TOWN OF NORTH ATTLEBOROUGH

Massachusetts

TEN MILE RIVER STUDY

Phase I – Preliminary Investigation and Report

BETA Group, Inc.
Engineers • Planners • Landscape Architects
Lincoln, RI - Norwood, MA - Hartford, CT

JULY 2014

North Attleborough, MA
Ten Mile River Study
Phase I – Preliminary Investigation Report
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SECTION 1 - Executive Summary

1.1 Purpose of Report

The Town of North Attleborough, through the Ten Mile River Committee, retained the services of BETA Group, Inc. (BETA) to conduct a preliminary study of the Ten Mile River, to research historic documents, investigate existing structural and sediment conditions along the river, and study how to Falls Pond dam functions. Also reviewed was the preliminary Hazardous Mitigation Report submitted to MEMA for review in 2010, as well as required permitting and funding sources for the recommendations of this report.

1.2 Report Approach

This Phase I study was divided into the following areas to investigate:

- Analysis of Dam Opening/Closing Procedures during Storm Events
- Resident Survey and Community Outreach
- Summary of Infrastructure and Sediment Investigation
- Preliminary Flood Storage Assessment
- Steps to Finalize Hazardous Mitigation Report
- Recommendations
- Cost Analysis
- Funding
- Permitting

1.3 Summary of Recommendations

Based on the results of the study, the priority to mitigating flooding events along the Ten Mile River between Whiting Pond dam and the outlet at Falls Pond is to increase the stormwater conveyance capacity and retention. This can likely be done by a combination of measures including replacing retaining walls in critical areas, providing some stormwater relief in storage areas, and removing sediment that has accumulated in certain areas. The cost for these repairs can be found in **Table 9-3**. These repairs can be divided into several manageable phases depending on funding.

A HEC-RAS model is recommended as the next immediate step to better understand the current hydraulics of the river within the study area boundaries and to test the recommendations of this report and to better assess the cost benefit for each.

Steps to finalize the Town's current draft Hazardous Mitigation Report have been included and it is recommended that the Town finalize its Hazardous Mitigation Report as this approved report may allow the Town to be eligible for funding sources through MEMA.

SECTION 2 - Introduction

2.1 Overview

The Ten Mile River is a 22-mile long river that begins at Savage Pond in Plainville, Massachusetts and discharges to Narragansett Bay. The Ten Mile River passes through North Attleborough, Attleboro, Seekonk, Pawtucket, and East Providence, then empties into the Seekonk and Providence Rivers of Narragansett Bay. The drainage tributary is approximately 54 square miles.

Flooding along the segment of the Ten Mile River between the Plainville line and Falls Pond has been an ongoing issue for the Town since the 1930's. A number of groups have investigated the cause of river flooding and produced reports and undertook minor construction projects over the years in attempts to mitigate flooding and deteriorating channel walls. However, none of these efforts have entirely mitigated flooding.

The Ten Mile River Committee has charged BETA Group with evaluating a stepped approached for identifying short and long term improvements to the flood storage capacity of the river. The portion of the river that has been evaluated in this program extends from the Whiting Pond dam and outlets to Falls Pond and is approximately 9,000 linear feet. This study is the first step in an overall approach that will ultimate relieve flooding along the River.

2.2 Project Goals

Project goals include:

- Investigate historical and current problems associated with the river, existing conditions information for the channel bed and sedimentation, retaining walls, and infrastructure for the study segment.
- Identify potential flood storage areas surrounding the river.
- Optimize operation of Falls Pond dam.
- Identify permitting requirements and funding sources.
- Assist Town in developing an approach to complete the Hazard Mitigation Plan.

SECTION 3 - Summary of Existing Documentation

3.1 Purpose

To better define the existing flooding along the study area, existing documentation has been gathered and reviewed. This information included available flood record documentation, newspaper articles, and video clips. This information provides a timeline and understanding of where and how often the river floods. Electronic copies of these documents can be found in the CD attached separately. Below is a summary of each of the primary sources of information gathered in this effort.

3.2 The Ten Mile River Basin Study

Alexander E. Rattray and Associates, Inc. & Cousins, Alden E. (1969). *The Ten Mile River Basin Study.*

The purpose of this study to emphasize the importance of proper land development along the river due to limited resources and that recreational improvements should be a high priority.

This study stresses the importance of developing a continuous, connected open space system along the Ten Mile River basin and to preserve and restore the landscape along the river. Although general ideas stated in the report are applicable today, the document is out-of-date since much has changed along the Ten Mile River since the report was written.

3.3 Interim Report on Flood Problems and Potential Solutions, 10 Mile River Watershed

US Dept. of Agriculture Soil Conservation Service (1979). *Interim Report on Flood Problems and Potential Solutions, 10 Mile River Watershed.*

The purpose of this report was to present alternatives that could be applied to reduce flood damage along the Ten Mile River watershed. Three mitigation recommendations pertain to the portion of river within the Town of North Attleborough.

One measure suggested flood reduction by establishing a reservoir management plan to regulate drawdown on Falls Pond to store floodwater. Water would be allowed to flow downstream through the Falls Pond dam until a pre-determined danger point, and then the remaining floodwater would be stored in Falls Pond until fully utilized.

The second measure suggested that accumulated sediment could be removed near Route 1 and Elm Street. Sediment in this area would be excavated and the sewer at Chestnut Street would be converted into an inverted siphon.

Option three proposed to increase the channel width to 20 feet from Elm Street and Route 1, south to East Washington Street. This option would require replacement of the bridge and inverted siphons for the sewer main at Chestnut Street. As part of this option, another alternative discussed was providing a 4-foot by 10-foot bypass culvert intersecting Orne Street and Elm Street.

3.4 North Attleborough Wetland Investigation and Preliminary Restoration Plan

Unknown Author. (Date Unknown). *North Attleborough Wetland Investigation and Preliminary Restoration.*

This preliminary study describes the physical characteristics and restoration goals for the two wetland areas near East Washington Street. Restoration goals proposed include elimination of invasive phragmites populations, expanding opportunities for recreational use, restoration of degraded wetlands areas, wildlife habitat enhancement, and improve water quality. Such goals could be met by eliminating the phragmites by mowing or dredging, removing stone walls and meander the river, recreating forested wetland as well as removal of fill and sedimentation materials. It was suggested that restoration components improve a variety of wetlands functions. Surface soil sampling suggests the possibility of lead contamination in the wetlands. State and Federal environmental permits may be necessary in order to execute restoration along the Ten Mile River.

