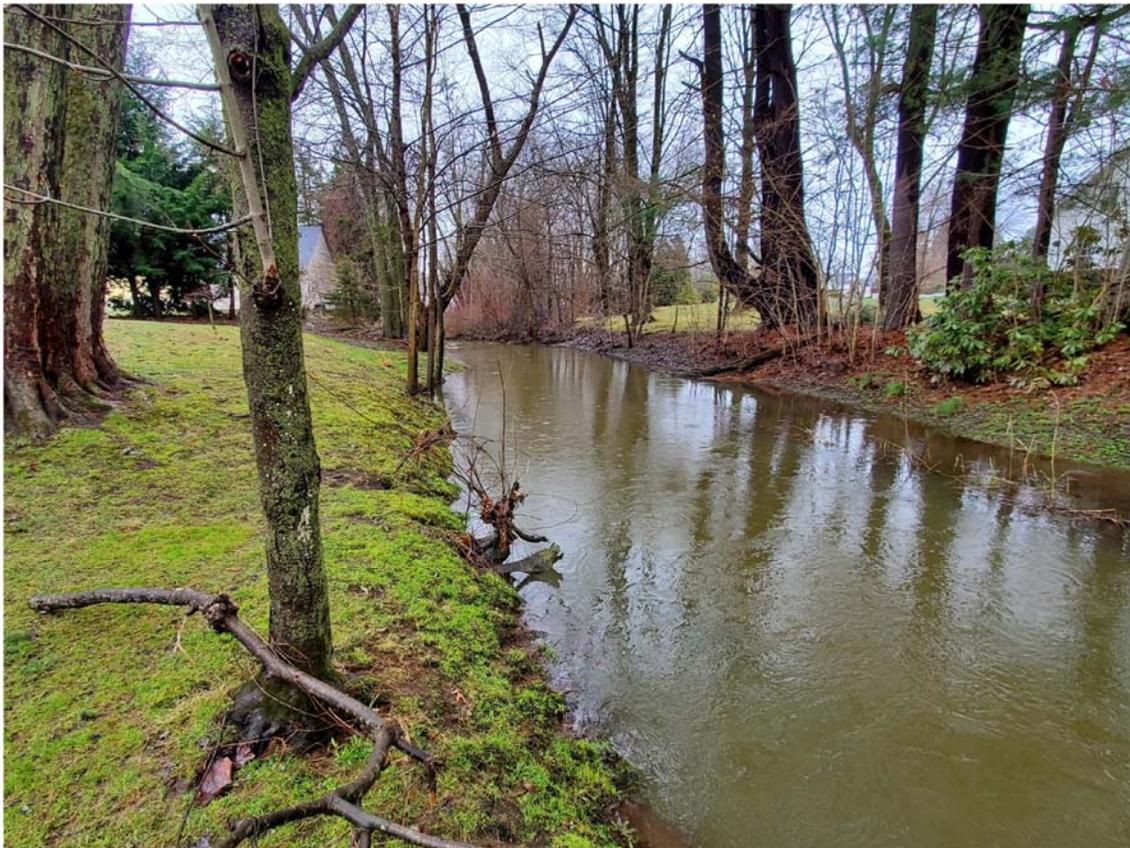


**Geomorphic Assessment of Bloody
and Sugarloaf Brooks**
South Deerfield - Deerfield, MA

Prepared for
Town of Deerfield



Bloody Brook in South Deerfield

Prepared by
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June 2025

1. Site visit and watershed tour

Field Geology Services first toured the Bloody Brook watershed in March 2024 with Town of Deerfield staff and members of the Franklin Conservation District (Figure 1). There was a light rain falling, but the pervasiveness of standing water was notable (in yards, on sidewalks, and on inundated floodplains) despite the limited amount of rain that had fallen. Undersized culverts certainly appeared to be one factor contributing to frequent flooding, with signs of frequent inundation upstream of the private crossing at Bloody Brook Farm, and upstream of Pleasant St, among others. One landowner lamented that residents no longer maintain the brook by clearing out debris and dredging sediment. While another landowner on Eastern Ave shared that their basement sump pump runs constantly, year-round, and their yard often still resembles a pond. Town staff mentioned the elevated water table as another concern.

