**[1]													3	15
Most favorable Water Table Depth (deepest in Parcel)	Implementation Feasibility																5	4	3	0									2	10
Parcel Area	Implementation Feasibility																				5	4	1						3	15
Parcel Average Slope	Implementation Feasibility																							3	5	1			1	5
Percent Impervious Area in Parcel	Implementation Feasibility																										5	2.5	1	5
Within 100 ft buffer of receiving water (stream or lake/pond)?	Implementation Feasibility	5	2																										2	10

Note 1: **X** denotes that parcel is excluded



BMP Hotspot Map (MassGIS (2015a), MassGIS (2015b), MassGIS (2017a), MassGIS (2017b), MassGIS (2020), MA Department of Revenue Division of Local Services (2016), MassGIS (2005), ArcGIS (2020), MassGIS (2009b), MassGIS (2012), ArcGIS (2020b))

Ctrl + Click on the map to view a full sized image in your web browser.

Appendix D – CEI Stormwater Improvement Opportunities - Bloody Brook Watershed Technical Memorandum

Technical Memorandum

To: Kimberly Noake McPhee, Franklin Regional Council of Governments (FRCOG)
Tamsin Flanders, FRCOG

From: Nick Cristofori, P.E., Comprehensive Environmental Inc. (CEI)
Bob Hartzel, CEI

Date: May 10, 2022

Subject: Stormwater Improvement Opportunities - Bloody Brook Watershed (Deerfield, MA)

---

1. INTRODUCTION

1.1 Project Overview

Bloody Brook is a perennial stream located predominantly in Deerfield, Massachusetts, with a small portion of its downstream (southern) reach located in Whately where it flows into the Mill River. Bloody Brook is listed in the Massachusetts 2018/2020 Integrated List of Waters for impairments including *E.coli* bacteria, total phosphorus, and turbidity. Stormwater pollution is a direct source of these pollutants to Bloody Brook. In response, the Franklin Regional Council of Governments (FRCOG) seeks to identify opportunities to reduce pollutant impacts to Bloody Brook and eliminate these impairments. A number of problem areas were identified as part of previously conducted studies, most of which were related to localized flooding and erosion along the stream channels. It does not appear that previous studies addressed stormwater runoff from specific parcels with large impervious area, instead addressing impervious area in the general sense on a watershed wide basis.

CEI is currently under contract to assist FRCOG with identifying potential stormwater projects for funding through the Massachusetts 319 Nonpoint Source Competitive Grant Program (319 program). Stormwater projects are anticipated to consist of structural Best Management Practices (BMPs) such as infiltration/detention basins, water quality swales, etc. capable of removing pollutants such as phosphorous, nitrogen, sediment, and bacteria from stormwater prior to discharging into sensitive waterbodies. This memorandum summarizes our findings and recommended next steps.

1.2 Field Inspections

In order to better understand the watershed and potential BMP implementation opportunities, Nick Cristofori from CEI conducted field inspections at locations within the Bloody Brook watershed on April 14, 2022. CEI was joined by representatives from FRCOG and the Town of Deerfield. The purpose of the field inspections was to observe the watershed in general, existing conditions of areas immediately surrounding the waterbody, and opportunities to provide improved stormwater treatment and/or erosion control. General conditions were documented, such as local topography, available space for retrofits, estimated contributing watershed area, etc. using a combination of field notes, sketches, and photographs. Existing conditions as observed are documented in the following sections.

2. EXISTING CONDITIONS

2.1 General

With the exception of the downtown South Deerfield area in the vicinity of Elm Street, North Main Street, and Conway Street, the watershed is generally rural and heavily agricultural (29%), with lesser amounts of woodland (23%) and low density residential (27%). Remaining land use consists mostly of a mix of high density residential (6%), open space (5%), commercial (4%), and roadways (4%). Bloody Brook is fed by several tributaries, including one major tributary that feeds into Bloody Brook near its intersection with Interstate 91, and multiple smaller tributaries which feed the main stem north of Kelleher Drive.