3.5 Ten Mile River Watershed – Massachusetts, An Assessment of Sediment Chemistry and Ecotoxicity

Hellyer, Greg. USEPA. (2000). *Ten Mile River Watershed – Massachusetts, An Assessment of Sediment Chemistry and Ecotoxicity*

This study was a collaborative effort between the EPA-New England and Massachusetts Department of Environmental Protection (MADEP) to assess sediment contamination as a result of past and present pollutants for the entire Ten Mile River. Sediment sampling was conducted at the Wetherells Pond dam, Falls Pond Dam, upstream Cedar Street, Mechanics Pond dam, Dodgeville Pond dam, Hebronville dam, and Route 15 dam. Identification of potential ecotoxicological concern was found at all sampling locations.

Chironomid sediment tests observed significant impairment of survival for the Dodgeville Pond dam, Route 15 Pond dam, and Wetherell Pond dam test site replicates. It is possible the tests underestimated the adverse effects of the sediment since a longer test period would be needed to identify sub-chronic effects.

Chemical and physical characterization of river sediment would be ideal to determine the aquatic system “health” since contaminates may be adsorbed by sediment. It is possible that the sediment may pose ecotoxicological and human health risks. Also noted of concern is the presence of rare wildlife and priority habitats along the Ten Mile requiring a high level of conservation and management of the landscape.

3.6 Ten Mile River Flooding Assessment Attleboro, North Attleboro, & Plainville, Massachusetts

Army Corps of Engineers. (2002). *Ten Mile River Flooding Assessment Attleboro, North Attleboro, & Plainville, Massachusetts*

In April 2002, the Army Corps of Engineers developed a preliminary report assessing potential flood storage locations for the Ten Mile River including Falls Pond, Manchester Pond Reservoir, and Dodgeville Dam.

The Falls Pond dam is raised from 167.5 ft. NGVD to 173.5 ft. NGVD in the Spring for recreational purposes. It is recommended by the Army Corps of Engineers that the difference between the summer and winter pools be utilized for flood storage by lowering the pool in anticipation of a flood event. Also, by opening one gate at the Fall Pond dam at the start of a storm, the 100-year flood elevation could be reduced by several feet.

As part of the Falls Pond evaluation, it was noted that the two wetland areas located 1,000 feet and 1 mile from Falls Pond, could provide approximately 0.57 inches of runoff storage assuming a depth of four feet. These wetlands areas would need to be cleared and dredged before providing any storage relief. It was also noted that the amount of storage potential from these wetlands would be minimal, and that they could potentially fill before the peak of a storm is experienced.

The assessment recommended that extensive hydraulic and hydrologic studies be completed to determine the flood damage reduction of Falls Pond and the wetlands.

3.7 Coastal Rivers, Monograph One, Recent Improvements to Water Quality of the Then Mile River in New England

Jobin, William R., SC.D. (2009) *Coastal Rivers, Monograph One, Recent Improvements to Water Quality of the Then Mile River in New England.*

The purpose of this monograph was to provide a historical record of the water quality at the Ten Mile River. The report provides a detailed history description, from the river's industrial past to present. The report also goes into detail about water quality studies conducted in 1984 and 2002. The studies indicate improvement in water quality, but test results in 2002 show that contamination remains. In 2009, the Ten Mile River of southeastern New England installed fish ladders to help herring cross some of the dam. However, it is not known whether or not the water quality is adequate for the herring to survive.

3.8 Historical River Flooding Events Timeline

The historical Ten Mile River flooding events timeline below is based on significant flooding events mentioned in reviewed newspaper articles and documents.

Date	Event
1886	**Historical Flood Event**
1901	**Historical Flood Event**
1920	**Historical Flood Event**
March 1968	**Historical Flood Event**
Unknown Date	**North opens dam, angering Attleboro** – Author Unknown
1992	**Historical Flood Event**
1995	**Historical Flood Event**
March 2010	**Historical Flood Event**
March 30, 2010	**Local, state official responding to flooding** – Sun Chronicle
October 2011	**Ten Mile River Committee is formed**
July 11, 2012	**North Attleborough Bridges** - BETA
October 8, 2012	**North takes step to ease flooding along Ten Mile** – Sun Chronicle

SECTION 4 - Analysis of Whiting Pond and Falls Pond Dams

4.1 Purpose

The purpose of this analysis was to review existing dam operation procedures, determine a rough hydraulic analysis of the storage capacity in Whiting and Falls Ponds, and make recommendations for protocol changes to improve storage capacity for storm events.

4.2 Current Dam Opening/Closing Procedures

On April 1, 2013, BETA met with Mark Hollowell, the Director of Public Works, as well as two DPW staff to review existing dam procedures and observe the dam closings at Whiting and Falls Ponds.

Every year, under jurisdiction of MassDEP, the Town closes both dams on April 1st and re-opens them approximately on November 1st. The idea is to open the dams and allow snowmelt to pass after the winter months but close the dams to allow for recreational activities at Whiting and Falls Ponds during the summer months. The Falls Pond Dam is opened before the Whiting Pond dam.

Careful consideration needs to be made when opening and closing the two dams due to flooding concerns with local downstream residents and the City of Attleboro. The Ten Mile River Flood Warning Response Plan and a supplemental Emergency Notification Procedure for Potential Flooding Events, both attached in **Appendix A**, were created in response to flooding concerns between North Attleborough and the City of Attleboro. These documents clarify Town officials' responsibilities in regards to notifications and operational procedures in case of a flood.

4.2.1 Whiting Pond Dam

The Whiting Pond dam is controlled by a 16-inch butterfly valve that was installed in the late 1990's inside a vault, as shown in **Figure 4-1**. Currently there is difficulty maneuvering the valve due to alternating wet and dry conditions leading to corrosion. The valve has recently been greased. BETA recommends a new safety hatch and lock to allow for easier and safer access to the gate valve.

In order to open or close the butterfly valve approximately 50 turns are required for each direction. This procedure currently requires two persons due to the difficulty of rotating the valve, as shown in **Figure 4-2**.