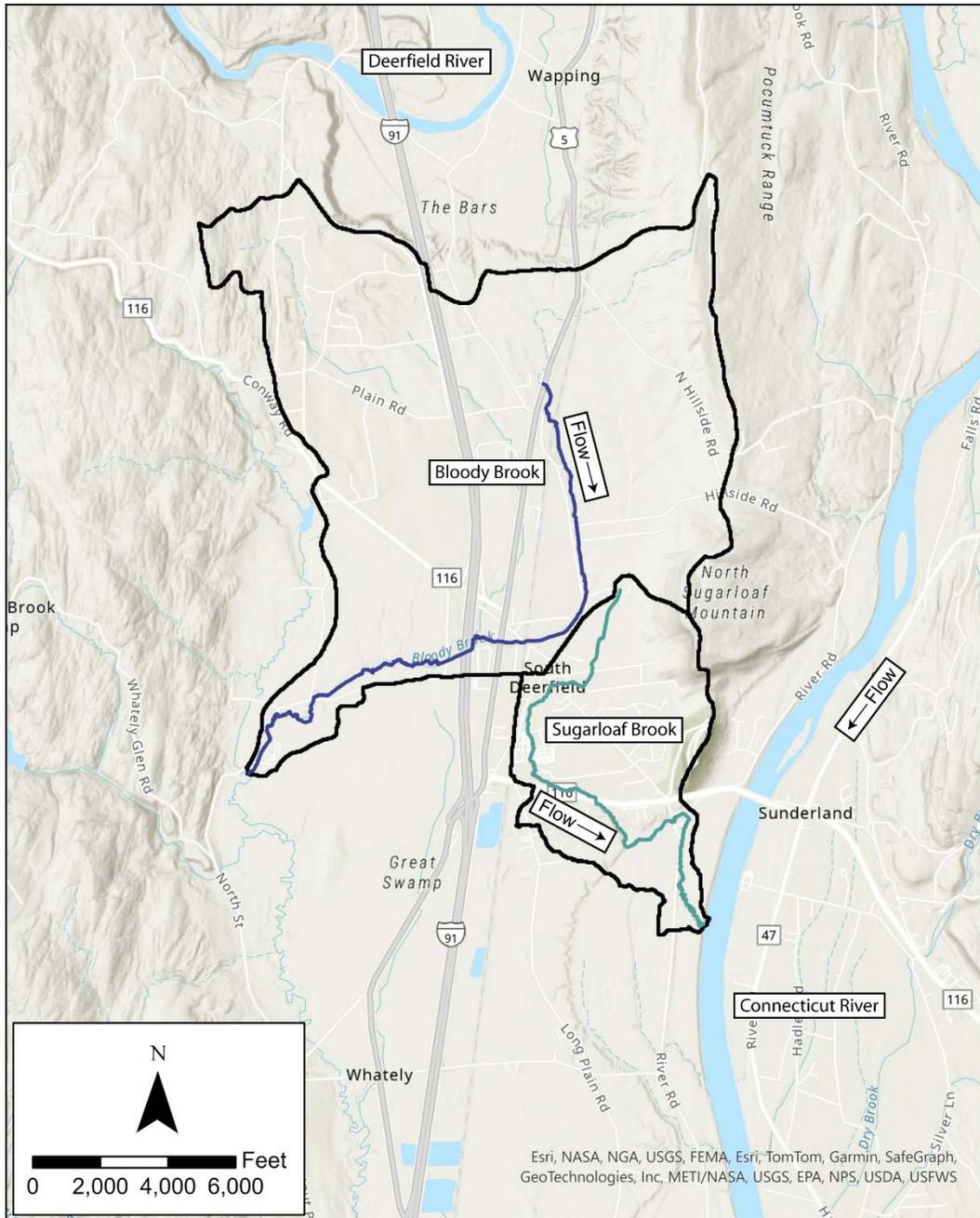


Figure 1. Overview map of the Bloody and Sugarloaf Brook watersheds

Following this initial site visit, funding was secured through a Massachusetts Municipal Vulnerability Preparedness (MVP) grant to study the problem with the goals of better understanding the causes of flooding,

prioritizing best management practices and infrastructure upgrades. As part of this current study, hydrologic and hydraulic HEC-RAS modeling was performed by GZA Geoenvironmental with assistance from Field Geology Services. Modeling is ongoing, and results and discussion will be included in subsequent memos produced by GZA. While not initially included in the project, Sugarloaf Brook, also known as Blacksmith Brook, was added to the modeling study to better understand the factors controlling flooding in South Deerfield. This memo primarily focuses on the details of the geomorphic assessment of Bloody Brook and includes only limited observations and analysis of Sugarloaf Brook.

2. Review of previous studies and archival materials

Field Geology Services reviewed past studies including the Watershed-Based Plan produced by the Franklin Regional Council of Governments (FRCOG) to better understand the locations of and issues associated with identified problem areas along the river (FRCOG, 2024a). The study included a review of online resources and visits to local public libraries to understand the history of the region and identify past alterations to the rivers and their watersheds.

The Bloody Brook watershed Watershed-Based Plan (WBP) focuses on the goal of reducing the pollutant load present in the river. Specifically, the plan outlines strategies to reduce the presence of E. coli, Total Phosphorus (TP) and turbidity which at their current levels have Bloody Brook classified as 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 (FRCOG, 2024a). There is a three-step plan to achieve this goal which starts with a hydraulic and hydrologic study of the watershed, which is part of the current project scope, followed by the implementation of structural and non-structural Best Management Practices to capture runoff and reduce E. coli, TP, and finally sediment loading as well as implementing of watershed education and outreach to achieve additional pollutant load reductions. The goals set for the reduction of pollutant load is a 64% reduction from the 2008 geomean recorded bacteria load in the next 5 years, a reduction in TP loading rate by 210 lb/year in the next 3-6 years and a reduction in total suspended solids (TSS) loading rate by 95 tons/year to reduce turbidity (FRCOG, 2024a).

Education and engagement on proper stormwater management and climate resilience are being implemented through Town-led public engagement and student projects. The Franklin Conservation District (FCD) has been implementing landowner outreach via workshops and property visits as well as through a landowner letter, informational booklet (FRCOG, 2024b), and survey created and distributed by FRCOG staff. Continuation of this outreach would include further focus on landowner education, cultivating a sense of investment in the WBP goals and identifying opportunities for projects that align with the stated goals (FRCOG, 2024a).

Deerfield residents have three main concerns listed in the WBP, apart from pollutant load. The first is the high-water table causing frequent flooding from the brook, exacerbated by undersized culverts (FRCOG, 2024a). The second concern is mosquito species carrying EEE and West Nile virus. Improving water quality and flood measures could reduce mosquito habitats. Lastly, residents are worried about invasive species like Japanese knotweed along Bloody Brook, which could spread during floods.

3. Analysis of historic topographic maps and aerial photographs

Field Geology Services gathered and analyzed historical topographic maps and aerial photographs of South Deerfield to determine what changes to the watershed and the stream channels could be discerned over the past several decades. Historic aerial photographs from 1962, 1966, 1970, and 1975 were gathered and analyzed. These photos are provided in Appendix 1. Topographic maps from 1895, 1935, 1941, 1955 and 1971 were also procured and analyzed and can be found in Appendix 2. The 1962 aerials were georectified in ArcGIS

Pro to analyze possible channel migration and land use changes. Google Earth imagery was also used to identify channel migration since 1992.

Observations and qualitative analysis of available aerial photographs led to several relevant findings. First, Bloody Brook and Sugarloaf Brook were both artificially straightened along much of their length, not unusual for New England where most rivers were heavily modified, channelized, dammed, and straightened dating back to the early colonial era (Figure 2).

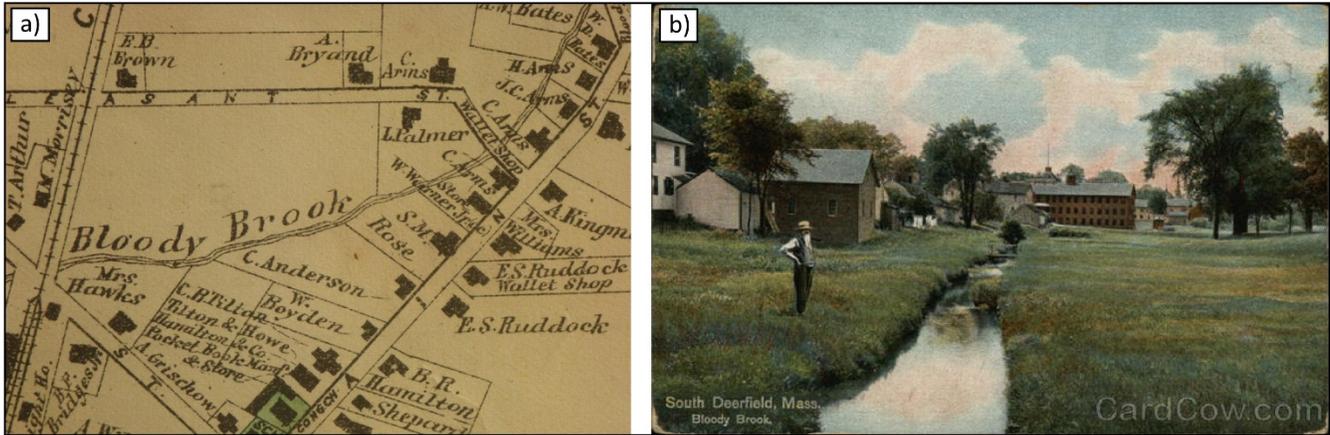


Figure 2. Evidence of channel straightening from archival sources includes a) straight channel planform on 1871 Beers Atlas map, and b) 1910 postcard view of straight Bloody Brook channel near the center of South Deerfield.