USGS StreamStats estimates that bankfull width for the majority Bloody Brook is approximately 20-feet wide and 1.5-feet deep, meaning that the stream should generally be wide and shallow. Observed conditions in Bloody Brook were generally consistent with these estimates in stream segments areas to the southwest, where development is minimal. However, sections of the stream further north and east become increasingly narrow and channelized, indicative of the more extensive development in this area and location closer to the headwaters with reduced contributing watershed area. Stakeholder discussions have indicated that most flooding and erosion concerns are located in areas that are heavily channelized due at least in part to construction of numerous undersized culverts.

Interstate 91 (I-91) is located in the middle of the watershed, but is generally located away from much of the Bloody Brook stream channel. Other major roads in the watershed include Route 5, Route 116, and North Main Street. With the exception of Interstate 91, all roadways are two-lanes. Non-state-owned roadways are generally lightly traveled. Drainage infrastructure consists of a mix of curbed roads with catch basins and non-curbed roads with country drainage. No available drainage infrastructure mapping (i.e., catch basins, manholes, outfalls, etc.) is available, however, culverts were assessed as part of an earlier project and classified as fair, poor, or critical. An active railroad is also located in the watershed generally running north to south, parallel to Route 5.

2.2 Main Branch, Upstream Reach

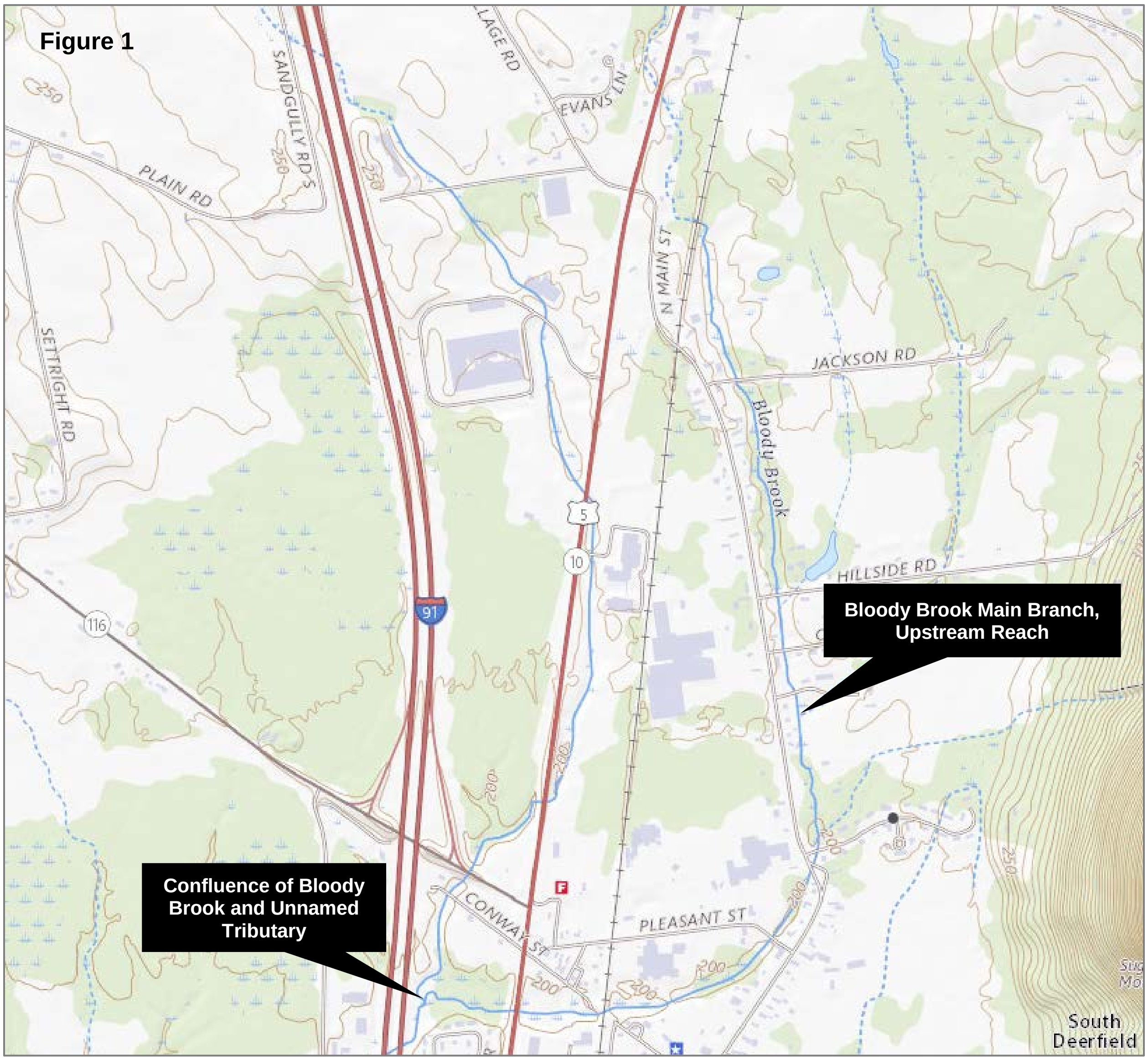
North of Kelleher Drive: The main branch of Bloody Brook (see Figure 1) to the north of Kelleher Drive was observed to be approximately 2 feet wide and highly channelized, running under multiple privately-owned driveway culverts. With the exception of a new culvert under Kelleher Drive, most culverts were of similar size and construction, consisting of granite block approximately 3- to 4-feet wide and high. Per discussions with stakeholders, this leads to localized stream flooding in this area to a depth of approximately 4 to 5 feet deep on a relatively frequent basis. Per USGS StreamStats, bankfull width in this area is calculated at approximately 20-feet wide and 1.5-feet deep, far in excess of the available 4-foot by 4-foot (approximate) culvert. Flooding further downstream from this area is generally less severe, likely due to the detention/retention of streamflow at the undersized culverts north of Kelleher Drive, reduced number of culvert crossings south of this point, and generally wider stream channel allowing for higher flow rates.