FIGURES 4-1 and 4-2: Closing Butterfly Valve at Whiting Pond Dam (April 1, 2013)

The valve is closed April 1st every year to increase the water level in Whiting Pond to allow for recreational activities. The valve is opened November 1st every year to allow for snow melt capacity. The dam is under jurisdiction of the conservation commission due to the invasive Japanese knotweed growing next to the dam. Prior to a large rain event after April 1st, the valve is opened approximately 10-12 turns, to create capacity in Whiting Pond. **Figures 4-3** and **4-4** are of Whiting Pond dam before and after closing the valve.

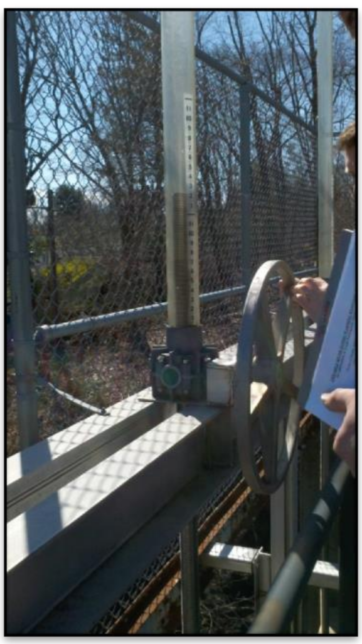
FIGURE 4-3: Whiting Pond Dam before Closing (April 1, 2013)

FIGURE 4-4: Whiting Pond Dam after Closing (April 1, 2013)

4.2.2 Falls Pond Dam

Falls Pond dam has four 24-inch sluice gates and two spillways. Under normal operation, flow is controlled by adjusting the sluice gate elevations by manually operating the handwheels for each gate. In unusually high flow conditions, operation is limited to the three sluice gates furthest right facing Falls Pond. Due to the close proximity of the Falls View Condiminums immediately downstream of the dam, caution must be taken to limit the amount of flow passing through the dam due to capacity limits, foundation concerns, and noise.

Similar to Whiting Pond dam, the Falls Pond dam is closed approximately April 1st and opened November 1st every year. During the winter months, either one gate will be left open set to 9 inch height or both gates will be left opened at 5 inch height. Before fully closing the dam for the summer, the gates are opened fully momentarily to allow debris to be removed. The left gate facing Falls Pond is remains only partially open due to the amount of noise and close proximity to neighbors.



FIGURES 4-5 and 4-6: Falls Pond Dam Gate Opening/Closing Mechanism (April 1, 2013)

FIGURES 4-7: Falls Pond Dam before Closing (April 1, 2013)

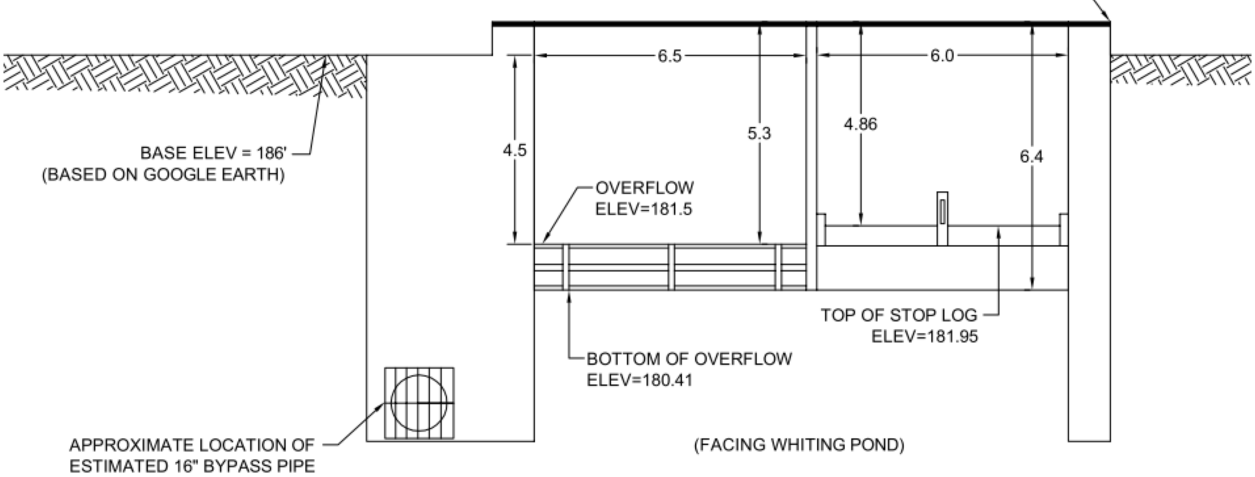
FIGURES 4-8: Falls Pond Dam after Closing (April 1, 2013)

4.3 Structural Measurements

On July 12, 2013 BETA accessed the Whiting Pond and Falls Pond dams to measure the dimensions of each dam. Survey equipment including level, survey rod, and laser distance measurer were used. The base elevation was derived using Google Earth. Due to accessibility constraints, measurements were generally close approximations.

4.3.1 Whiting Pond Dam Structure

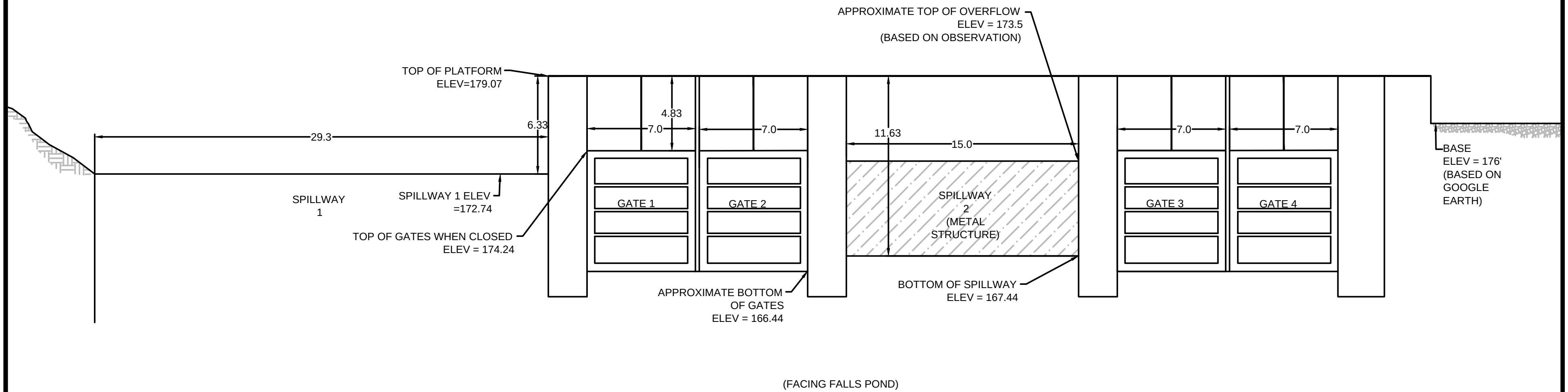
Figure 4-9 below illustrates the information gathered during the investigation. Stop logs can be added and removed to regulate flow through the dam.