Based on the 1895 topographic map (surveyed 1884-85), Bloody Brook was straightened prior to 1885 (Web citation 1 and Appendix 2). Historic aerial photographs (since 1962) showed few changes in channel location in the section of Bloody Brook that runs through South Deerfield. This is due at least in part to past channel manipulations of the river channel to facilitate residential, commercial and civic development (FRCOG, 2024a).

4. Watershed characteristics – Bloody Brook

Bloody Brook, with a drainage area of 4.7 square miles at Interstate 91, the downstream end of the project area (USGS StreamStats), flows into Mill Brook, a tributary to the Connecticut River. The Bloody Brook watershed is situated almost entirely within the town of Deerfield, with only the downstream-most quarter mile of the stream in the town of Whately. The stream drains the west side of the Pocumtuck Range with its headwaters north of North Sugarloaf Mountain, the watershed has a mean basin elevation of 263 feet above sea level (USGS StreamStats). The Bloody Brook watershed consists largely of agricultural or residential development with the middle section of the watershed containing South Deerfield village which includes dense residential, commercial and light industrial development. The watershed is more developed than most of Franklin County watersheds and Bloody Brook is not buffered through these developed areas. The sources of E. coli, TP, and turbidity were listed as unknown in the WBP although stormwater and agricultural land use are likely causes and all agricultural lands have been identified as potential sources of nutrients and sediment. The dissolved oxygen levels are also below the Massachusetts Surface Water Quality Standard (FRCOG, 2024a).

In an analysis of land cover performed for this study (based on 2016 aerial imagery) the watershed is 48.5 percent forested, 43.1 percent open land, and 8.4 percent developed (Table 1 and Appendix 3). The percentage of developed land and forested land have both increased since 1962, at the expense of open land as agricultural lands have been developed or reverted to forested land use (Figure 3).

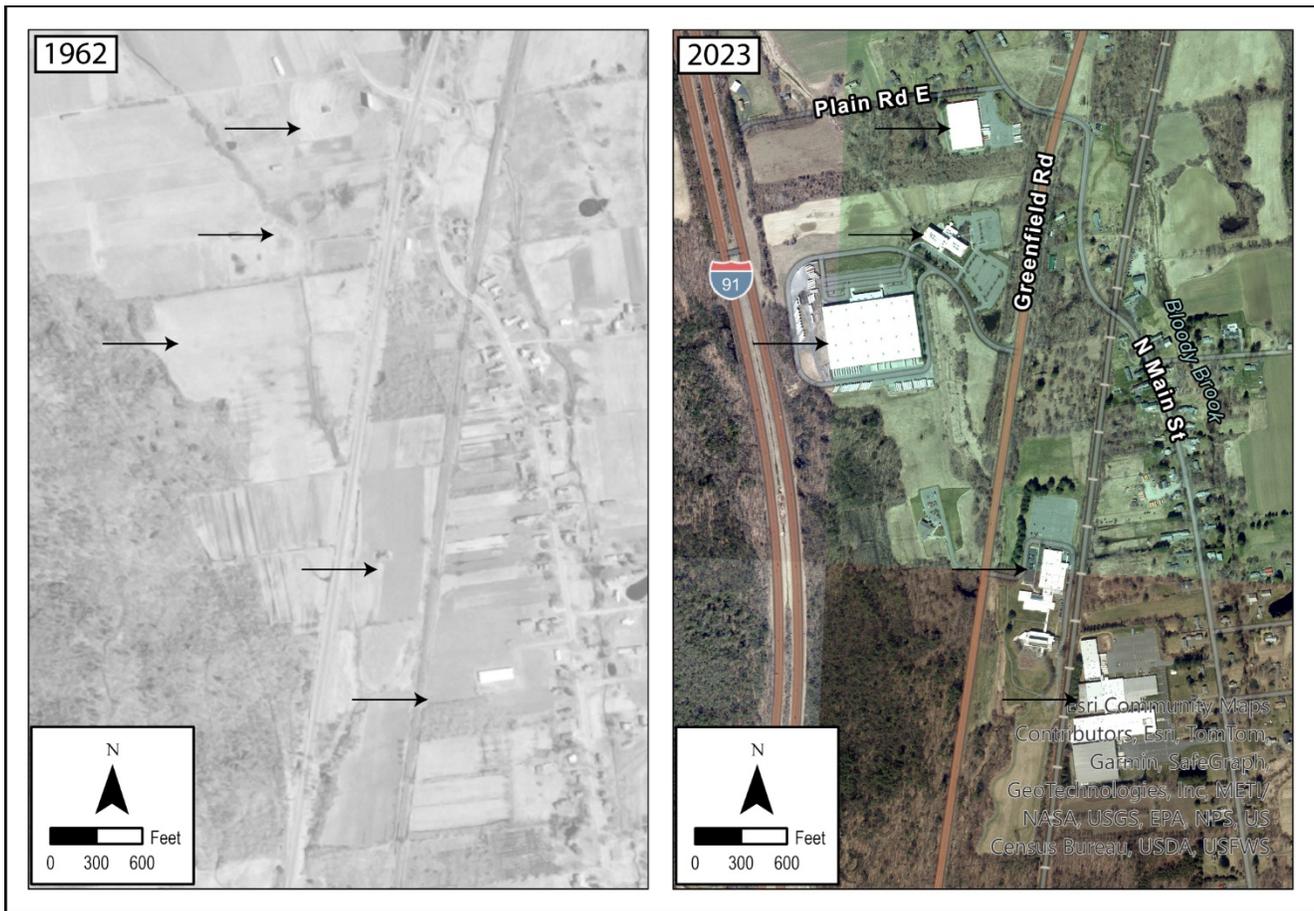


Figure 3. Geo-rectified historic aerial photo from 1962 (left) shows a portion of the Bloody Brook watershed prior to the building of I-91 when land use was largely agricultural. Black arrows point to the same locations in both photos and highlight the increase in commercial and industrial buildings and impervious surface.

Our analysis shows a 30.8 percent reduction in open land use during this time period while developed land has increased by 97.4 percent (Table 1 and Figure 4). Impervious surface covers nine percent of the Bloody Brook watershed, based on a 2005 MassGIS analysis (FRCOG, 2024b).

Table 1. Land cover analysis and historic change

Land Cover Type	Year		% Change
	1962	2016	
Developed	4.3	8.4	97.4
Open Land	62.2	43.1	-30.8
Forest	33.5	48.5	44.9

Soils maps of the project area show the majority of the soils along the river corridor are derived from silty glaciolacustrine, loamy glaciofluvial, and loose sandy glaciofluvial deposits (Appendix 4). This is consistent with the location within the boundaries of historic Glacial Lake Hitchcock, which occupied the Connecticut River valley during the Pleistocene glacial epoch (Stone et al., 2025). Silt loams and fine sandy loams are the most common soil units mapped for the project area (Appendix 4). This corresponds well with field observations of exposed silty and loamy stream banks.