I-91 to Kelleher Drive: The main branch of Bloody Brook between I-91 and Kelleher Drive is the most highly developed area of the watershed. A large complex of municipal properties is present at the southeast corner of the watershed for this stream reach, including Deerfield Town Hall, Deerfield Elementary School, and the Frontier Regional School. Smaller impervious parking lots and buildings are also present. The stream channel in this area is approximately 6-feet wide with banks approximately 6-feet deep, meaning that this stream reach has more storage capacity than areas further upstream. Stakeholders report that flooding has generally not been a problem in this area. However, pollutant contributions may be highest here due to the relatively high level of imperviousness of nearby parcels.

2.3 Unnamed Tributary to Upstream Reach

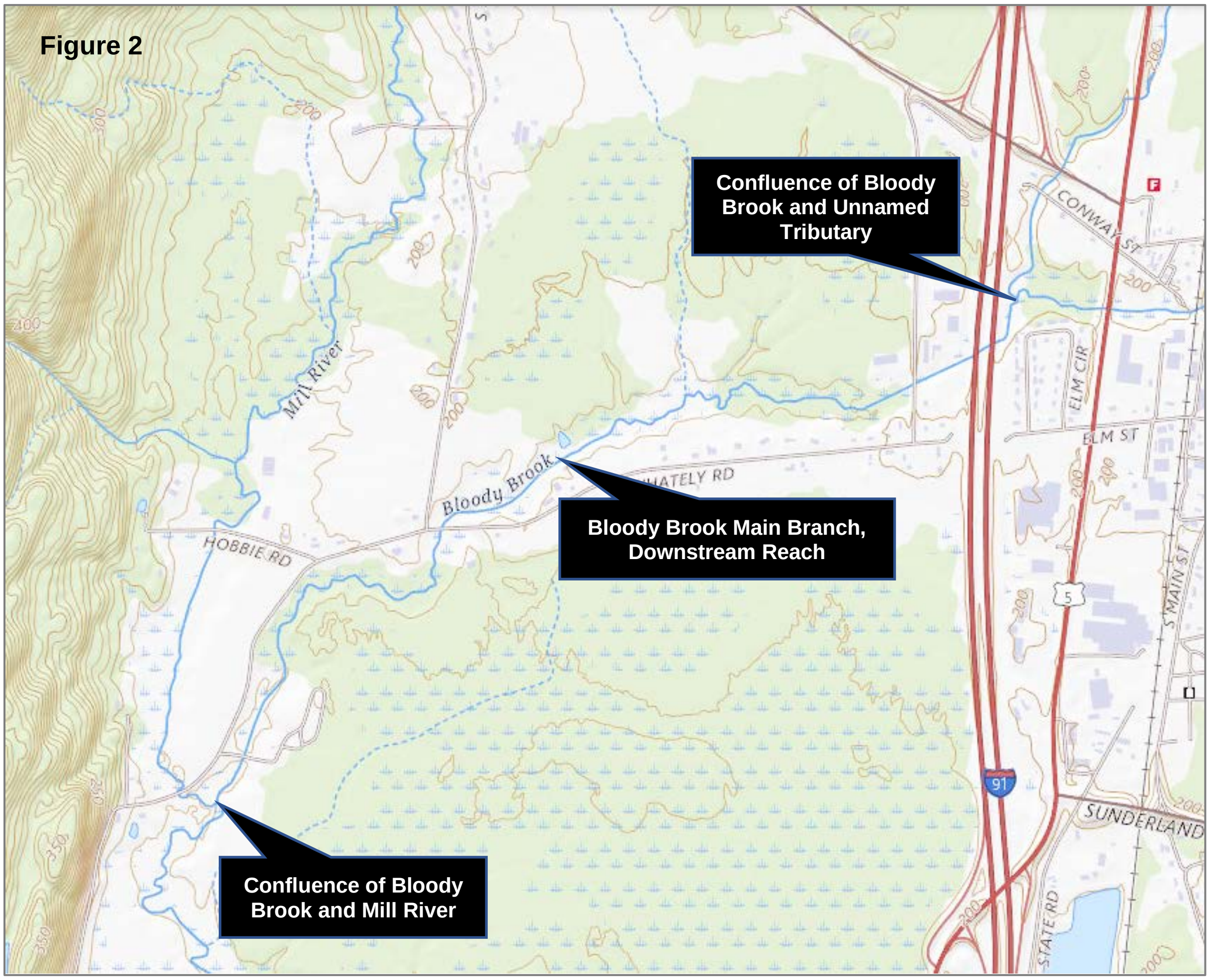
An unnamed, perennial tributary flows into the Bloody Brook just to the east of I-91 (see Figure 1). This tributary was observed to be several feet wide with banks approximately 4 feet high. This tributary had substantially fewer culverts than stream reaches along the main branch of Bloody Brook. Contributing areas to this tributary are largely agricultural and forested, with the notable exceptions being runoff from the large privately owned Yankee Candle and Treehouse Brewing parcels. Additionally, due to its close proximity to Route 5 and Interstate 91, it is likely that at least some stormwater runoff enters this branch from these roadways. Discussions with stakeholders and previous studies indicate that this tributary has had less flooding and erosion issues.

Figure 1



2.4 Main Branch, Downstream Reach

