

Maidford River Restoration Project
Middletown, Rhode Island
30% Design Report

SUBMITTED TO
Fuss & O'Neill and Southeast New England Program (SNEP) Network

FEBRUARY 2022

inter·fluve

Maidford River Restoration Project
Middletown, Rhode Island
30% Design Report

SUBMITTED TO
Fuss & O'Neill
146 Hartford Road
Manchester, CT 06040

and

Southeast New England Program (SNEP) Network

PREPARED BY
Inter-Fluve, Inc.
220 Concord Ave., 2nd Floor
Cambridge, MA 02138

This product has been funded wholly or in part under a Contract for Special Services with the New England Environmental Finance Center at University of Southern Maine (UMaine System) to administer the SNEP Network project A00655, a project of the Southeast New England Program. The contents of this document do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does the U.S. EPA endorse trade names or recommend the use of any products, services or enterprises mentioned in this document.

Table of Contents

1. Executive Summary iv

2. Introduction 1

2.1 Project Goals 1

2.2 Project Partners 1

3. Project Area 2

3.1 Project Site 2

4. Data Collection and Review 3

4.1 Desktop Data Review 3

4.1.1 Land Use/ Land Cover, Geology, and Soils 3

4.1.2 FEMA Studies and Mapping 4

4.1.3 Utilities 4

4.1.4 Infrastructure 4

4.1.5 Land Ownership 4

4.1.6 Wetlands and Ecology 5

4.1.7 Historical/ Cultural Resources 5

4.1.8 Climate Change 5

4.1.9 Data Gaps 6

4.2 Field Data Collection 6

4.2.1 Topographic Survey 6

4.2.2 Geomorphic Assessment 6

4.3 Site Constraints and Design Criteria 7

5. Project Design 8

5.1 Site Access and Staging 8

5.2 Culvert Replacement 9

5.3 FloodPlain Grading 9

5.4 Channel Form and Habitat 9

5.4.1 Stream Channel Morphology 9

5.4.2 Stream Channel Dimensions 11

5.4.3 Channel and Bank Stabilization 12

5.5 Vegetation 12

5.6 Suggest Construction Sequence 13

6. Engineer's Opinion of Probable Construction Costs 14

7. References 15

Appendices

Appendix A: Maidford River Restoration Feasibility Assessment of Conceptual Alternatives

Appendix B: Engineer's Opinion of Probable Construction Cost

1. Executive Summary

This design report document outlines the approach taken to develop the restoration designs for the Maidford River. The sections below describe the data collected, methods used, and data analyzed; it also summarizes the design elements shown on the design plans. We have provided a recommended construction sequencing and have described and presented the engineer's opinion of probable construction cost. This document is not meant to be used by the construction contractor to construct the work.

The 30% designs described herein have been developed to help meet the stakeholders' goals of restoring natural stream and floodplain processes and habitats, reducing the frequency and magnitude of local fluvial-induced flooding, and improving stream water quality. The described scope of work is focused on stream restoration and will be implemented together with designs by Fuss & O'Neill, Inc. to replace culverts and modify roads to provide adequate flood conveyance and reduce flood risk in vulnerable areas. Together, the work will satisfy the stakeholders' goals.

The existing Maidford River from Berkeley Avenue downstream to Green End Avenue has been heavily modified. It lacks in-stream habitat complexity as well as functional floodplain to safely convey flood waters down valley. The restoration design includes constructing a new, sinuous channel along a new alignment farther from Berkeley Avenue. The floodplain adjacent to the new channel will be excavated to provide flood storage and wetland habitat. The new channel will be immediately stabilized using natural streambed material and bioengineering bank construction techniques. Pools, riffles, and large wood structures will provide in-stream habitat, and floodplain topography and plantings will enhance existing wetlands and provide new habitat for amphibians and other wildlife.

2. Introduction

The Maidford River, located in Middletown, Rhode Island on Aquidneck Island, exhibits degraded water quality and ecological function as a result of anthropogenic impacts. In October 2020, Inter-Fluve began working with Fuss & O'Neill, Inc. (F&O) on a feasibility study and development of design concepts for channel and floodplain restoration of an approximately 0.5-mile reach of the river. Feasibility stage work included:

- Stakeholder meetings,
- Geomorphological reconnaissance survey,
- Feasibility analysis, and
- Development and assessment of conceptual design alternatives.

A technical memorandum was produced and is included as an appendix to this report (Inter-Fluve, 2020). In May 2021, Inter-Fluve was contracted by F&O to progress the restoration design to the preliminary completion, or 30% design, level. The scope of work for this 30% design phase included survey, design plans, and reporting. Hydrologic and hydraulic analyses have been completed by F&O and are described in a separate report by F&O.

This report provides a summary of Inter-Fluve's work to date and presents the information that forms the basis of the preliminary restoration design. The design described herein is focused on the restoration of stream and floodplain function and habitat. The accompanying plan set is dated December 7, 2021. Other design elements necessary to meet the project goals such as road modifications and road crossing improvements are being completed by F&O.

2.1 PROJECT GOALS

Specific goals of the Maidford River Restoration Project (the project) are to:

- Restore natural stream and floodplain processes and habitats,
- Reduce the frequency and magnitude of local fluvial-induced flooding, and
- Improve stream water quality.

2.2 PROJECT PARTNERS

The Project benefits from the support of the following project partners:

- Town of Middletown,
- Southeast New England Program (SNEP) Network,
- Save the Bay,
- Aquidneck Land Trust,
- Eastern RI Conservation District,
- Elizabeth Scott Consulting, and
- Fuss & O'Neill, Inc.

3. Project Area

3.1 PROJECT SITE

The project site consists of an approximately 0.5-mile reach of the Maidford River that runs parallel to Berkley Avenue in Middletown, Rhode Island. The reach is bounded by a culvert under Berkley Avenue to the north and a culvert under Green End Avenue to the south (Figure 1). The Maidford River has a relatively small watershed upstream of Green End Avenue, approximately 1.4 square miles, that is predominately used for agriculture or is developed. The island has a long history of agricultural use, and the current geomorphic condition of the Maidford River is the result of modifications that have likely included floodplain draining, channel straightening, and dredging.



Figure 1. Project area location map. The reach in red is the project site.

4. Data Collection and Review

4.1 DESKTOP DATA REVIEW

We conducted a desktop review of existing data during the feasibility stage (Inter-Fluve, 2020) to understand the broader context of the site and restoration project, and to identify design constraints and opportunities. Additional data were collected and reviewed to inform the preliminary design and are described within this section. Text taken directly from our 2020 report is shown in italics with updated information in normal font. Citations for GIS data sources are included in the References section of this report. More details of watershed characteristics, water uses, water quality impairments, and flooding are provided in a previous report by Fuss & O'Neill (2015).

4.1.1 Land Use/ Land Cover, Geology, and Soils

*Surficial geologic mapping shows that the parent material in the study area is till. Soils are mapped as Type D soils with very low infiltration rates and high runoff potential when wet. Data from the USDA describes the soils as hydric with ongoing wetness and a very shallow water table. The soil map unit name is the Stissing silt loam, which is derived from till. The series is known to include small areas of soils with stones at the surface or a surface layer of topsoil underlain by sandy loam, which is similar to the field conditions observed at this site (*see Section 4.2*). Forest cover native to the Stissing series includes red maple, elm, ash, willow, gray birch, white pine, alders, and hemlock.*

Aquidneck Island was once inhabited by the Wampanoag and Narragansett Tribes of the Algonquin peoples. In the 1600s, the island was deeded to European settlers who took over farming and trade (Rhode Island Historical Preservation Commission, 1979). Middletown itself was incorporated in 1743. With a long history of farming, earth moving, and development in the watershed, it is unclear what the historical Maidford River looked like. The river was mapped in its current location along what is now called Berkeley Avenue as early as the 1880s (USGS, 1891). Although historical topography shows a subtle valley feature along its course, it is likely that the Maidford River was straightened and confined to construct the road and clear land for farming. Evidence remains of ditching to drain adjacent fields, indicating that riparian wetlands were likely more prevalent historically than they are today.