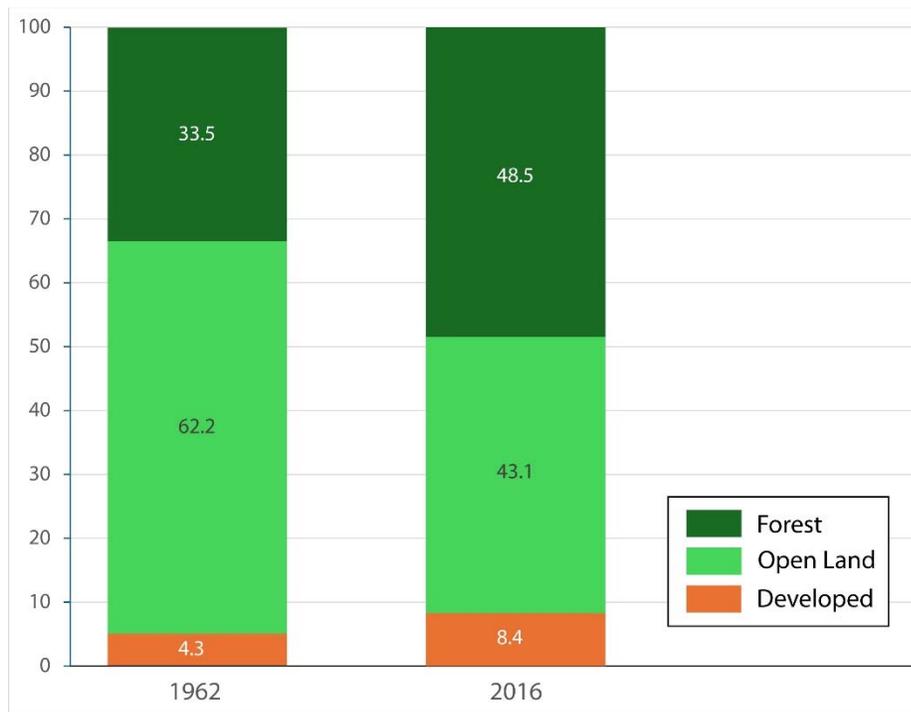


Figure 4 – Changes in land cover from 1962 to 2016.

Bloody Brook has been channelized and straightened throughout both its upper and middle watershed to aid in residential, commercial and civic development along the brook. Many of these developments lie within the 100 and 200ft buffer zone. The river is low gradient (see further discussion in Section 6), and channelized, which has likely led to increased impacts from flooding and an increase in the contamination load post flooding. In the late 1990s Bloody Brook was channelized along Mill Village Hillside and North Hillside roads to reduce localized flooding which cut off the brooks access to floodplains through those locations potentially increasing the impacts of flooding further downstream (FRCOG, 2024a).

Bloody Brook is a warm water fishery (WWF) and a tributary to the Mill River. The Mill River contains Massachusetts’ most diverse community of freshwater mussels including 4 state-listed endangered species and the federally endangered Dwarf Wedge Mussel. Downstream of the Bloody Brook and Mill River confluence are two drinking wells used by the Town of Whately located close to the Mill River. Despite ongoing work to stabilize the river bank the wells remain at risk of contamination due to flooding and/or fluvial erosion (FRCOG, 2024a).

5. Assessment results and geomorphic reach descriptions – Bloody Brook

Assessment results and geomorphic reach descriptions for Bloody Brook incorporate field observations and data collected during the detailed channel features mapping and topographic surveying field work. Surveying and mapping of portions of Sugarloaf Brook were also performed as part of this study. That work was primarily completed to inform the hydraulic modeling and was not included within the scope for the geomorphic assessment. Analysis of ArcGIS Pro mapping data and surveyed channel cross sections combined with the context provided by archival resources, historic aerial photographs and topographic maps provide a basis for understanding stream morphology and identifying likely stressors and restoration options. Figure 5 shows the stream reaches delineated within the Bloody Brook study area.