The downstream reach of Bloody Brook (see Figure 2), located between its confluence with Mill River and Interstate 91, appears to be slower and wider, with more available natural wetland areas, wooded areas, and other non-agricultural vegetation. Discussions with stakeholders and previous studies indicate that this section has had less flooding and erosion issues, likely because of the more naturalized stream channel and contributing areas.



3. RETROFIT CANDIDATE SITES

3.1 Municipally Owned Properties

A large complex of municipally owned properties is located at the southeast corner of the watershed. Another municipal property was identified at the intersection of North Main Street and Route 5 that may have the potential to treat stormwater from the surrounding roads. An additional municipally-owned parcel is located just south of the Pelican Products parcel and is currently in the design phase of a new park area that will address stormwater runoff from this parcel. Additional municipal properties were also identified within the watershed, however, these sites were generally located away from impervious areas or were very small.

Deerfield Town Hall

The Deerfield Town Hall parcel consists of a municipal office building and medium-sized parking lot, with a soccer field and baseball field located behind the building. Stormwater runoff from the front side of the parcel appears to flow to Conway Street and a pair of catch basins that discharge to an unknown location. Stormwater from the rear of the site appears to sheet flow to the ball fields behind the parcel and eventually to Bloody Brook, located between the Town Hall and Deerfield Elementary School. Stakeholders indicated that ball fields may be converted to a new building in the future, and thus the fate of this parcel is unknown at the time. Although retrofit opportunities appear to be somewhat limited at this location, it appears that stormwater improvements could be constructed along the site perimeter at the front and rear.