As noted above, the modern Maidford River watershed upstream of the project area is predominately used for agriculture (55%) or is developed (36%) (USGS, 2016). Potential sources of soil contamination are associated with agricultural and road runoff, cemeteries, and leaking of underground storage tanks. State records show one existing (Middletown Cemetery) and five historical cemeteries in the watershed upstream of Green End Avenue. State records also show two occurrences of leaking underground storage tanks, one at the Middletown Department of Public Works on Berkeley Avenue and the other attributed to Eastern Utilities, Newport Electric at 12 Turner Road. Both leaks occurred in the 1990s.

4.1.2 FEMA Studies and Mapping

FEMA mapping shows the project site as within Zone AE, or within the 1% annual chance flood inundation extents and with determined base flood elevations (BFEs) (FEMA, 2013). Floodplain management standards will apply to work at the site. Specifically, no reduction in the storage capacity of the 100-year floodplain will be allowed. Refer to the Town of Middletown, Rhode Island, Code of Ordinances Appendix A, Article 5, Section 517. Discussion of flood related impacts and implications for floodway and flood risk mapping is provided in a separate report by F&O.

4.1.3 Utilities

Water utilities records were obtained by F&O from the Town of Middletown. They show that most of the utility lines in and around the project site run along Berkeley Avenue, Berkeley Avenue Extension, and Green End Avenue. One exception is a sewer line serving the Whitehall Farm Condominiums that appears to be buried in the floodplain along the western edge of the project site. It is shown to connect into the main on Green End Avenue. Immediately upstream of the Green End Avenue culvert, the sewer line crosses over the Maidford River channel.

The records also show one stormwater outfall into the Maidford River at the Berkeley Avenue road crossing and five outfalls at the downstream end of the project area within 900 feet of Green End Avenue. Although not shown on the records, anecdotal evidence suggests that stormwater runoff from the Maidford Common area of the Whitehall Farm Condominiums collects at the northeastern corner of the development (Elizabeth Scott, personal communication, September 8, 2021). An existing swale with no formal outlet into the river can be seen on aerial photographs.

4.1.4 Infrastructure

The project site includes three culverts: 1) an approximately 8.2-foot by 4-foot concrete box culvert under Berkeley Avenue, 2) an approximately 8.1-foot by 5-foot concrete box culvert under Berkeley Avenue Extension, and 3) an approximately 12-foot by 4.5-foot concrete box culvert under Green End Avenue. The two upstream culverts (Berkeley Avenue and Berkeley Avenue Extension) will be replaced as a part of this study (design by F&O.).

The Town Council has approved a project to design a roundabout at the intersection of Berkeley Avenue, Green End Avenue, and Paradise Avenue at the downstream end of the project site. This may lead to replacement of the Green End Avenue culvert in the future.

4.1.5 Land Ownership

The project will involve work on four parcels: Two are privately owned (Holland and Crowninshield), one is owned by the National Society of the Colonial Dames, and one is owned by the Whitehall Farm Condominiums. At the time of developing the preliminary proposed design contained herein, it was understood that planform changes through the Crowninshield parcel (Station 16+25 to 18+10 on Sheet 2 of the project plans) should be avoided.

4.1.6 Wetlands and Ecology

The National Wetlands Inventory shows the channel and floodplain to the north of Whitehall Road mapped as freshwater emergent wetland and the channel and proximal floodplain through the undeveloped parcel to the immediate south of Whitehall Road mapped as freshwater forested/shrub wetland. Other wetland areas are mapped to the north and south of the site.

Wetlands were field delineated by Kate McPherson, PWS, of Save the Bay on September 21-24, 2020; March 10, 2021; June 23, 28, and 30, 2021; and July 15, 2021. The delineations are shown on the accompanying 30% design plans. The project will seek to expand and enhance wetland habitat; therefore, alteration of the existing wetlands, some of which are low quality, is expected to be acceptable to Rhode Island Department of Environmental Management. Disturbance of wetlands outside the footprint of restoration work should be avoided.

The site is within an area mapped as containing observations of a community or nesting site of state or federally listed rare or threatened species or species deemed noteworthy by the state. The river itself is designated by RIDEM as critical habitat for rare and endangered species. Information received from the Rhode Island Natural History Survey (RINHS) indicates that protection, creation, and enhancement of habitat to support amphibians should be incorporated into the project. Further coordination with the RINHS will be required as the project progresses through the design and permitting phases.

4.1.7 Historical/ Cultural Resources

Whitehall on Berkeley Avenue Extension (address 311 Berkeley Avenue) is listed in the National Register of Historic Places, and there are a few listed sites downstream of the project area. While the sites are outside the limits of disturbance, the proposed design should be reviewed by the Rhode Island Historical Preservation & Heritage Commission.

Additionally, there is a low stone wall running along the channel adjacent to Berkeley Avenue. *Historic stone walls are protected by the Town of Middletown, Rhode Island, Code of Ordinances Title IX, Chapter 97. The historic value of the stone wall in the project area is unknown; however, the design should aim to avoid alteration or removal of the wall.*

4.1.8 Climate Change

The project site is affected by climate change impacts, including increased frequency of higher magnitude storm events, increased air temperatures, and extended periods of drought. Our restoration design approach at the site will aim to help build climate resiliency by incorporating an adaptable stream form that can adjust its size and location over time as the hydrology changes. In addition, the inclusion of variable floodplain topography to encourage a range of vegetation species and habitats that will promote continued habitat diversity through future climate changes.

4.1.9 Data Gaps

Records for electrical, gas, and other private utilities have not yet been reviewed. These should be requested, reviewed, and included on the design plans in the next design phase. Additional investigations needed to inform final design are:

- Survey for wildlife species of concern;
- Heritage and cultural resources study;
- Investigation of groundwater conditions at the site; and
- Sediment sampling and testing to determine reuse feasibility and disposal options.

4.2 FIELD DATA COLLECTION

4.2.1 Topographic Survey

Inter-Fluve collected topographic and bathymetric survey data on May 14 and June 22, 2021 using Real Time Kinematic surveying equipment. Inter-Fluve captured the hydraulic control features and critical channel elevations from approximately 500 feet upstream of Berkeley Avenue to approximately 300 feet downstream of Green End Avenue. Survey was focused on the riparian corridor including the channel, banks within approximately 50 feet of the channel, edge of pavement along Berkeley Avenue, and details of culverts and outfalls. The swale running along the northern edge of the Maidford Common condominiums was also captured. Outside of the survey extents, existing topography was supplemented with LiDAR data (USGS, 2014). The existing topography is shown on the accompanying 30% design plans.

4.2.2 Geomorphic Assessment

Inter-Fluve conducted a geomorphic assessment at the project site on September 21, 2020. Observations are summarized in our previous memo provided as an appendix (Inter-Fluve, 2020). Key points are copied here (in italics) for ease of reference. Additional information is provided in normal type.