FIGURES 4-9: Whiting Pond Dam Dimensions

4.3.2 Falls Pond Dam Structure

Figure 4-10 below illustrates the information gathered at Falls Pond dam. The four gates can be raised up to 2-feet to regulate flow through the dam. Assumptions are listed in the figure.



NOTES:
1. IT IS ASSUMED ALL GATES ARE IDENTICAL AND AT THE SAME ELEVATION.
2. IT IS ASSUMED THAT THE ELEVATION AT THE BOTTOM OF THE GATES IS 1 FOOT BELOW THE BOTTOM SPILLWAY 2 ELEVATION, BASED ON OBSERVATION.
3. THE ELEVATION AT THE TOP OF THE SPILLWAY 2 IS BETWEEN THE ELEVATION OF SPILLWAY 1 AND THE TOP OF THE GATES.
4. FIELD WORK CONDUCTED JULY 12, 2013.

FIGURES 4-10: Falls Pond Dam Dimensions

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4.4 Falls Pond Dam Discharge Analysis

Based on the dimensions in **Figure 4-10**, equations were established to calculate the discharge rate for each gate and spillway. These equations can be found in **Appendix B**. The amount of discharge through the dam is dependent on the water level of Falls Pond.

Page 52 of the FEMA Flood Insurance Study for Bristol County, Volume 1 of 3, revised May 31, 2013, lists the peak discharge rates for 10, 50, 100, and 500 year storms at Falls Pond dam which can be found in **Appendix C**. Also provided in **Appendix C** is table established by Cornell University of extreme precipitation estimates for various storm categories.

Using the discharge equations for each dam and spillway, **Figure 4-11** illustrates the discharge rates based on various gate settings. Ideally, knowing the weather forecast ahead of time and using the extreme precipitation table, the category of storm could be predicted. Looking at the graph, the Town could estimate which elevations to set the gates at in order to maintain the desired Falls Pond water level for a particular storm event.

4.5 Falls Pond Dam Storm Event Gate Settings

As discussed in Section 4.2, mitigation efforts made prior to storm events can help minimize flooding of local downstream residents and the City of Attleboro. In order to prepare for an anticipated storm event, Falls Pond Dam gates should be opened to allow an appropriate volume of water to pass, creating capacity in Falls Pond. **Table 4-1** shows the approximate discharge rate required to pass through Falls Pond Dam for a given advanced notice duration. Using Table 4-1 and **Figure 4-11**, operations staff can determine the appropriate gate settings for a particular storm.

Example: If a 10-year storm is predicted 3 days prior to the event, the operations staff would look up the required discharge rate (378 cfs) on Table 4-1. Then, knowing the actual water surface of Falls Pond prior to the storm, use Figure 4-11 to determine the recommended gate setting (assume for this example that the pond is at elevation 172 and using the discharge rate of 378 cfs, the gate setting would be between 4 gates open at 12 inches and 3 gates open at 24 inches. Since the actual point is between the two settings, the staff could either open 4 gates a little more than 12 inches or 3 gates a little less than 24 inches.)

Table 4-1: Falls Pond Dam Discharge Rate for Anticipated Storm Event

Storm Event	2 Days Notice Discharge (cfs)	3 Days Notice Discharge (cfs)	4 Days Notice Discharge (cfs)
1 Year Storm	315	210	158
5 Year Storm	475	317	238
10 Year Storm	567	378	284
25 Year Storm	718	479	359
50 Year Storm	859	572	429
100 Year Storm	1029	686	514
200 Year Storm	1234	822	617
500 Year Storm	1571	1047	785

Please note this table does not factor downstream capacity. **Based on conversation with the DPW, downstream capacity may be limited to two gates open 6-inches each or approximately 80 cfs at a water elevation of 172 feet. Because of this restriction, Falls Pond operation cannot be fully optimized.**

For example:
Allowable 4-day discharge rate is approximately 80 cfs or 53.9 mgd.
4-day allowable discharge volume = 215 MG
10 year storm 4-day volume = 733 MG
Excess volume = 733 MG – 215 MG = 517 MG
This excess volume would raise the water level in Falls Pond as well as increase the discharge over one or both spillways.