Deerfield Elementary School

The Deerfield Elementary School parcel consists of a large building, large parking lot located across Pleasant Street, and numerous smaller impervious areas associated with access roads/paths, parking/drop off areas, and a playground. An existing stormwater BMP (appears to consist of a narrow detention or infiltration system that overflows towards the rear of the site via an overflow structure) is located at the west side of the building and appears to capture parts of the basketball court, nearby access roads, and portion of the roof. Catch basins were observed along Pleasant Street and discharge to an unknown location. The parking lot to the north of the site has a small stormwater BMP (appears to be a bioretention area) at the rear of the site which appears to capture stormwater runoff from a small portion of the parking area before discharging to a wetland complex to the north (*Note: the drainage connection between this wetland and Bloody Broody could not be determined during the site visit*). Additional stormwater retrofits may be possible in this parking lot, such as utilizing space allocated towards raised islands and additional space surrounding the edges of the parking lot (e.g., retrofit these areas as bioretention, water quality swale, and/or other infiltrating features).

Frontier Regional School and Pleasant Street

The Frontier Regional School parcel has a single large school building, extensive parking and access roadways, tennis courts, and other pervious ball fields located to the northwest. This parcel includes approximately 8.2 acres of impervious area, the third highest in the watershed. Stormwater from the parking lots flow to catch basins located on or near the site, although the final discharge location is unknown. Due to the close proximity to Bloody Brook, which runs along much of the southeast perimeter of the site, it is likely that stormwater flows untreated directly to Bloody Brook. A vacant grassed area approximately 100-feet by 60-feet is located at the far southern side of the site and may be used to treat runoff from a portion of the parking lot. This same area may be used to treat a portion of runoff from Pleasant Street as noted below. Additional stormwater treatment may be possible within the vegetated islands and/or site perimeter.

As noted above, a number of catch basins were observed along Pleasant Street and discharge to an unknown location. Pleasant Street in part connects the elementary school with the Frontier Regional School located to the northeast. Stormwater from at least a portion of the roadway is collected in a series of catch basins where it flows untreated directly to Bloody Brook near the intersection of Pleasant Street and North Main Street. A vacant piece of municipally owned land approximately 100-feet by 60-feet is located directly across the street from this outfall and may be used to treat stormwater from Pleasant Street. This same area may be used to treat a portion of runoff from the Frontier Regional School parking lot as noted above.

Municipal Property at North Main Street and Route 5

A vacant municipally owned parcel approximately 400-feet by 180 feet is located at the intersection of North

Main Street and Route 5. Catch basins were observed in the surrounding area and discharge to an unknown location. At least a portion of runoff from Route 5 appears to discharge into a swale running along the west side of the roadway. The parcel is generally located below Route 5 but above North Main Street, meaning that it may be possible to collect stormwater from much of the intersection and pipe it to a new stormwater BMP constructed on this parcel.

3.2 Privately Owned Properties

Privately owned impervious area is spread among many properties. However, extensive impervious area is associated with three properties: Pelican Products, Yankee Candle, and Tree House Brewing Company. Other parcels are located throughout the watershed, but are generally located further from Bloody Brook or its tributaries, or are substantially smaller.

Pelican Products

The Pelican Products parcel has several interconnected buildings, consisting of a mix of manufacturing, distribution, and offices. Impervious area totals approximately 11.5 acres, the second highest in the watershed. Two large parking areas are also present, with additional active construction work taking place on another access and parking area. Current parking appears insufficient, as numerous vehicles were parking on lawns and in similar areas. Catch basins were observed onsite, which likely connect to the municipally owned drainage system. However, the outfall locations for these catch basins (e.g., Bloody Brook or unnamed tributary) could not be determined during the site visit. It appears that some relatively small pervious areas are present onsite, however, the site is largely impervious and fully built up.

Yankee Candle

The Yankee Candle parcel consists of an administration building, large distribution center, and extensive parking and access roadways. Impervious area totals approximately 18.8 acres, the most in the watershed. Drainage infrastructure such as catch basins were observed throughout the property and appear to discharge to the unnamed perennial tributary to Bloody Brook and a large retention pond at the intersection with Yankee Candle Way and Route 5. The property was observed to be in generally good condition with new landscaping throughout. Due to available space and site characteristics, this location may have the potential for a public-private partnership project to address stormwater discharges from the site.