Maidford River channel dimensions within the project site vary, but average measurements are approximately 10 feet wide by 2 feet deep. The channel bed and banks are nearly entirely sand and silt within the study area. Small to medium gravel can be found 0.75 to 1.5 feet below the channel bed in some places. The banks are well vegetated, which helps provide stability and resistance to erosion. No signs of active bank erosion or lateral migration were noted in the field. The channel was dry at the time of the survey.

Some larger bed material (i.e., gravel and cobbles) is present downstream of the project site. Where there is stone present within the project site, such as in the channel where it runs adjacent to Berkeley Avenue, it appears to be rip rap and other large stone placed to protect the road embankment from scour. Pebble counts were completed at select locations where stone was present. The average D_{50} within the project site is 69 mm, and the D_{50} in a reach downstream is 89 mm.

Few channel habitat features were observed in the project area. The limited number of features that do exist are in the areas of trees and shrubs where the water has been forced around tree roots and fallen logs, creating

deeper scour pools, additional cover, and general increased complexity. In some of these deeper scour pools, small to medium gravel is exposed.

Floodplain soils were augered to a depth of approximately four feet at 10 different locations on the floodplain adjacent to the channel. Soils were found to be composed of topsoil over fine sand and silt; no coarse material was encountered at the inspection locations.

We anticipate that the silt and sand [in the channel and floodplain] *is a combination of native material and deposition. The likely source of the deposition is agricultural runoff.* Specifically, runoff from Hoogendorn Nursery is thought to have been a substantial historical source of sediment to the project site (Elizabeth Scott, personal communication, October 29, 2021). A stormwater detention basin was constructed by the Town of Middletown in 2017 to manage runoff from the nursery site and is thought to have reduced sediment input to downstream reaches.

4.3 SITE CONSTRAINTS AND DESIGN CRITERIA

Restoration of the Maidford River will focus on supporting natural fluvial processes and riparian habitats. The resulting channel construction may not approximate the native form of the Maidford River, about which little is known. It will, however, support desired functions and species as defined in the project goals.

Inter-Fluve synthesized existing data and field information to define site constraints and design criteria relevant to the restoration design. The primary constraints at the site are:

- A buried sewer line running through the southeast part of the site;
- Sandy soils with little to no coarse material;
- Existing culvert inverts and the extent of potential raising or lowering of inverts and/or road levels;
- Existing wetlands and amphibian habitat;
- Land ownership;
- Existing development, specifically the Maidford Common area of the Whitehall Farm Condominiums and associated stormwater runoff paths; and
- Presence of potentially historically important stone walls along the existing Maidford River bank.

Design criteria were developed through discussions with F&O and project stakeholders. Inter-Fluve participated in two stakeholder meetings, one on September 8, 2021 and another on October 29, 2021. The resulting design criteria are described below.

- Flood risk: The project should increase the storage capacity of the floodplain to the greatest extent possible while managing costs and avoiding adverse impacts to existing development.
- Vertical stability: The constructed channel should be designed to minimize the risk of incision and to efficiently transport sediment through the reach. Upstream land management

and sediment source issues are outside the scope of this project but should be addressed to reduce the risk of substantial deposition within the constructed channel.

- Lateral stability: Bioengineering practices should be implemented to reduce the risk of avulsion and substantial lateral erosion in the short term and to support the establishment of riparian vegetation. Over the long term, lateral movement moderated by riparian vegetation and large wood is acceptable.
- Sediment management: Sediment release during and after construction should be minimized to avoid clogging of downstream channels and culverts. Excess excavated material will need to be removed off site.
- Fish passage: The project should be designed to support passage of a wide variety of species that are present or were likely historically present along the river, including American eel, shad, and herring.
- Aquatic habitat and wetlands: The project should be designed to support a rich diversity of riparian plants and habitats, including wetlands, off-channel habitat for amphibians, and in-stream aquatic habitats.

5. Project Design

The project scope of work includes lowering the Maidford River floodplain and constructing a meandering channel between Berkeley Avenue and Green End Avenue as shown on the accompanying plan set. Project elements include constructing riffles for grade control; installing large wood to protect banks and create habitat variability; installing biodegradable fabric to protect banks; creating floodplain microtopography and pond features to improve vegetative and plant diversity; and planting a range of riparian species.

5.1 SITE ACCESS AND STAGING

This project site runs along a busy road (Berkeley Avenue) and includes a number of existing wetlands. We have identified two primary access and staging areas described below that take into account traffic safety and avoidance of unnecessary impacts to wetlands. These are shown on the accompanying plans.

- Berkeley Avenue Extension – This location would provide access to and staging for channel construction and floodplain excavation between Berkeley Avenue and Berkeley Avenue Extension. The suggested staging area is located on the same parcel as the proposed construction and is in a cleared area outside the limits of existing wetlands.
- Corey Lane – This location would provide access to and staging for channel construction and floodplain excavation between Berkeley Avenue Extension and Green End Avenue. The suggested staging area is outside the limits of existing wetlands and proposed floodplain grading. The access route between the staging area and the area of active

work crosses over a buried sanitary sewer line. The contractor will be responsible for determining the depth to the pipe and designing protective measures to prevent damage.

5.2 CULVERT REPLACEMENT

As previously described, the culverts under Berkeley Avenue and Berkeley Avenue Extension will be replaced as part of a separate scope of design work being completed by F&O. For the purposes of 30% design, we assumed that the downstream invert of the Berkeley Avenue culvert will remain as existing. This assumption may be changed in subsequent design phases. To allow for adequate floodplain grading and to prevent backwatering, the invert at Berkeley Avenue Extension will need to be lowered by approximately 1.3 feet.

At a minimum, the new culvert openings should be 1.2 times the bankfull channel width or 25.4 feet (see Section 5.3). We recommend open-bottom, free-span structures to reduce the risk of scour and to support hydraulic conditions for successful aquatic and terrestrial organism passage.

5.3 FLOODPLAIN GRADING

The floodplain between Berkeley Avenue and Green End Avenue will be lowered to improve flood storage capacity by reconnecting the river with its floodplain, and to support wetter floodplain conditions for improved ecosystem function. The extent of floodplain lowering varies with existing topography and ranges from zero to up to four feet. The width of the grading was selected to accommodate the proposed planform and at the same time manage costs associated with excavation and off-site disposal.

5.4 CHANNEL FORM AND HABITAT

The constructed channel will be a meandering channel with sinuosity calculations based on channel size, watershed size, slope, and regional reference reaches. Its alignment will be shifted away from Berkeley Avenue.

5.4.1 Stream Channel Morphology

Inter-Fluve attempted to identify local undisturbed streams (or streams that appear to be stable under current conditions associated with watershed land use and hydrology) to serve as analogs for our design. When choosing an analog or reference stream, the analog should have similar watershed and morphological attributes to the proposed restored channel, including:

- Watershed size;
- Surficial geology;
- Bordering vegetation;
- Soils; and
- Land use.

There are few sites that check all the boxes because most streams and wetlands in New England, including Rhode Island, have been manipulated for farming, development, or other means for hundreds of years. We analyzed aerial photographs and maps of streams on and around Aquidneck Island to find potential reference sites. Most streams observed are similar to the Maidford River with sinuosity (i.e., ratio of stream channel length to valley length) close to 1. Naturally, streams at 0.5% slope with sandy or gravelly bottoms will tend to form sinuous planforms (i.e., sinuosity > 1) characterized by pools and riffles. The general absence of sinuosity across the area's streams suggests that they were and continue to be managed to facilitate agriculture and development.

We found one stream with notable sinuosity: Dundery Brook in Little Compton, Rhode Island. The watershed is a similar size (2.3 square miles vs. the Maidford River's total 2.4 square miles) and has similar geology and soils. Land use and bordering vegetation differ, with Dundery Brook largely forested along its length. The sinuosity of Dundery Brook is 1.5.