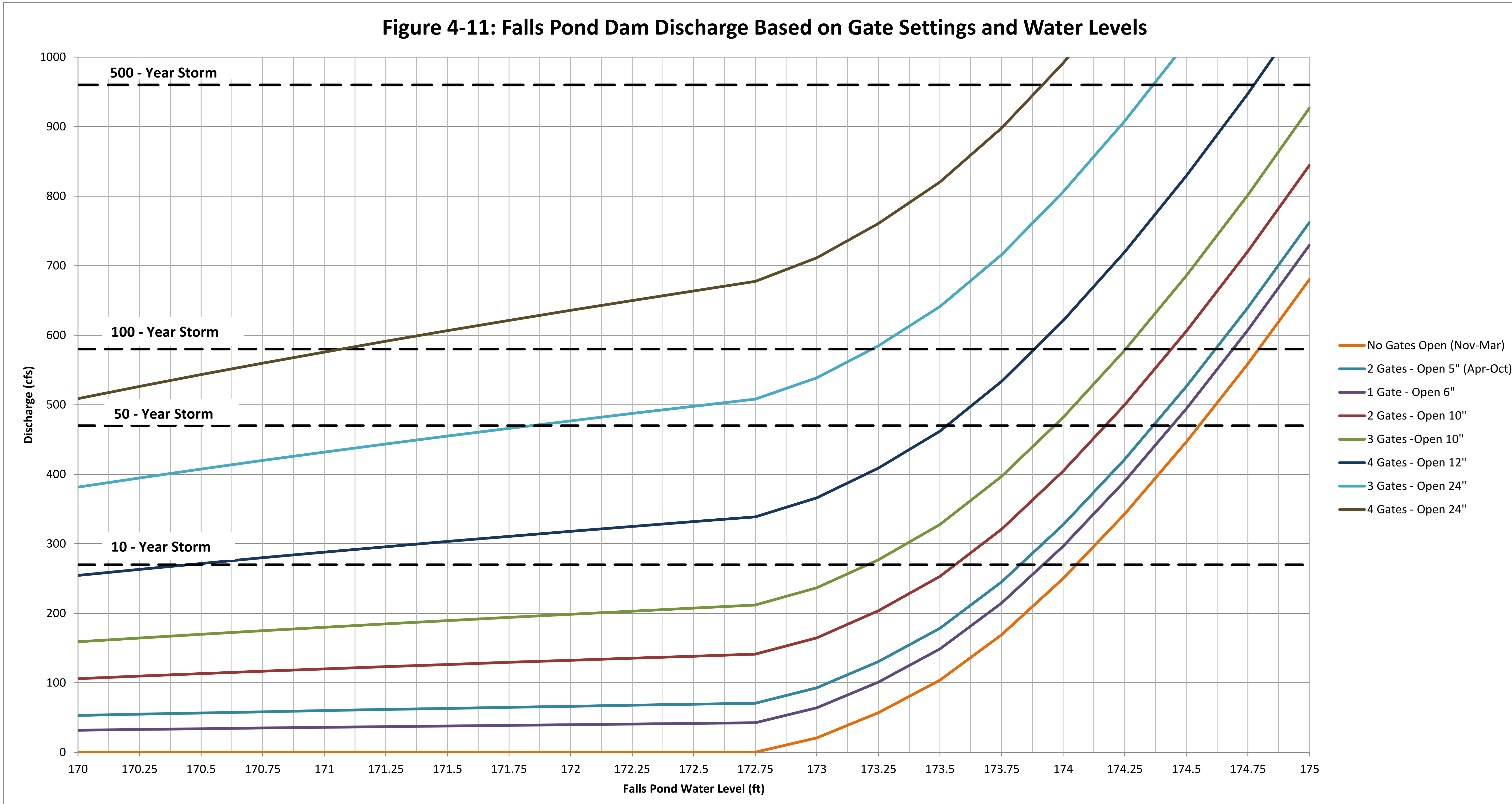
Figure 4-11: Falls Pond Dam Discharge Based on Gate Settings and Water Levels
500 - Year Storm
100 - Year Storm
50 - Year Storm
10 - Year Storm
Discharge (cfs)
Falls Pond Water Level (ft)
0
100
200
300
400
500
600
700
800
900
1000
170
170.25
170.5
170.75
171
171.25
171.5
171.75
172
172.25
172.5
172.75
173
173.25
173.5
173.75
174
174.25
174.5
174.75
175
No Gates Open (Nov-Mar)
2 Gates - Open 5" (Apr-Oct)
1 Gate - Open 6"
2 Gates - Open 10"
3 Gates -Open 10"
4 Gates - Open 12"
3 Gates - Open 24"
4 Gates - Open 24"

SECTION 5 – Community Outreach and Resident Survey

5.1 Approach

In an effort to reach out to the North Attleborough community directly impacted by river flooding and to get a firm understanding of first-hand knowledge of where flooding occurs and for how long, BETA, in conjunction with the Town and Ten Mile River Committee, developed a resident survey. The Town distributed these surveys in March 2013. BETA then assessed and summarized the findings.

5.2 Resident Survey

Questions on the survey pertained to the frequency of flooding, extent of flooding on the property and inside buildings, and frequency of flooding. Three different types of rain events within the past 7 years were chosen to be included in the questionnaire to see how different storm intensities and length of rain time affect residential flooding. Rain events included in the questionnaire were: Hurricane Irene August 27-29, 2011 (heavy, consistent rain for three days), March 30, 2010 (3-inches of rain in one day), and May-June 2006 (long period of wet weather).

In March 2013, The Town distributed the surveys to neighboring residents by mail and electronically through the Town's webpage. The surveys were collected until April 15, 2013. A typical distributed questionnaire can be found in **Appendix D**.

Only 12 surveys were returned. Data collected in from the survey can be found in **Table 5-1** in **Appendix D**. As shown in **Figure 5-1**, there was not enough information collected to conclude with statistical accuracy which areas along the river are most prone to residential flooding. However, those that noted flooding were primarily in the northern half of the study area, between Whiting Pond and Orne Street.

5.3 Continued Community Outreach

In an effort to remain in communications with the local community, BETA will hold a public meeting discussing the finding of this report after a review period by the Town and the Ten Mile River Committee.