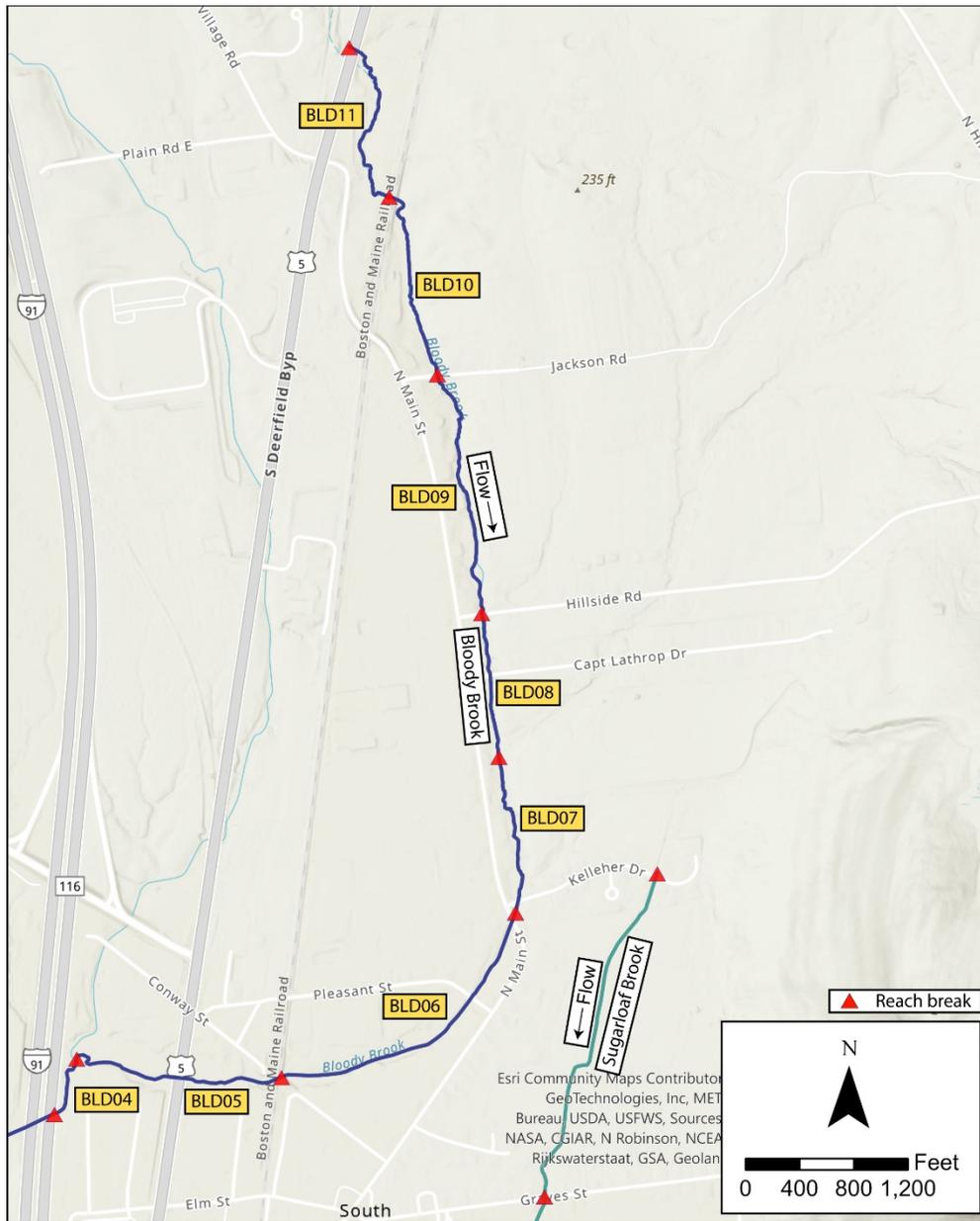


Figure 5. Map of Bloody Brook reaches within the study area.

Reach BLD11

Reach BLD11 is the upstream-most reach in the Bloody Brook study area, starting at Route 5&10 and extending to the upper railroad culvert, a distance of 1470 feet (the stream crosses under the railroad grade again in the upstream section of Reach BLD05). This reach of Bloody Brook is ephemeral and was mostly dry during November 2024 field mapping; homeowners adjacent to the brook report that this is normal, but that the stream often floods during periods of extended rain, backwatering upstream of the undersized railroad culvert and transforming residential yards into short-lived ponds. The artificially straightened channel is still relatively straight, although there is evidence of meander reformation. The channel substrate is sand and fine gravel.



Backwatering upstream of undersized railroad culvert



Channelized stream lacks riparian buffer

Reach BLD10

Downstream of the railroad grade there is a deep scour pool, evidence of the increased flow velocities exiting the undersized railroad culvert (Table 2). Like Reach BLD11, this reach is also ephemeral but often becomes backwatered during wet periods. Upstream of Jackson Road the stream resembles a wet meadow, supporting a suite of wetland plants; the substrate is silt, consistent with the wetland vegetation. Land use in the stream corridor is mostly agricultural. Areas of artificial fill, including the railroad grade itself, encroach upon the stream corridor confining flood flows (see photo below).



Upstream view of grassy wetland channel in BLD10



Barn built on artificial fill along edge of stream corridor

Table 2. Stream crossing dimensions and predicted bankfull channel width

Crossing/Location	Drainage Area (sq.mi.)	Predicted Bankfull Channel Width (ft)	Mass State Standard Culvert Width (ft)	Actual Measured Culvert Width (ft)	Actual Measured Culvert Height (ft)
Bloody Brook					
Railroad (US crossing)	0.74	13.3	16.0	2.3	3.3
Jackson Rd	0.80	13.7	16.5	3.8	4.0
Captain Lathrop Drive	0.98	14.9	17.9	5.0	3.9
Kelleher Drive	2.11	20.3	24.4	9.8	5.3
Pleasant St	2.11	20.3	24.4	5.8	4.6
Railroad (DS crossing)	2.22	20.8	24.9	9.2	5.8
I-91	4.68	28.1	33.7	18.0	7.0
Mill Brook confluence	5.65	30.3	36.3	N/A	N/A
Sugarloaf Brook					
Kelleher Dr	0.05	4.5	5.4	1.1	0.6
Graves St	0.22	8.2	9.8	2.9	2.9
Sugarloaf St	0.42	10.6	12.7	3.9	3.3
Thayer St	0.51	11.5	13.8	6.0	5.8
Rt 116	0.95	14.7	17.7	5.3	5.4

Reach BLD09

Reach BLD09 stretches 1936 feet from Jackson Road to Hillside Road. The right bank of the stream is composed of residential backyards, while the left bank is a mix of residential and agricultural lands. Just downstream of Jackson Rd is a wide, deep scour pool created by the undersized Jackson Rd culvert (Table 2), as well as a well-established stand of Japanese knotweed (see photo below).



Scour pool downstream of Jackson Rd



Beaver dam impounding water in Reach BLD09

The channel has been severely altered historically through channel straightening and has been encroached upon by residential development. Several areas show evidence of artificial fill constricting the floodplain. Bank erosion has increased from upstream reaches, and metrics for bank stability classification are described in Table 3, with streambanks categorized along a spectrum ranging from stable to severely eroding and armored. Overall 15.6 percent of the streambanks were mapped as either actively eroding or armored (Table 4). The artificial fill surfaces in the stream corridor are prone to erosion and are often armored by riprap

Table 3. Bank stability classification

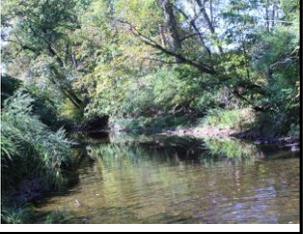
Bank classification	Bank angle	Failure type	Herbaceous Vegetation	Trees/shrubs	Other characteristics	Representative photo
Stable	low to high	None	Yes, often thick coverage	Upright growth, no significant root scour	Point bars or other depositional features often along bank	
Armored	low to high	Past failures or perception of instability but currently faced with large rock	Possible on upper slope, but not typically growing on the rock	Possible on upper slope, but not typically growing on the rock	Historic armoring may utilize native boulders; armor may be failing in places and no longer preventing erosion	
Eroding minor	low to high	Scour along toe and/or bank face, slight undercutting or minimal slip or topple features possible	Yes, sometimes significant coverage	Upright growth habit, some scoured roots	Roots and vegetative growth largely resist scour forces	
Eroding moderate	moderate to undercut	Planar slip, rotational slump, topple blocks	Yes, with some bank sediments exposed	Leaning trees/shrubs, roots may show significant scour	On spectrum between minor and severe erosion, this is most common classification	
Eroding severe	high, near vertical to undercut	Planar slip, rotational slump, grain flow, topple blocks that have in some cases been mobilized and transported downstream	Bank sediments exposed across entire bank profile	Fallen trees/shrubs, recruited trees in channel and downstream	Often located along meander cutbanks and downstream of straightened channels	