To develop planform geometry values for design of the Maidford River channel, we examined meander belt width, meander length, radius of curvature, and channel top width for Dundery Brook and field measurements of channel top width for the Maidford River. We compared top widths and found similar ranges of 10 to 21 feet for the Maidford River and 10 to 24 feet for Dundery Brook. Given the similarities in watershed size and channel width, we used the ranges of each planform geometry parameter for Dundery Brook to guide the planform of the new Maidford River channel. We designed the stream to have a slightly irregular meander pattern based on the reference site and general observations of meandering channels. The planform values that guided our design are listed in Table 1. The resulting planform shown on the accompanying plans has a sinuosity of 1.4 and planform values within the ranges in Table 1.

Table 1. Planform values measured for Dundery Brook

Meander belt width	120-250 feet
Meander length	150-390 feet
Radius of curvature	45-95 feet

The current plan set does not show the introduction of sinuosity within the Crowninshield parcel from Station 28+00 to Station 30+00. Pending discussions with the landowner, sinuosity may be added in the next design phase.

5.4.2 Stream Channel Dimensions

The project site is upstream of the tidal influence and therefore, channel size is determined by watershed hydrology. F&O led the hydrologic analysis for the 30% design and provided the following peak runoff discharges for relevant rainfall events:

Table 2. Peak runoff discharges for the Maidford River

1-year storm (100% annual exceedance probability)	150.8 cfs
2-year storm (50% annual exceedance probability)	209.3 cfs

Peak discharges occurring with a frequency of 1-2 years have been shown in the geomorphic literature to be most closely correlated with channel capacity, or size, in alluvial rivers. Whether or not flood recurrence intervals correlate with storm recurrence intervals depends on watershed characteristics and antecedent moisture conditions. For the purposes of this preliminary design, we have assumed that the two correlate reasonably well and have used the peak discharges in Table 2 as the basis for our channel design.

Measured channel bottom widths, top widths, and depths of the existing Maidford River channel in the project area are 4 to 13 feet (bottom), 10 to 21 feet (top), and 0.4 to 2.6 feet (depth). We used Manning's equation with input values of 0.004 for the design slope and 0.035 for the roughness coefficient and iteratively adjusted widths and depths within these ranges to achieve capacities of 150.8 and 209.3 cubic feet per second (cfs).

Our design channel dimensions of 12-foot bottom width, 2.3-foot depth, 2(H):1(V) side slopes, and 21.2-foot top width were selected such that the channel is sized for current hydrologic conditions with the ability to adapt to changing and uncertain factors such as intensifying precipitation events and periods of drought. The existing capacity of the channel corresponds to the peak runoff from a 1-year storm, or approximately 150 cfs. We sized the channel to the lower event in order to support the establishment of wetland habitat on the floodplain. More information on groundwater conditions at the site is needed; however, field observations indicate that the existing river runs dry at times throughout the year. Thus, lower floodplain elevations and great frequency of floodplain inundation will better support the targeted range of habitats. We have selected a relatively wide channel bottom to provide space for the construction of bars and pools around bends.

5.4.3 Channel and Bank Stabilization

The primary considerations in determining channel and bank stabilization approaches are the risks of avulsion into the former channel and short-term erosion prior to vegetation establishment. The sandy nature of the floodplain soil means that it will be particularly susceptible to erosion immediately following construction. We have therefore planned bed and bank stabilization along the length of the constructed channel. We reviewed 2D HEC-RAS modeling results by F&O (see separate report) and found that predicted shear stresses and velocities are compatible with using a bioengineering approach.

Bed stabilization will be in the form of riffles constructed of a wide gradation of rounded streambed material (i.e., sand to cobbles). At the apices of meander bends, we have designed large wood structures to stabilize the bank as well as create habitat complexity by maintaining scour pools and overhangs. Large wood bank construction incorporates riffle substrate to provide a source of coarse streambed material in the absence of supply from upstream. At riffles and other locations with elevated flow velocities, we have specified fabric encapsulated soil (FES) lifts constructed of biodegradable coir fabrics, soil, and riffle substrate. Where relatively low velocities are anticipated, such as the inside of meander bends, the new bank surface will be covered with biodegradable coir fabrics. One exception to the bioengineering approach is the inclusion of along the banks at culvert entrances and exits. Riprap was incorporated to provide extra protection against scour at these locations.

Hydraulic modeling will be updated and the results reviewed in more detail during future design phases. The type and distribution of stabilization measures will be confirmed and the details further developed based on predicted shear stresses and velocities.

5.5 VEGETATION

We propose to replant river banks and disturbed floodplain areas with native seed and native potted trees and shrubs. In the next phase of design, we will provide a more detailed species list with proposed quantities and locations. Different areas of the site will develop into different vegetative ecosystems:

- River edge – A rich riparian community dominated by woody species such as willow, cottonwood, red maple, elm, and black elderberry;
- Floodplain upland and transitional areas – Native grasses and wildflowers as well as shrubs and trees such as black elderberry, red maple, dogwood, sycamore, cottonwood, and white oak; and
- Wetlands – A range of plants from emergent herbaceous vegetation to moisture-tolerant woody species such as American hornbeam, willow, swamp white oak, cottonwood, and red maple.

5.6 SUGGEST CONSTRUCTION SEQUENCE

In this section, we provide a recommended construction sequence of restoration activities. Once a contractor has been selected, they will submit a detailed work plan with their own recommendations for sequencing.

- Mobilization
    - Install traffic control measures
    - Install sediment and erosion control features
    - Install stabilized construction entrances
    - Create staging areas
- Construct the new channel and excavate the floodplain from approximately Station 12+00 upstream to Station 27+00 offline
- Construct the tie-in at Green End Avenue, leaving the connection with the existing channel open
- Replace the culvert at Berkeley Avenue Extension and construct the channel from approximately Station 31+00 to 27+00, releasing flow into the new downstream channel
- Complete bank construction at Green End Avenue to close off the former channel
- Replace the culvert at Berkeley Avenue and construct the channel and excavate the floodplain between Berkeley Avenue and Berkeley Avenue Extension
- Seed newly exposed and constructed areas immediately following completion
- Restore staging and access areas
- Complete seeding and planting
- Remove traffic signs as appropriate
- Remove sediment and erosion controls

6. Engineer's Opinion of Probable Construction Costs

We have developed a planning level engineer's opinion of probable construction cost (EOPCC) for the restoration work commensurate with a 30% level of design (Appendix B). Our EOPCC is based on recent bid prices for similar items on projects in the northeast region, cost factors specific to Rhode Island, and applicable reference cost data. The EOPCC includes earthwork, channel bed and bank treatments, large wood structures, microtopography, and plantings. Key assumptions and approximations made in estimating the cost are described below.

- The area for clearing and grubbing was measured off of aerial photographs as the total area of tree and shrub cover within the limits of disturbance.
- The volume of material for excavation and off-site disposal was calculated as the difference between existing and final grade. We have assumed that excavation for construction of large wood bank protection and FES lifts and reuse of the material will be incorporated into the project as incidental to those items.
- Excavated material for off-site disposal is not contaminated.

The cost estimate is presented in 2021 USD. To estimate construction cost in a future year, escalation of approximately 3% per year should be added. At this level of design, we have assumed a 30% design and construction contingency to account for future scope or design changes, uncertainty in quantities or other factors associated with the level of design, and potential construction cost overruns. This will decrease in later phases of design.