Treehouse Brewing

The Treehouse Brewing parcel is located just downstream (south) from Yankee Candle along the unnamed perennial tributary. This parcel includes a single large manufacturing, office, and sales facility with a large parking lot and several access roads. Impervious area totals approximately 5.2 acres. Runoff from much of the site appears to sheet flow to a low spot at the tributary before flowing untreated to the stream channel. Due to available space, presence of an untreated stormwater discharge, and stream channel characteristics, this location may have the potential for a public-private partnership project to address stormwater discharges from the site, as well as provide additional treatment of the stream tributary by naturalizing the stream channel. Additionally, it is understood that this facility will be pursuing approval of a Notice of Intent (NOI) for a site development project in the near future.

4. RECOMMENDATIONS AND NEXT STEPS

4.1 Recommended Sites

The following sites are identified as having potential stormwater BMP retrofit opportunities, in order of recommendation:

1. **Site 1: Frontier Regional School and Pleasant Street**. Construct a new stormwater BMP, likely an extended detention basin or gravel wetland depending on field conditions assessed as part of a future project, near the entrance to the Frontier Regional School adjacent to Pleasant Street. Use this BMP to treat portions of runoff from Pleasant Street and/or the adjacent parking lot. Map all stormwater existing infrastructure and determine if additional stormwater BMPs can be constructed at the site. Before finalizing BMP type, onsite soil investigations should be completed to determine expected infiltration rates and depth to groundwater. Due to the close proximity to Bloody Brook, groundwater is expected to be high in this area and thus infiltration may be infeasible.

2. **Site 2: Municipal Property at North Main Street and Route 5**. Construct a new stormwater BMP, likely an infiltration basin depending on field conditions assessed as part of a future project, near the intersection of Route 6 and North Main Street to treat runoff from the surrounding roadways. Map all stormwater existing infrastructure. Before finalizing BMP type, onsite soil investigations should be completed to determine expected infiltration rates and depth to groundwater. Due to the upland location of the parcel, groundwater is expected to be relatively low in this area and infiltration may be feasible depending on soil types.

3. **Site 3: Treehouse Brewing**. Inquire about a potential public-private partnership to construct a BMP within and/or adjacent to the stream channel to treat parking lot runoff before it enters the stream. The actual BMP type and location is to be determined pending site constraints such as depth to groundwater and soils type, however, will likely consist of a constructed wetlands or similar structure. Evaluate the feasibility of adding vegetation to the stream channel and establishing a vegetated buffer around the stream channel. Addition minor regrading or similar work may be also be performed to allow for additional flood storage within the stream channel. Before finalizing BMP type, permitting constraints should be evaluated, as well as additional site constraints as noted above.

4. **Site 4: Yankee Candle**. Inquire about a potential public-private partnership to improve the parking lot to retrofit the existing retention pond to provide additional stormwater treatment. Determine if additional BMPs can be constructed on the property or within close proximity to the stream channel. Map all existing stormwater infrastructure. The actual BMP type and location is to be determined pending site constraints such as depth to groundwater and soils type.

5. **Site 5: Deerfield Elementary School**. Improve the parking area, such as by establishing a more comprehensive vegetated buffer at the rear of the site along Bloody Brook, and converting the raised islands to depressed islands. It may be possible to retrofit the existing narrow detention or infiltration system BMP in the parking lot and other BMP along the west side of the school to increase water quality treatment capacity. Map all stormwater existing infrastructure.

6. **Site 6: New Park Area**. It is recommended that the new park area to be located adjacent to the Pelican Products site be designed to include stormwater management BMPs to treat runoff both from

the new park and from the adjacent North Main Street as much as feasible.

4.2 Grant Project Recommendations

In light of the above, the following projects may be eligible for implementation under a 604b and/or 319 grant:

1. **Watershed-Wide Municipal Property BMP Implementation.** Complete a comprehensive watershed-wide study of municipal properties for stormwater BMP implementation opportunities. This will include the high priority sites identified above, including the Frontier Regional School (Site 1), municipal property at North Main Street and Route 5 (Site 2), Deerfield Elementary School (Site 5), Deerfield Town Hall, and as well as other smaller properties that were not identified as part of this project. In order to be funded as a grant project, a project typically must look at the entire watershed and prioritize locations for successful implementation of stormwater BMPs. This approach will allow looking at the entire watershed, and will likely end up targeting municipal properties with large amounts of impervious area for stormwater BMP implementation.