Table 4. Mapped bank stability - Bloody Brook

Reach	Description	Length (ft)*	%
BLD11	Stable	2789	95.6
BLD11	Minor	42	1.4
BLD11	Moderate	85	2.9
BLD11	Severe	0	0.0
BLD11	Armored	0	0.0
BLD11	Total Unstable	127	4.4
BLD10	Stable	2936	98.4
BLD10	Minor	0	0.0
BLD10	Moderate	0	0.0
BLD10	Severe	0	0.0
BLD10	Armored	48	1.6
BLD10	Total Unstable	48	1.6
BLD09	Stable	3266	84.4
BLD09	Minor	111	2.9
BLD09	Moderate	59	1.5
BLD09	Severe	0	0.0
BLD09	Armored	434	11.2
BLD09	Total Unstable	604	15.6
BLD08	Stable	1574	72.2
BLD08	Minor	249	11.4
BLD08	Moderate	155	7.1
BLD08	Severe	0	0.0
BLD08	Armored	202	9.3
BLD08	Total Unstable	606	27.8
BLD07	Stable	1836	73.6
BLD07	Minor	135	5.4
BLD07	Moderate	484	19.4
BLD07	Severe	0	0.0
BLD07	Armored	39	1.6
BLD07	Total Unstable	658	26.4

Reach	Description	Length (ft)*	%
BLD06	Stable	3118	67.2
BLD06	Minor	880	19.0
BLD06	Moderate	316	6.8
BLD06	Severe	0	0.0
BLD06	Armored	326	7.0
BLD06	Total Unstable	1522	32.8
BLD05	Stable	989	29.8
BLD05	Minor	75	2.3
BLD05	Moderate	1803	54.4
BLD05	Severe	320	9.7
BLD05	Armored	129	3.9
BLD05	Total Unstable	2327	70.2
BLD04	Stable	294	29.9
BLD04	Minor	0	0.0
BLD04	Moderate	612	62.2
BLD04	Severe	78	7.9
BLD04	Armored	0	0.0
BLD04	Total Unstable	690	70.1
Study Area	Stable	16802	71.9
Study Area	Minor	1492	6.4
Study Area	Moderate	3514	15.0
Study Area	Severe	398	1.7
Study Area	Armored	1178	5.0
Study Area	Total Unstable	6582	28.1

*Combined length of left and right banks

or retaining walls; armoring was mapped along 11.2 percent of the streambanks in the reach (Table 4). The stream is impounded in several locations, by private driveways, pedestrian bridges, undersized culverts, and one beaver dam.



Backwatering in side channel



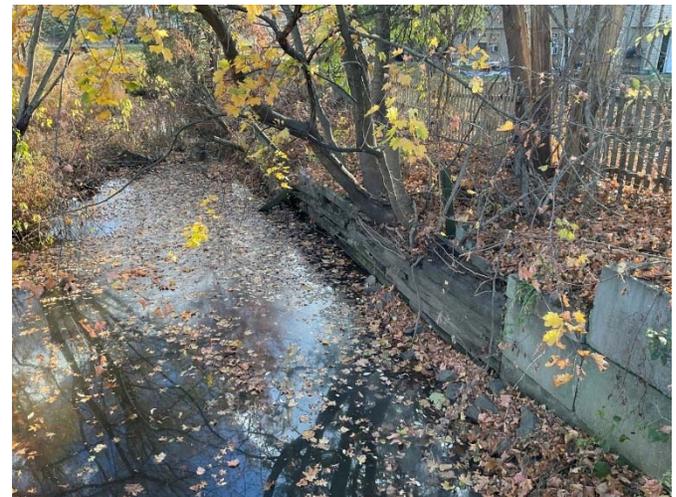
Retaining walls along straightened channel

Reach BLD08

The straight channel continues downstream of Hillside Road and crosses through several undersized crossings that constrict the channel: a private residential right-of-way, Captain Lathrop Drive, and then a private driveway at Bloody Brook Farm. The stream is re-meandering through this reach with deposited point bars paired with erosion on the opposite bank. Erosion and bar deposition are both more prevalent in this reach than in upstream reaches (Table 4). One eroding bank of note is just downstream of Captain Lathrop Dr, where the artificial fill surface along the right bank was protected by a timber retaining wall that is now failing (see photo). The low gradient channel is filled with vegetation, sticks, and organic debris. The substrate is a mix of silt and sand. Evidence of repeated flood inundation includes a house at the corner of North Main St and Captain Lathrop Dr with placed sandbags at first floor doors to hold back floodwaters (see photo).



Low gradient channel filled with debris



Failing timber retaining wall along right bank fill



Ponding upstream of undersized culvert at private drive



Sandbags at first floor doors = evidence of flooding

Reach BLD07

Reach BLD07 begins at the confluence with a large left bank tributary that flows from the Pocumtuck Range and crosses under Hillside Road. At this point the drainage area is now large enough to support a perennial stream that largely flows year-round. There are four undersized culverts in this reach, two private driveways at 130 North Main St and 124 North Main St, and two public roads – Kelleher Dr and North Main St. The Kelleher Drive culvert was replaced in 2021, but it is still significantly smaller than the Massachusetts State Stream Crossing Standards would recommend (Table 2). The upsized Kelleher Dr culvert is most likely adequate for more frequent smaller flow events, but these benefits are muted by the smaller dimensions of the North Main St culvert just downstream. Hydraulic modeling to be completed in FY2026 as part of this project will more completely address the extent to which these crossings are undersized.

The stream corridor is relatively well-forested with a more intact riparian buffer than elsewhere along Bloody Brook. Frequent overbank sand deposition was mapped along with two channel-spanning log jams and a significant quantity of instream large wood. 19.4 percent of the stream banks were mapped as moderately eroding (Table 4).



Recently replaced culvert at Kelleher Drive



Courtesy of Stacy and Michael Martin

Flooding upstream of 130 North Main St.

Reach BLD06

At 2322 feet, Reach BLD06 is one of the longest reaches in the study area. The reach begins at North Main St and continues downstream to the lower railroad crossing. Located adjacent to the heart of the village of South Deerfield, the reach includes parcels for Frontier Regional High School, Deerfield Elementary School, the town offices, town library, and a local church. The reach is frequently impounded by undersized culverts and by other obstructions to flow (see photos below). There were thirty channel-spanning debris (log) jams mapped along Bloody Brook, ten of which are in this reach, many backwatering segments of the stream (Table 5). Land use in the stream corridor is more heavily residential and municipal in this reach, and the dumping of leaves, organic debris, and yard waste while evident elsewhere was very significant in this area.



Channel-spanning debris jams upstream of Pleasant St



Thick layers of leaves and organic debris in stream

The Pleasant St culvert is significantly undersized, and this condition is worsened by the dumped riprap at the culvert outlet, which is at a higher elevation than the inlet. This geometry forces backwatering, with its accompanying sediment and debris deposition, at even low flows. The Pleasant St crossing was selected by Field Geology Services as one of the areas for more detailed topographic survey efforts (Figure 6). During surveying a significant quantity of trash and debris was noted partially blocking the culvert and limiting its hydraulic capacity. This debris has since been removed.