Finally, our final cost opinion is presented as a range that reflects the potential accuracy range of cost estimation at the 30% design level given uncertainties in bidding and market conditions.

7. References

FEMA, 2013. Flood Insurance Study for Newport County, Rhode Island. FIS Number 44005CV000B.

Fuss & O'Neill, 2015. Maidford River Watershed Assessment & BMP Design.

Inter-Fluve, 2020. Maidford River Restoration Feasibility Assessment of Conceptual Alternatives. Technical Memorandum.

Rhode Island Historical Preservation Commission, 1979. Historic and Architectural Resources of Middletown, Rhode Island: A Preliminary Report. Rhode Island Historical Preservation Commission, Providence, Rhode Island.

RIGIS, 1989. Rhode Island Glacial Deposits. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

RIGIS, 1994. Bedrock Geology of Rhode Island. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

RIGIS, 2012. Historical Cemeteries. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

RIGIS, 2012. Leaking Underground Storage Tanks. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

RIGIS, 2018. Soils; soils18. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.edc.uri.edu/rigis, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

RIGIS, 2019. Rhode Island Natural Heritage Areas; natHeritage19. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (accessed on 30 September 2020).

U.S. Geological Survey [USGS], 1891. Rhode Island Sheet No. 6, Topographical Atlas of the State of Rhode Island and Providence Plantations. Surveyed in 1885 and 1888. Geo. H. Walker & Co., Boston and New York.

U.S. Geological Survey [USGS], 2014. Rhode Island Coastal 2014 USGS CMGP Sandy Lidar (USGS Contract No. G10PC00057; Task Order No. G13PD00796; Woolpert Order No. 073667). Originator: Woolpert, Inc. Available from RIGIS: https://www.rigis.org/pages/2014-usgs-lidar-dem

U.S. Geological Survey [USGS], 2016. The StreamStats program, URL: http://streamstates.usgs.gov (accessed on 9 June 2020).

Appendix A
Maidford River Restoration Feasibility Assessment of Conceptual Alternatives

TECHNICAL MEMORANDUM

To: Joshua Wilson, PWS[1]

From: Candice Constantine, PhD, PE[2] and Nick Nelson, CERP[3]

Date: October 13, 2020 **Project:** Maidford River Restoration

Re: Feasibility assessment of conceptual alternatives

This memorandum summarizes the results of Inter-Fluve's existing data review and geomorphological reconnaissance survey for the Maidford River Restoration Project.

BACKGROUND

The site borders an approximately 0.45-mile reach of the Maidford River in Middletown, Rhode Island that is bound by a culvert under Berkley Avenue to the north, beneath Whitehall Road, and a culvert under Green End Avenue in the south. The Maidford River has a relatively small watershed upstream of the site, approximately 1.4 square miles, that is predominately used for agriculture (55%) or is developed (36%). The island has a long history of agriculture, and the current geomorphic condition of the Maidford River is the result of modifications that may have included floodplain draining, straightening, and dredging.

Fuss & O'Neill has been working with the City of Newport and neighboring towns to improve water quality that has been adversely impacted by agricultural and urban runoff. In the course of their work, Fuss & O'Neill also identified inland flooding as a substantial problem stemming from land conversion, management practices, and soils with low infiltration rates. Fuss & O'Neill outlined a list of potential actions that could help to alleviate flooding, including flooding along Berkley Avenue upstream of Green End Avenue. The current project was conceived as a part of those efforts, and stakeholders have elected to move forward with design and implementation.

Based on our current understanding, project goals and objectives include:

- Reducing the frequency and magnitude of local fluvial flooding;
- Improving downstream water quality; and
- Restoring natural stream and floodplain processes and habitats.

[1] Fuss & O'Neill, Project Manager
[2] Inter-Fluve, Project Manager
[3] Inter-Fluve, Senior Fluvial Geomorphologist

Offices Nationwide
501 Portway Avenue, Suite 101, Hood River, Oregon 97031
541.386.9003 www.interfluve.com

Three conceptual design alternatives have been defined by Fuss & O'Neill and further developed by Inter-Fluve (see text in bold italics). These are described below and illustrated on an attached sketch by Fuss & O'Neill.

Alternative 1

- Lower stream channel to the north and south of Whitehall Road to match the new culvert invert elevation. ***Remove sand and silt deposits in the channel and expose the coarse gravel below.***
- Create new floodplain storage and riparian buffer along the existing stream channel to the north of Whitehall Road. ***Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant with native trees and shrubs.***
- Create new floodplain storage and riparian buffer to the west of the existing stream channel on the condo association property. ***Where present, remove existing wall and vegetated berm to the west of the channel. Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant with native trees and shrubs.***
- No excavation proposed on the undeveloped parcel to the immediate south of Whitehall Road with the exception of lowering the stream channel.

Alternative 2

- Lower stream channel to the north and south of Whitehall Road to match the new culvert invert elevation. ***Remove sand and silt deposits in the channel and expose the coarse gravel below.***
- Reconstruct stream to create sinuosity, floodplain storage and riparian buffer to the north of Whitehall Road. ***Re-meander channel and construct pool-riffle habitat. Construct banks using fabric encapsulated soil (FES) lifts with a lower lift containing a rock/soil mixture for toe stability. Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant banks and floodplain with native trees and shrubs.***
- Reconstruct stream to create sinuosity, floodplain storage and riparian buffer on the condo association property***. Re-meander channel and construct pool-riffle habitat. Construct banks using fabric encapsulated soil (FES) lifts with a lower lift containing a rock/soil mixture for toe stability. Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant banks and floodplain with native trees and shrubs.***
- No excavation proposed on the undeveloped parcel to the immediate south of Whitehall Road with the exception of lowering the stream channel.

Alternative 3

- Lower stream channel to the north and south of Whitehall Road to match the new culvert invert elevation. ***Remove sand and silt deposits in the channel and expose the coarse gravel below.***
- Create new floodplain storage and riparian buffer along the existing stream channel to the north of Whitehall Road. ***Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant with native trees and shrubs.***
- Reconstruct stream to create sinuosity, floodplain storage and riparian buffer on the condo association property. ***Re-meander channel and construct pool-riffle habitat. Construct banks using fabric encapsulated soil (FES) lifts with a lower lift containing a rock/soil mixture for toe***

stability. Remove sand and silt accumulated on floodplain to increase storage and create new wetland habitat. Plant banks and floodplain with native trees and shrubs.

- No excavation proposed on the undeveloped parcel to the immediate south of Whitehall Road with the exception of lowering the stream channel.

Inter-Fluve was contracted by Fuss & O'Neill to complete a qualitative assessment of these three options to aid the project partners in selecting a preferred approach.

EXISTING DATA REVIEW

We carried out a brief review of existing data sources, and our relevant findings are summarized below.