2. **Public-Private Partnership, Yankee Candle and/or Treehouse Brewing.** Reach out to Treehouse Brewing (Site 3) and/or Yankee Candle (Site 4) to see if they would be interested in teaming on BMP implementation. Private property owners would be responsible for providing an easement for BMP construction and committing to ongoing maintenance of stormwater BMPs. Implementation of public education kiosks could also be a grant component. CEI and FRCOG could provide design and construction services support.

3. **Watershed-Wide Ditch Mapping and Flooding Abatement.** Map agricultural drainage ditches throughout the watershed, particularly at critical junctions such as where ditches meet stream tributaries and/or roadways. This project could identify features such as locations of minimal or no vegetated buffer, areas where water could be impounded to alleviate downstream flooding impacts, areas where water could be treated such as through implementation of native vegetation, and other best practices. Work would be focused on privately owned agricultural areas. At the conclusion of the project, FRCOG could reach out to private property owners to see if they would be interested in teaming on a demonstration project which could be a follow-up project.

Appendix E – List of Source Water Protection Agricultural BMPs with USDA NRCS Code

FY23 Massachusetts list of NRCS source water protection practices. The "Field Office Technical Guide" can be accessed at https://efotg.sc.egov.usda.gov/#/state/MA/documents/section=4&folder=-3. Detailed information on each BMP can be found under "Section 4 - Practice Standards and Supporting Documents" > "Conservation Practice Standards & Support Documents"

207-Site Assessment and Soil Testing for Contaminants Activity
216-Soil Health Testing
217-Soil and Source Testing for Nutrient Management
309-Agrichemical Handling Facility
311-Alley Cropping
313-Waste Storage Facility
316-Animal Mortality Facility
317-Composting Facility
327-Conservation Cover
328-Conservation Crop Rotation
329-Residue and Tillage Management, No Till/Strip Till/Direct Seed
330-Contour Farming
332-Contour Buffer Strips
340-Cover Crop
342-Critical Area Planting
345-Residue and Tillage Management, Reduced Till
355-Water Well Testing
360-Waste Facility Closure
366-Anaerobic Digester
386-Field Boarder
390-Riparian Herbaceous Cover
391-Riparian Forest Buffer
393-Filter Strip
395-Stream Habitat Improvement and Management
410-Grade Stabilization Structure
412-Grassed Waterway
436-Irrigation Reservoir
449-Irrigation Water Management
472-Access Control
528-Prescribed Grazing
561-Heavy Use Area Protection
575-Trails and Walkways
580-Streambank and Shoreline Protection
590-Nutrient Management
600-Terrace
601-Vegetative Barrier

612-Tree/Shrub Establishment
629-Waste Treatment
634-Waste Transfer
635-Vegetative Treatment Area
638-Water and Sediment Control Basin
656-Constructed Wetland
309-Agrichemical Handling Facility
311-Alley Cropping
314-Brush Management
315-Herbaceous Weed Control
338-Prescribed Burning
350-Sediment Basin
351-Water Well Decommissioning
356-Dike
362-Diversion
367-Roofs and Covers
378-Pond
380-Windbreak/Shelterbelt Establishment
381-Silvopasture Establishment
382-Fence
402-Dam
422-Hedgerow Planting
430-Irrigation Pipeline
441-Irrigation System, Micro irrigation
442-Sprinkler System
443-Irrigation System, Surface & Subsurface
462-Preision Land Forming
464-Irrigation Land Leveling
468-Lined Waterway or Outlet
484-Mulching
511-Forage Harvest Management
512-Forage and Biomass Planting
516-Livestock Pipeline
558-Roof Runoff Structure
560-Access Road
574-Spring Development
578-Stream Crossing
582-Open Channel
585-Stripcropping
587-Structure for Water Control
595-Integrated Pest Management
603-Herbaceous Wind Barriers
607-Surface Drain, Field Ditch
608-Surface Drain, Main or Lateral
614-Watering Facility

620-Underground Outlet
632-Solid/Liquid Waste Separation Facility
642-Water Well
643-Restoration and Management of Declining Habitats
644-Wetland Wildlife Habitat Management
650-Windbreak/Shelterbelt Renovation
657-Wetland Restoration
658-Wetland Creation
659-Wetland Enhancement