Upstream view of debris blocking Pleasant St culvert



Fallen tree trapping debris downstream of Pleasant St

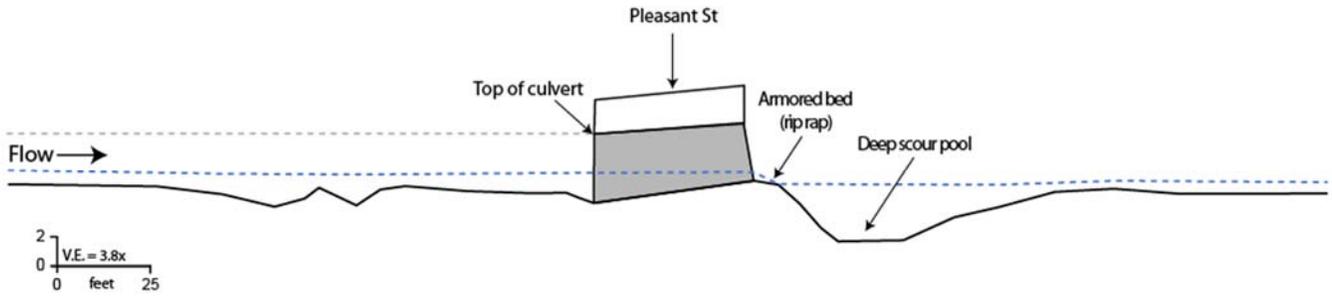


Figure 6. Longitudinal profile surveyed through Pleasant St crossing showing higher bed elevation at the culvert outlet than inlet upstream and a deep scour pool that has developed downstream of the undersized crossing

Table 5. Bloody Brook mapped channel features

Mapped features	Bloody Brook total count
Instream habitat features	
Large wood	286
Log jams	30
Deep pools	14
Beaver dams	3
Channel stability / sediment loading	
Grade controls	1
Mass failures	0
Eroding banks	59
Channel bars	30
Migration features	
Avulsions	0
Flood chutes	2
Oxbows/cutoffs	0
Side channels	2
Knickpoints	0
Stream crossings (culverts and bridges)	24

Downstream of the elementary school, the railroad crossing is a retro-fitted arch with a poured concrete bed and marks the downstream end of the reach. With a maximum width of 9.2 feet and a height of 5.8 feet (Table 2), this culvert has a much greater capacity than the Pleasant St culvert upstream; however, this culvert is still well smaller than those required by the Massachusetts State Stream Crossing Standards. A more in-depth discussion of optimal culvert dimensions will be possible once the proposed conditions hydraulic modeling has been completed in FY2026 and will be discussed in a subsequent memo produced by GZA.



Retro-fitted railroad culvert (downstream view)



Backwatering upstream of railroad culvert in BLD06

Reach BLD05

Invasive vegetation downstream of the lower railroad crossing makes the stream difficult to access. Industrial mill buildings are situated along the left bank corridor, while residential parcels are located along the right bank upstream of Route 5 and 10. Near the former North St crossing, a sewer pipe and a natural gas line cross the stream (see photo). These structures have accumulated a significant quantity of wood and debris. This is one of seven debris jams mapped in the reach. A deep scour pool has formed next to the sewer and gas lines, indicating increased fluvial erosion risks. The natural gas utility was contacted by a Town representative following this discovery and was told the line had been decommissioned. The utility will work to remove the gas line.



Sewer and gas lines crossing Bloody Brook



Box culvert under Route 5 and 10 (downstream view)

Downstream of Route 5 and 10 Bloody Brook runs along the backside of Elm Circle, a residential street that was built in the early 1970s between Route 5 and 10 and Interstate 91. The channel is incised into a grassy wetland and 66.3 percent of the steep silt loam banks are mapped as eroding (Table 4). Reach BLD05 ends at the confluence of a large unnamed tributary that enters on the right bank.

Reach BLD04

Reach BLD04 of Bloody Brook flows approximately 500 feet from the confluence with an unnamed tributary to the double box culvert under Interstate 91; this is the downstream-most reach in the project study area. This is also the downstream extent of the hydraulic model. The unnamed tributary flows from its headwaters in a pond off of Meadowwood Drive and along I-91 and Route 5 and 10 for more than two miles. Given the proximity to these major roads, this tributary is assumed to have degraded water quality although no water sampling was done as part of this study. Accessing this short reach is difficult and the channel could only be observed for a short distance from the upstream reach break. The culvert dimensions for the I-91 crossing were obtained from 1977 MassDOT design plans.



Confluence with unnamed tributary at reach break



Downstream view with I-91 in background

6. Discussion

The goals of the geomorphic assessment of Bloody and Sugarloaf Brooks were to inform the Town of Deerfield, Deerfield residents, the Franklin Conservation District, and other project stakeholders on the causes of the frequent flooding that effects the watersheds and the village of South Deerfield. A major part of this study is still in progress, the hydraulic model analysis, which has been extended into FY2026. The initial results from the existing conditions model show that undersized crossings are indeed having significant impacts on flood inundation in the village of South Deerfield. These results are not unexpected, but further analysis including the continued development of the proposed conditions hydraulic model will help prioritize stream crossing upgrades.

Outside of the hydraulic modeling analysis, there are several observations and findings from the geomorphic assessment that can contextualize the frequency of flooding in the Bloody Brook and Sugarloaf Brook watersheds. These include observations on channel morphology, watershed characteristics and land use, and best management practices.

Bloody Brook is a very low gradient stream with a total relief (as measured from the modeled 1-year recurrence interval water surface) of 24 feet in the project study area. From BLD11 to the downstream end of BLD04 (at I-91) the total stream length is 22,067 feet, or 4.2 miles. This yields a water surface slope of 0.0011; less than 6 feet per mile, a very low gradient. In general, wood is a very important feature in natural stream systems, it provides hydraulic roughness, slows flow velocities, increases sediment sorting, provides opportunities for instream and floodplain sediment storage, increases floodplain connection, carves pools, provides cover, contributes nutrients for aquatic invertebrates, and countless other benefits for stream morphology and habitat. However, in low gradient settings such as the Bloody Brook watershed, hydraulic

roughness may need to be reduced to maintain flow velocities and sediment transport capacity. Therefore, it may be appropriate to remove channel-spanning wood and naturally recruited woody material in this setting to maintain the movement of water and sediment through the stream system.

Mapping of Bloody and Sugarloaf brooks revealed that many homeowners are dumping leaves, yard waste, organic debris, demolition materials and other trash along the riparian area and directly in the channel itself. This was noted most significantly in BLD09, BLD06, SUG08, and SUG07 where the streams run through the backyards of heavily residential parcels. Many homeowners hire landscaping companies, some of whom were seen blowing leaves directly into the stream channels.



Leaves blown from lawn into Bloody Brook



Branches and debris dumped along Sugarloaf Brook

Rivers adjust their hydraulic geometry (reducing width/depth) relative to upstream reaches by carving deeper channels for a given width. Therefore, filling the channel with organic materials and leaves shallows the channel and disrupts the sediment transport continuity. This is particularly problematic upstream of undersized culverts that can easily be clogged or partially blocked with this dumped waste. Mechanical removal of sediment and organic materials equates to dredging, which is regulated within the State of Massachusetts. While this may be appropriate in this setting permits must be acquired, and care must be taken not to negatively impact channel stability and aquatic species habitat.