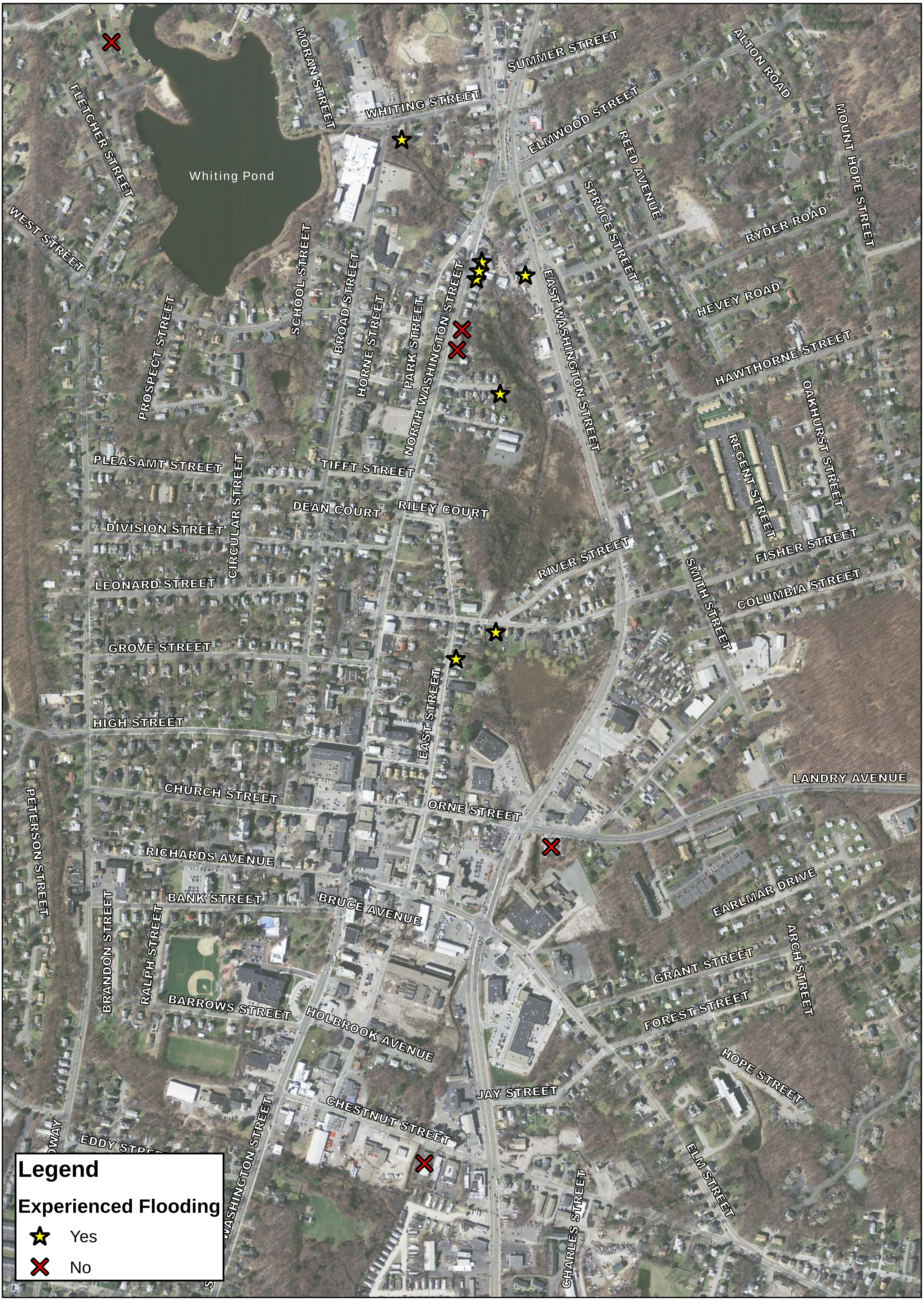

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Figure 5-1: Resident Survey Results

1 inch equals 500 feet

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SECTION 6 – Field Investigations

6.1 Purpose

The purpose of the sediment investigation was two parts. The first was to evaluate the quantity and location of sediments in the river. The locations and depths of sediment will help determine areas that may require restoration. The second was to locate and evaluate the condition of infrastructure in the study area including culverts, bridges, and retaining walls. Utilities encountered during the investigation were also recorded.

The portion of the river in the wetlands between North Washington Street and Fisher Street was not navigable due to the depth of water in the river. At this portion of the river, measurements were limited to those that could only be recorded from the eastern bank.

6.2 Field Investigation

BETA conducted a field investigation from December 4 to December 19, 2012 to locate and assess the condition of the existing structures in the study area along the Ten Mile River. Structures part of the investigation included retaining walls, culverts, bridges as well as utilities crossing the river. By assessing the condition of structures along the entire length of the river, a prioritized recommendation can be made to remedy poor structural conditions.

The field and sediment investigations were conducted simultaneously in December 2012. The investigations began at the Whiting Pond dam and continued to the outlet at Falls Pond. Two BETA engineers hiked in and along the river, measuring and recording information on an iPad using Utility Cloud asset management software. Information was recorded with orientation facing upstream. Photographs were taken at every structural and sediment investigation data point.

Conditions for the structures were categorized as good, fair, and poor. Good condition indicates that no work is needed and that the structure does not require maintenance. Fair condition indicates that there is minor damage to the structure, likely due to age, and no urgent maintenance is needed. Poor condition indicates that the structure has been damaged, either physically or age and that restoration is necessary.

6.2.1 Retaining Walls

The retaining wall conditions were assessed from Whiting Pond dam to the river's outlet at Falls Pond. Retaining walls exist throughout most of the length of the river. In order to more easily classify reaches that may need repairs, retaining walls were segmented into the following sections shown in **Table 6-1**.

Table 6-1: Retaining Wall Segments			
Section	**Start**	**Finish**	**Retaining Wall IDs**
A	Whiting Pond Dam	Broad Street	RW7 – RW15
B	Broad Street	N. Washington Street	RW1 – RW6, RW16 – RW21
C	N. Washington Street	Fisher Street	RW22 – RW46
D	Fisher Street	E. Washington Street (at Orne Street)	RW47 – RW50
E	Landry Avenue	Elm Street	RW51 – RW54
F	E. Washington Street (at Elm Street)	Chestnut Street	RW55 – RW61
G	Chestnut Street	Stream Inlet	RW62 – RW68
H	Stream Inlet	Falls Pond	RW69 – RW75

Data points were established at the start and finish of each section for each side of the river. Additional data points were collected for atypical portions of the walls such as gaps in the wall, missing walls, heavy damage, collapses, or undermining. **Figures 6-1A and 6-1B** show the location of each data point collected.

Information recorded at each data point includes: orientation (left or right side of river), section, location (beginning, middle or end of section), height, material, condition, photo number and comments. **Table 6-2**, in **Appendix E**, lists information collected. For each data point, an inspection report log was also created, including picture, which can be found in **Appendix F.**

As seen in **Figures 6-1A and 6-1B**, large portions of the retaining walls along the river are in poor condition, sections C, D, F, and G being in the worst condition. Sections A and B, although generally in fair condition, had several undermined areas. Section G was the only area that was in generally good condition.

6.2.2 Culverts

Culverts were assessed from the Whiting Pond dam along the river to the outlet at Falls Pond. **Figures 6-2A** and **6-2B** show the locations of each culvert.