- FEMA mapping shows the project site as within Zone AE, or within the 1% annual chance flood inundation extents and with determined base flood elevations (BFEs). See the attached mapping by the Town of Middletown. Floodplain management standards will apply to work at the site. Specifically, no reduction in the storage capacity of the 100-year floodplain will be allowed. Refer to the Town of Middletown, Rhode Island, Code of Ordinances Appendix A, Article 5, Section 517.
- The FEMA Flood Insurance Study (FIS) that covers the Maidford River shows the existing slope of the channel downstream of Whitehall Road is approximately 0.9%. This may be further flattened when the invert of the Whitehall Road culvert is reset at a lower elevation and accumulated sediments are removed upstream and downstream of the culvert as a part of this project.
- Surficial geologic mapping shows that the parent material in the study area is till.
- Soils are mapped as Type D soils with very low infiltration rates and high runoff potential when wet. Data from the USDA describes the soils as hydric with ongoing wetness and a very shallow water table. The soil map unit name is the Stissing silt loam, which is derived from till. The series is known to include small areas of soils with stones at the surface or a surface layer of topsoil underlain by sandy loam, which is similar to the conditions observed at this site (see the next section). Forest cover native to the Stissing series includes red maple, elm, ash, willow, gray birch, white pine, alders, and hemlock.
- The National Wetlands Inventory shows the channel and floodplain to the north of Whitehall Road mapped as freshwater emergent wetland and the channel and proximal floodplain through the undeveloped parcel to the immediate south of Whitehall Road mapped as freshwater forested/shrub wetland. Other wetland areas are mapped to the north and south of the site. F&O has recently completed a wetland delineation of the project site, which will provide more detail. The project should focus on enhancing existing wetlands and should avoid fill operations within wetland limits.
- The site is within an area mapped as containing observations of a community or nesting site of state or federally listed rare or threatened species or species deemed noteworthy by the state. The river itself is designated by RIDEM as critical habitat for rare and endangered species. Fuss & O'Neill contacted the Rhode Island Natural History Survey for more information, and it is likely that further study and monitoring will be required.
- Public records do not indicate heritage constraints at the site, but the proposal should be reviewed by the Rhode Island Historical Preservation & Heritage Commission.

- Watershed characteristics, water uses, water quality impairments, and flooding are discussed in a previous report by Fuss & O'Neill (2015).

RECONNAISSANCE FIELD SURVEY

An Inter-Fluve fluvial geomorphologist visited the site on September 21, 2020 to document field conditions and collect basic geomorphological data. This information is summarized below.

- Channel dimensions vary, but average measurements are approximately 10 feet wide by 2 feet deep.
- The channel bed and banks are nearly entirely sand and silt within the study area. Small to medium gravel can be found 0.75 to 1.5 feet below the channel bed in some places. The banks are well vegetated, which helps provide stability and resistance to erosion. No signs of active bank erosion or lateral migration were noted in the field.
- Some larger bed material (i.e., gravel and cobbles) is present downstream of the project area. Where there is stone present within the project area, such as in the channel where it runs adjacent to Berkeley Avenue, it appears to be rip rap and other large stone placed to protect the road embankment from scour. Pebble counts were completed at select locations where stone was present (Figure 1 through Figure 3). The average D_{50} within the project area is 69 mm, and the D_{50} in a reach downstream is 89 mm.
- Where the channel is exposed to the sun, vegetation has grown along the channel bed in many places. Where the channel has more canopy cover, the channel bed is generally bare of vegetation and has sand and silt exposed.
- Floodplain soils were augered to a depth of approximately four feet at 10 different locations on the floodplain adjacent to the channel (Figure 4 and Figure 5). Soils were found to be composed of topsoil over fine sand and silt; no coarse material was encountered at the inspection locations.
- We anticipate that the silt and sand is a combination of native material and deposition. The likely source of the deposition is agricultural runoff. The channel is small and relatively low gradient; therefore, sediment transport capacity is limited. Deposition in low velocity areas such as the floodplain and insides of meander bends is anticipated to continue following project implementation unless sediment generation within the watershed is addressed at the source.
- Few channel habitat features were observed in the project area. The limited number of features that do exist are in the areas of trees and shrubs where the water has been forced around tree roots and fallen logs, creating deeper scour pools, additional cover, and general increased complexity (Figure 6). In some of these deeper scour pools, small to medium gravel is exposed.
- A low stone wall runs along the channel. Where the stone wall separates the channel from the floodplain, it likely forms an outer barrier that exacerbates flooding of Berkeley Avenue by limiting floodwaters from spreading into the adjacent fields (Figure 7 and Figure 8). Historic stone walls are protected by the Town of Middletown, Rhode Island, Code of Ordinances Title IX, Chapter 97. The historic value of the stone wall in the project area is unknown; however, the design should aim to avoid alteration or removal of the wall.

- Invasive honeysuckle is pervasive along the vegetated corridor adjacent to the channel. We also observed Japanese knotweed around road crossings and *Phragmites* in large stands outside the study area.



Figure 1. Channel bed at the Reservoir Road crossing downstream of the project site. This exposed channel bed suggests that there are sources of gravel and cobble within the watershed, although the larger boulders were likely placed during bridge construction. The larger gravel and cobble may be limited to the steeper downstream reaches, though this is unknown. Further assessment of the channel slope may help determine the likelihood of coarser substrate elsewhere.

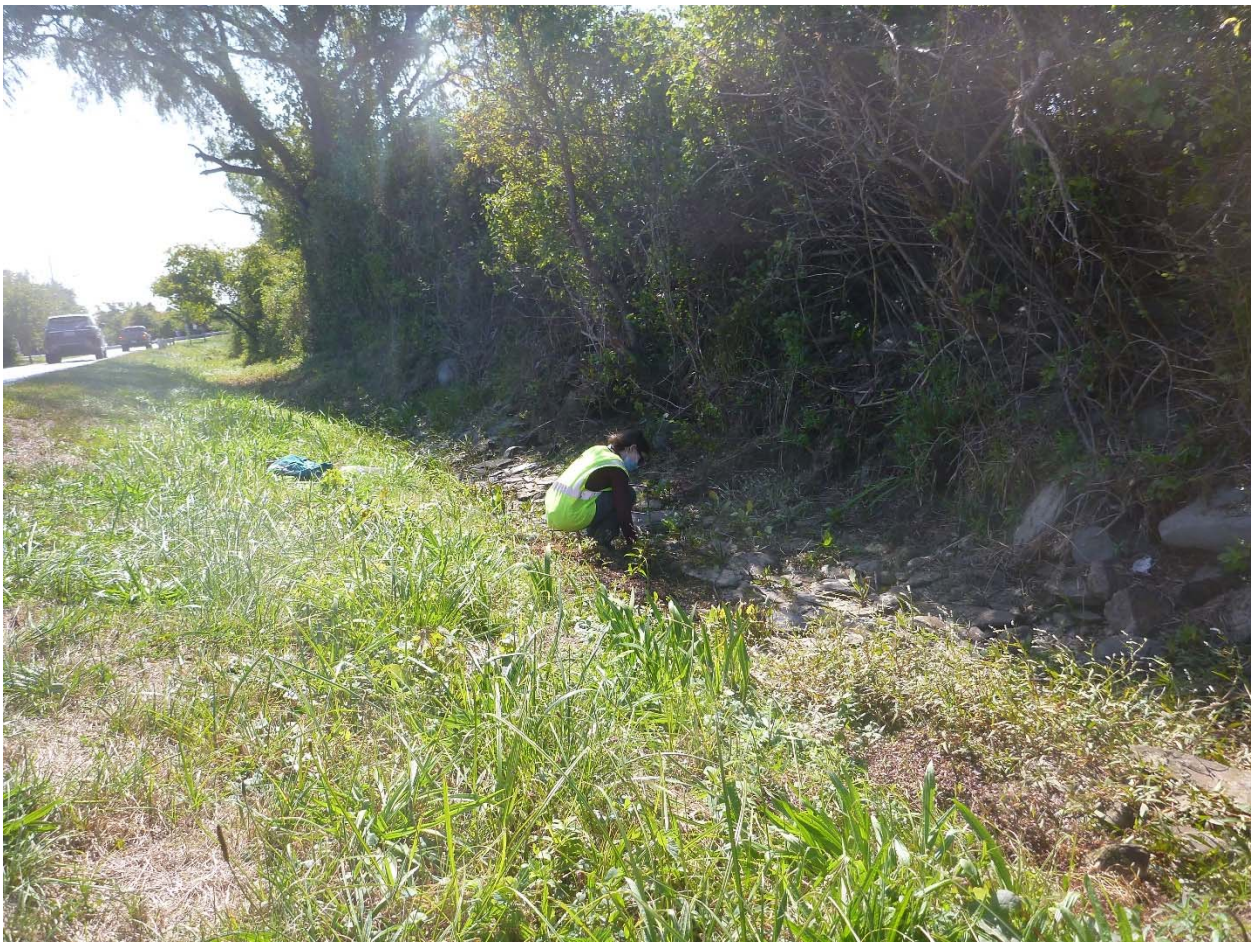


Figure 2. Conducting a pebble count in the channel west of Berkeley Avenue near Tally Ho Court. Much of the stone in this area appeared to have been placed during channel construction and stormwater management activities.