As noted earlier in this memo, a discussion and prioritization of culvert upgrades will be included in future memos once the hydraulic modeling and analysis has been completed in FY2026. However, there are several practices that can be applied throughout the watersheds. First, there is the need for culverts to be inspected and maintained. Several culverts were observed to be crushed, partially blocked, or otherwise compromised. Routine maintenance is required, and could be delegated to landowners or other residents, with the understanding that properly sized crossings will require less routine maintenance. Second, there are many crossings where the roadway approaches on either side of the culvert block the floodplain. In these cases, the roadway can act as a dam during high flows increasing flood inundation upstream and fluvial erosion hazards at the crossing. One good example of this is the private driveway at Bloody Brook Farm, which appears to dam Bloody Brook during frequent high flow events (Figure 7). Floodplain relief culverts can be installed to mitigate the flooding and erosion hazards in these situations. This is often a relatively inexpensive alternative to full culvert replacement and is expected to require less permitting effort.

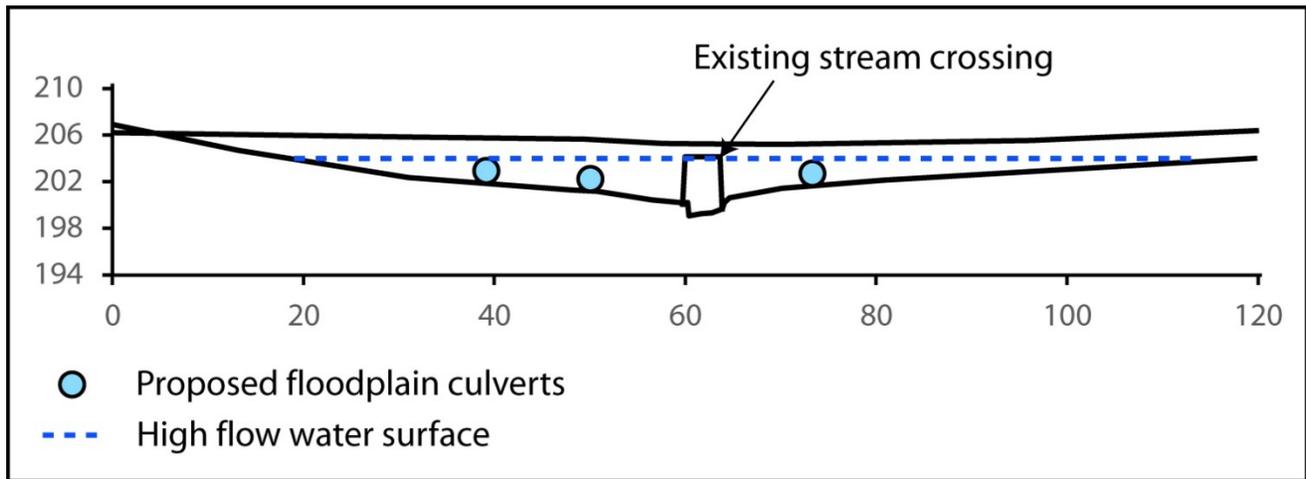


Figure 7. Surveyed cross section of private crossing at Bloody Brook Farm showing undersized culvert and floodplain blocked by roadway approaches that disrupt sediment transport and increase flood inundation upstream. Floodplain relief culverts could be considered to reduce flooding and erosion hazards.

As stated in Section 4 above, development in the Bloody Brook watershed has increased by 97.4 percent from 1962 to 2016 (Table 1), while impervious surface has increased to cover 9 percent of the land surface (FRCOG, 2024b). This relatively high value of impervious surface, some of which is directly connected to the stream, leads to high discharges of untreated runoff, with all the implications for water quality impacts. This also means that there is a significant opportunity for upgrading stormwater infrastructure throughout the watershed. Upgrades and retrofits to parking lots, such as at Frontier Regional High School, have been studied and proposed, and in some cases designed (Tighe & Bond, 2020). Opportunities for stormwater retention in parking lots, underutilized village lots, medians, and other locations should be studied, pursued, and implemented as funding allows.

Limiting runoff and sediment and nutrient inputs to Bloody and Sugarloaf brooks can be improved by establishing and enhancing riparian buffers. Grass and herbaceous filter strips have been shown to reduce sediment loading from agricultural fields by 60 to 90 percent (Daniels and Gilliam, 1996). Forested buffers effectively reduce sediment and nutrient loading (Klapproth and Johnson, 2009), while also providing a myriad of habitat and ecosystem services such as forage and cover for a wide range of birds, amphibians, reptiles, and mammals. FRCOG found that riparian buffers in the Bloody Brook watershed were limited and absent in many stream reaches (FRCOG, 2024a). Buffer enhancement can include planting native trees and shrubs, wetland, and pollinator plants, and mitigating invasive species such as Japanese knotweed.



Sugarloaf Brook agricultural fields lacking a buffer



Forested buffer planted along North River in Colrain MA

Invasive species outcompete native plants and offer limited wildlife benefits. Japanese knotweed is especially prevalent in the Bloody Brook and Sugarloaf Brook watersheds and warrants special mention here. Japanese knotweed spreads through rhizomes and encourages erosion, Colleran (2013) writes:

"Over the long term, knotweed can eliminate groundcovers that hold down soil during regular overland flow events, like runoff from a normal rainstorm, and from season flood events in a floodplain. So knotweed can increase soil erosion from ground level. By outcompeting other residents of a riparian ecosystem complex, it leads to the loss of the big, deep, strong roots that hold many streambanks in place, and replaces those roots with the brittle rhizomes of knotweed."

Japanese knotweed rhizomes may be brittle, but they are tenacious, even growing through rock and concrete, with roots extending up to 4.5 meters in depth and 20 meters laterally from the main aboveground stand (Beerling et al., 1994). Knotweed is allelopathic and changes soil chemistry to prevent other plants from growing (Parepa et al., 2013). This is one reason to be concerned about knotweed stands along rivers in general and in South Deerfield in particular; because decades into the future after riparian trees have succumbed to old age there will be no new trees to replace them, only a monoculture stand of knotweed. Knotweed has the potential to completely eliminate a functional riparian ecosystem and can be expected to relatively quickly eliminate the groundcovers, the understory, and the canopy of infested areas (Colleran, 2013). Left unchecked, Japanese knotweed infestations have the potential for total ecosystem loss (Colleran, 2013). Grant opportunities through federal, regional, and local organizations exist for planting native species and mitigating invasives and can be pursued by municipalities, individual landowners, and cooperatively by multiple landowners and stakeholder groups.

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APPENDIX 1 – Historic Aerials
(digital files)

APPENDIX 2 – Historic Topographic Maps
(digital files)

APPENDIX 3 – Land Cover Land Use Maps
(digital files)

APPENDIX 4 – Soils Maps
(digital files)