Information collected for each culvert included shape (circular or rectangular), width (inside the culvert), height (from top of river bed sediment), material, condition, upstream and downstream photos, as well as any comments. **Table 6-3**, in **Appendix E,** provides information collected for culverts during the investigation. Inspection report logs for each culvert can be found in **Appendix F**.

As seen in **Table 6-3**, culverts C2, C6, C7, and C11 are in most need of repair. Culvert C6 was fenced off and not accessible. Culvert C7 was not a true culvert, as it was part of an

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Figure 6-1A: Retaining Walls Conditions

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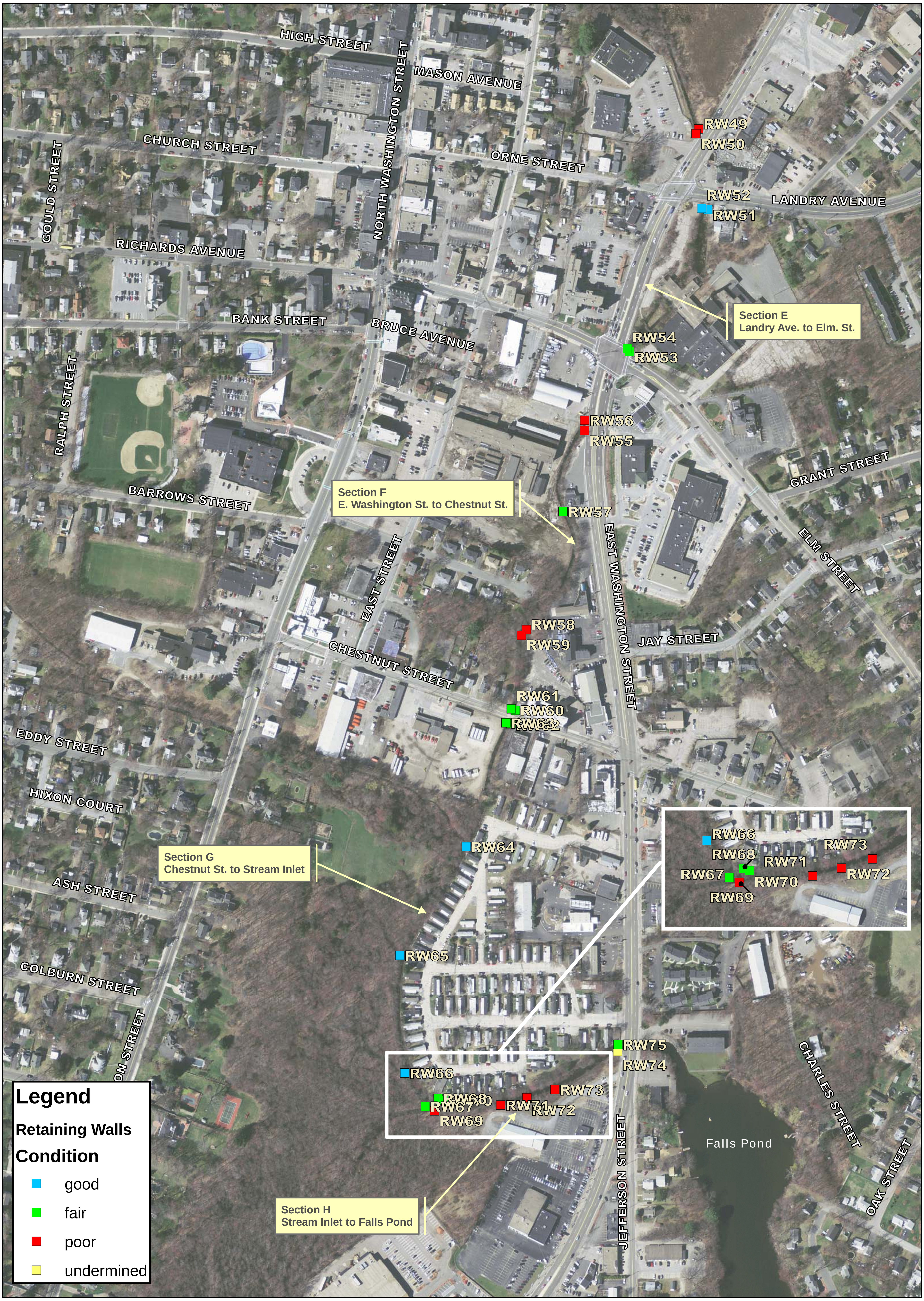

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Figure 6-1B: Retaining Walls Conditions