Figure 3. We also conducted a pebble count in the only other area with public access and a stone-based channel bed. This reach of the channel is immediately west of Paradise Avenue and south of Prospect Avenue, and the location is adjacent to Paradise Valley Park downstream of the study area. Although some of this stone may have been imported, much of it appeared to be native rounded gravel and cobble.



Figure 4. Typical floodplain view. The fields west of the channel and Berkeley Avenue and north of Green End Avenue. Former farm ditches are still apparent in the fields, with subtle differences in elevation and vegetation.



Figure 5. Soil from pits explored in the fields between the channel and Berkeley Avenue north of Whitehall Road. This area contained approximately 1.5 feet of topsoil with over 2.5 feet of fine sand and silt below. The maximum auger depth was 4 feet. No coarse material was encountered.



Figure 6. Within areas where trees and shrubs provide cover over the channel, we observed evidence that some in-channel habitat complexity may be present during periods of active flow. Scour around tree roots and fallen trees has exposed some small to medium gravel and created pools that would be 1 to 2 feet deep.



Figure 7. Looking north (upstream) from Green End Avenue at the channel between the Berkeley Avenue (right side of picture) and the berm and stone wall (left side of picture where the trees and shrubs are). Note the vegetation growing in the bottom of the channel which appears to be maintained during road-side mowing.



Figure 8. Looking north (upstream) at the channel adjacent to Berkeley Avenue. The thick vegetation that has grown on top of the crumbling stone wall combines with the wall to limit movement of water away from the road and onto the floodplain to the west.

ASSESSMENT DETAILS

		Alt 1 – Grading upstream channel and floodplain	Alt 2 – Alt 1 + full re-meander of the channel	Alt 3 – Alt 1 + downstream re-meander of the channel
Benefits	**Potential Flood Reduction**	Floodplain and channel excavation will enhance flood storage potential upstream of Whitehall Road. Downstream, the existing low stone wall may continue to send floodwaters preferentially towards Berkeley Avenue. The stone wall may be historic, so removal is not recommended; however, if this option is selected, removal or alteration may be possible pending Planning Board approval.	See Alt 1. Re-meandering will slow flows and encourage overbank flooding relative to Alt 1. Excavated material may be used to construct a shallow, vegetated berm separating the restored channel and floodplain from Berkeley Road. These options do not require removal of the existing low stone wall to provide flood risk benefits. Some alteration of the wall may be required and would need Planning Board approval.	
	Ecological Uplift	Extent of wetland habitat will be expanded. Revegetation plan will include invasives treatment/ removal and planting of native trees and shrubs, providing additional terrestrial habitat complexity.	See Alt 1. In addition, increased channel length will result in additional aquatic habitat. Designs may include habitat features such as constructed riffles and pools as well as large wood structures. Aquatic habitat improvements will support a species of concern.	
	Water Quality	Additional residence time of floodwaters will allow for enhanced settling of turbidity and nutrient uptake. The project will have a greater impact on water quality if combined with measures to address the generation of sediment and nutrients at the source(s).	See Alt 1	
Constraints	**Geology/ Geomorphology**	Grading will address immediate issue of capacity within the channel, but sand dominates the channel bed and banks further upstream, and agricultural runoff is an ongoing issue. Aggradation is likely to recur unless the source of the silt and sand is addressed.	See Alt 1. In addition, floodplain soils adjacent to the existing channel consist of 4+ feet of topsoil, fine sand, and silt. No large gravel, boulders, or bedrock appears to be present to provide geologic controls on bed or bank erosion, so the stream bed and bank material for channel construction will need to be imported.	
	Constructability	Sufficient access and staging areas are available. Substantial work in the vicinity of Whitehall Road will require coordination with residents and traffic control. Relatively simple construction to remove sand and silt from the channel and floodplain. Will require vegetation removal and replanting. Control of invasives during and following construction will be important for native plant success. Excavated floodplain material may potentially be used to grade the floodplain edges to limit flooding to roads and other infrastructure. Additional beneficial reuses should be explored as a cost-saving measure.	See Alt 1. Constraints associated with utilities have not yet been investigated by Inter-Fluve, and this task should be completed in future phases. Existing stormwater infrastructure and drainage patterns also need to be reviewed by Inter-Fluve. The project must be designed to adequately manage stormwater drainage off of adjacent roads.	
	Permitting	Alterations to wetlands, the channel, and the floodplain will be subject to federal, state, and local regulations. The proposed work will not raise base flood elevations, but there may be strict restrictions on filling operations. Alteration or removal of the existing stone wall will require Planning Board approval. Continued consultation with the Rhode Island Natural History Survey will be required to plan mitigation of potential impacts to species of concern.	See Alt 1.	
	Cost	$$	$$$$	$$$

CONCLUSION

Our review of existing and field data suggests that Alternatives 2 and 3 have the potential to provide the greatest benefit but also carry the highest cost burden. Additional investigations and analyses will be necessary to develop preliminary designs and provide quantitative cost estimates, including:

- Topographic survey;
- Utilities searches;
- Stormwater system and drainage study;
- Hydrologic analyses; and
- Hydraulic analyses for culvert and channel design.

Other investigations or studies that may be requested by regulatory agencies include:

- Survey for species of concern;
- Heritage and cultural resources study; and
- Sediment sampling and testing to determine reuse feasibility and options.

REFERENCES

FEMA, 2013. Flood Insurance Study for Newport County, Rhode Island. FIS Number 44005CV000B.

Fuss & O'Neill, 2015. Maidford River Watershed Assessment & BMP Design.

RIGIS, 1989. Rhode Island Glacial Deposits; s44ggl88. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (last date accessed: 30 September 2020).

RIGIS, 1994. Bedrock Geology of Rhode Island; s44gbr95. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (last date accessed: 30 September 2020).

RIGIS, 2018. Soils; soils18. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.edc.uri.edu/rigis, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (last date accessed: 30 September 2020).

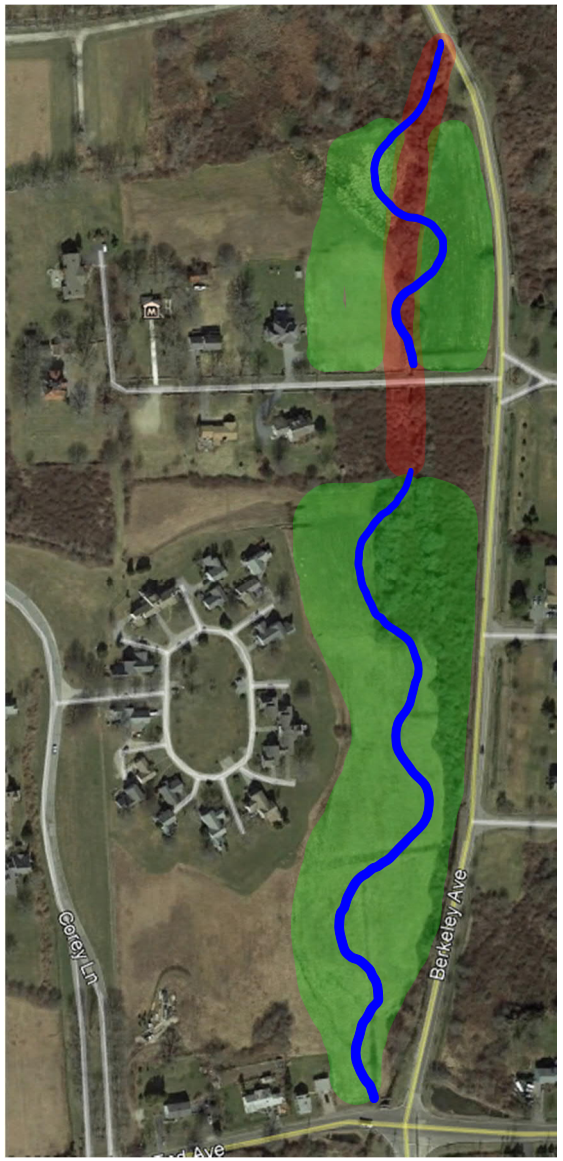
RIGIS, 2019. Rhode Island Natural Heritage Areas; natHeritage19. Rhode Island Geographic Information System (RIGIS) Data Distribution System, URL: http://www.rigis.org, Environmental Data Center, University of Rhode Island, Kingston, Rhode Island (last date accessed: 30 September 2020).

ATTACHMENTS

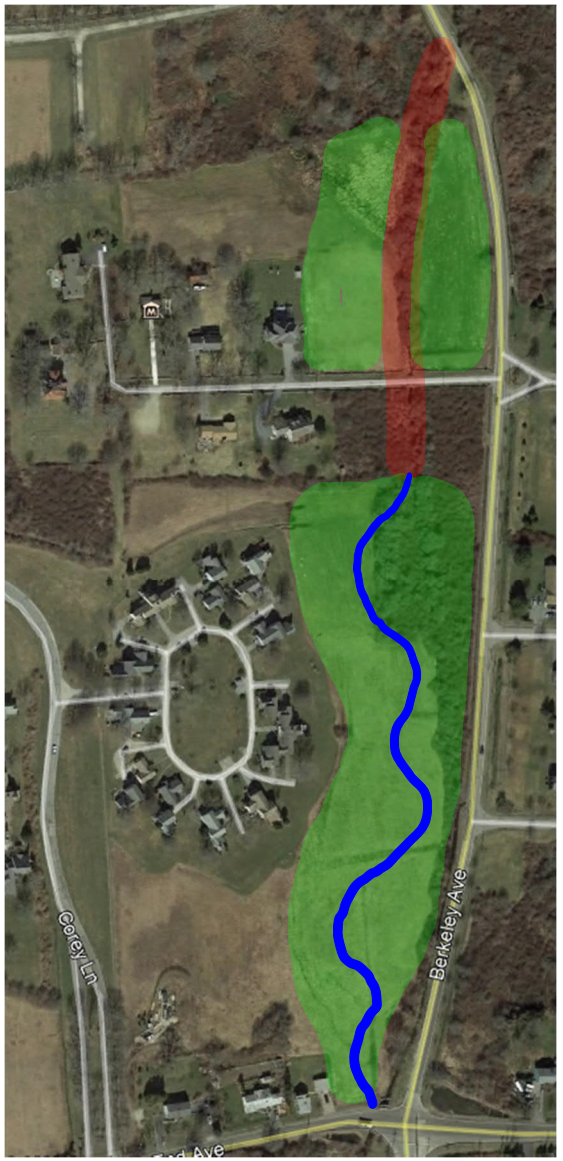
ALTERNATIVE 1



ALTERNATIVE 2



ALTERNATIVE 3



TOWN OF MIDDLETOWN

FLOOD HAZARD MAPPING
FEMA FLOOD ZONES 2017

FEMA Flood Zone

- A/ AE
- VE
- X
- 0.2 % Annual Chance

Streams

Ponds

Roads

Airport Runway

Parcels

NARRAGANSETT BAY

PORTSMOUTH

NEWPORT

SAKONNET RIVER

Green End Pond

Maidford River

Nelson Pond

Gardiner Pond

0 0.5 1 2
Miles

N

The information depicted on this map is for plannning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analysis. Sources: Town of Middletown, RIGIS, National Flood Hazard Layer Version 1.1.1.0 FEMA-NFHL Federal Emergency Management Agency. Author: RL

Date: 5/26/2017

FEMA Flood Zone Definitions

A/AE- Zone: Areas subject to inundation by the 1-percent-annual-chance flood event. Mandatory flood insurance purchase requirements and floodplain management standards apply.

V-Zone: Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. Mandatory flood insurance purchase requirements and floodplain management standards apply.

X-Zone: Areas of minimal flood hazard determined to be outside the 1-percent-annual-chance and the 0.2-percent-annual-chance flood events.

0.2-Percent-Annual-Chance Area: Moderate flood hazard areas in Zone B or Zone X. They are the areas between the limits of the 1-percent-annual-chance flood event and the 0.2-percent-annual-chance flood.

Appendix B
Engineer's Estimate of Probable Construction Costs

Maidford River Restoration Costs - 30% Design December 2021						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Notes**
1	Mobilization & demobilization	1	LS	$ 156,730	$ 156,730	10% of other items; includes traffic management as necessary
2	Erosion, pollution & water control	1	LS	$ 10,000	$ 10,000	
3	Clearing and grubbing	3.5	AC	$ 8,000	$ 28,000	
4	Excavation and offsite disposal	34,690	CY	$ 20	$ 693,800	Excavation and offsite disposal
5	Floodplain microtopography	4	DAYS	$ 1,500	$ 6,000	Creation of microtopography and amphibian habitat. Assumes on-site reuse of excess material.
6	Imported riffle substrate	1,440	CY	$ 150	$ 216,000	Provision and placement of riffle substrate in riffles, lower FES lift, and large wood bank stabilization. Filter gravel is incidental.
7	Imported riprap	150	CY	$ 150	$ 22,500	Provision and placement of rock for riprap on stream banks. Granular filter layer is incidental.
8	FES lifts	6,910	FF	$ 40	$ 276,400	Bank construction comprising fabric encapsulated lifts. Includes excavation, lift construction, and seeding. Salvage and reuse of soil are incidental.
9	Large wood bank stabilization	140	EA	$ 700	$ 98,000	Provision and installation of large wood (root wads, logs, and log piles) for bank stabilization
10	Surface fabric bank treatment	960	SY	$ 12	$ 11,520	Provision and installation of surface fabric on stream banks. Anchoring is incidental.
11	Native seed	13	AC	$ 10,000	$ 130,000	
12	Live stakes	3,910	EA	$ 10	$ 39,100	
13	2-gallon containerized plants	600	EA	$ 60	$ 36,000	Provision and installation of native trees and shrubs. Includes warranty and maintenance per specs.
				Construction Subtotal	$ 1,724,050	
				30% Contingency	$ 258,610	
				Project Contruction Total	**$ 1,982,660**	
				AACE Class 3 Low Range (-10%)	$ 1,784,400	
				AACE Class 3 High Range (+30%)	$ 2,577,460	

Notes: Floodplain large wood not included
Invasives control not included