N W E S

1 inch equals 300 feet

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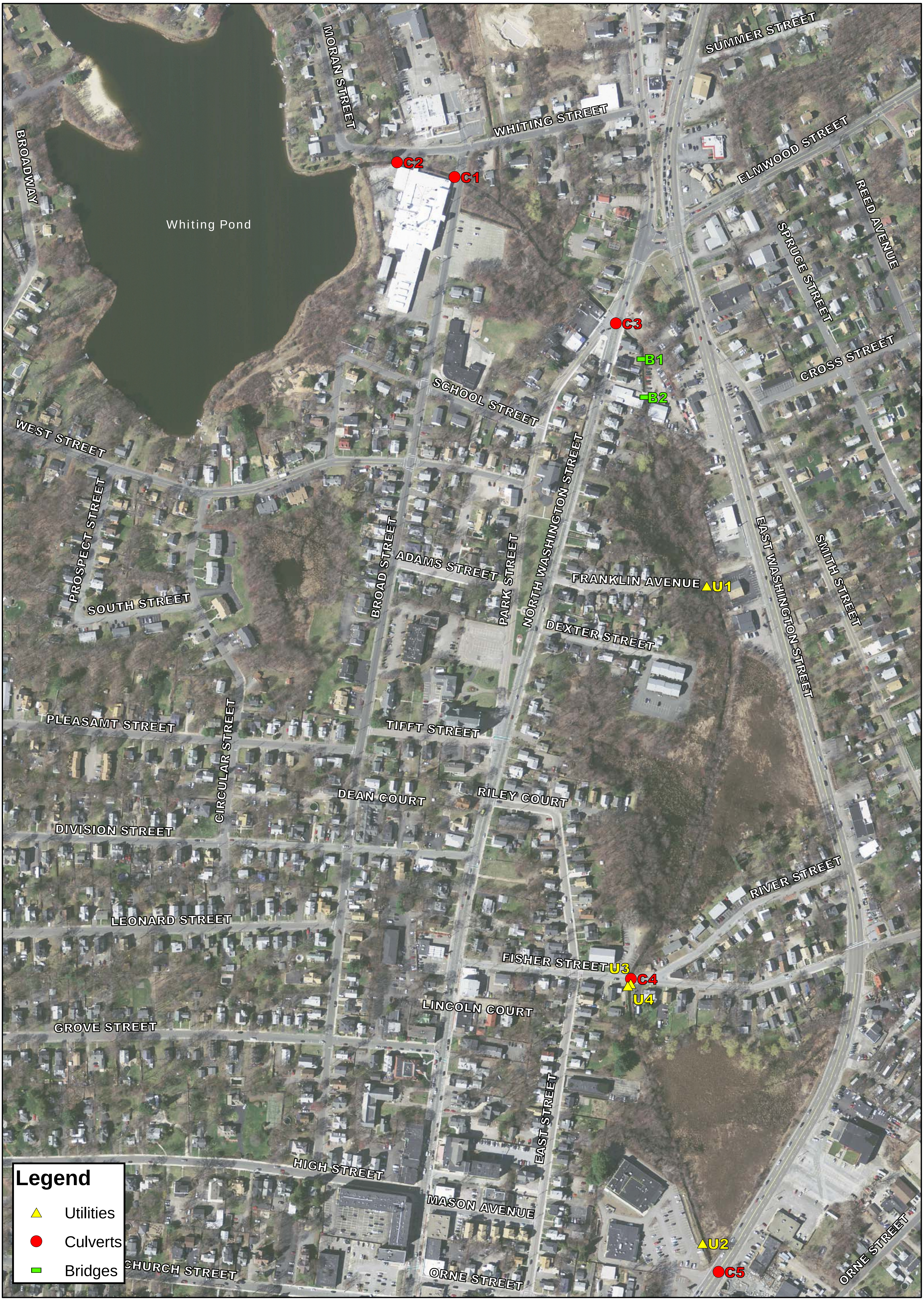

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Figure 6-2A: Utilities, Bridges,Culverts

N
W E
S

1 inch equals 300 feet

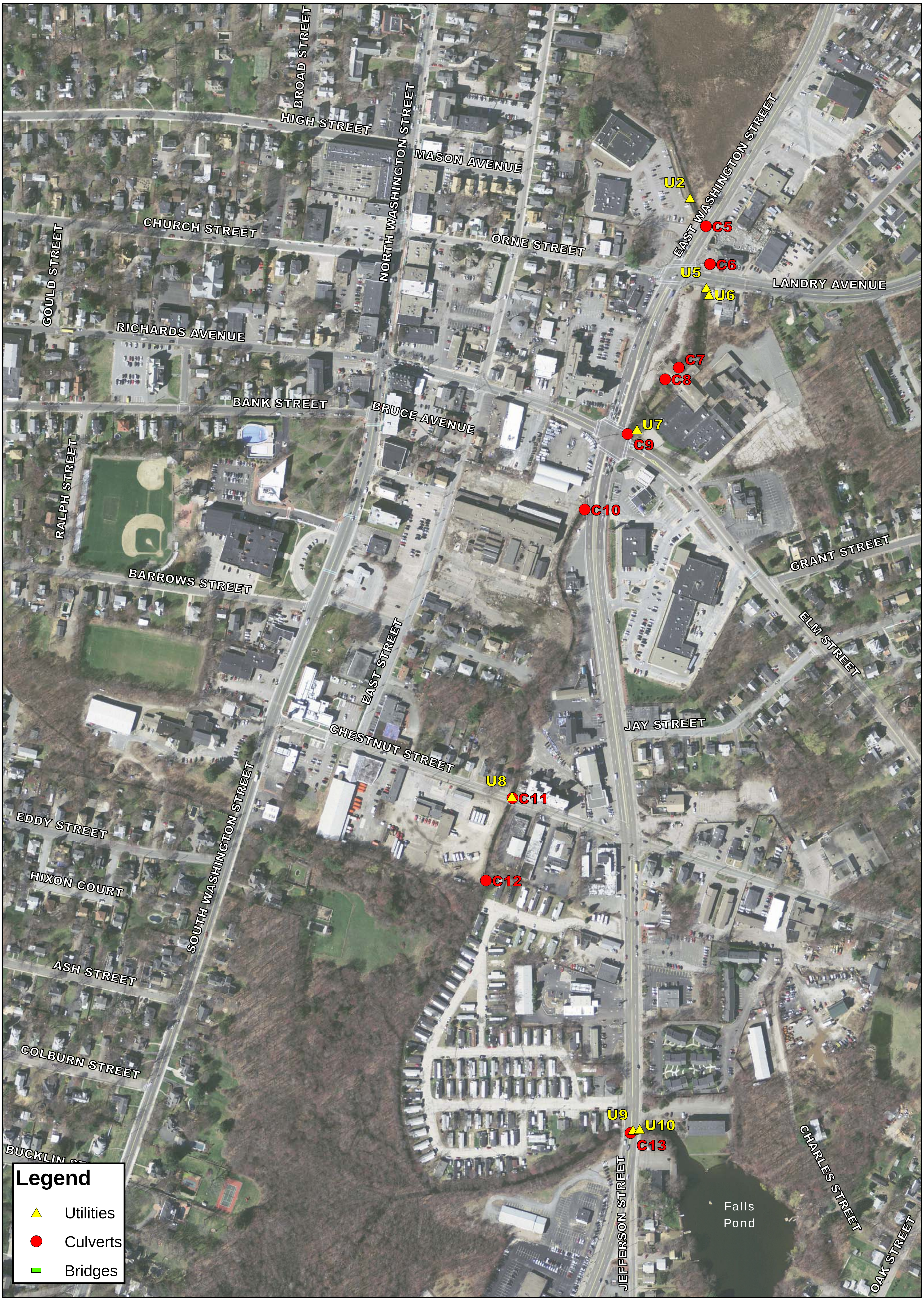

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Figure 6-2B: Utilities, Bridges,Culverts

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1 inch equals 300 feet

abandoned building. The culvert C11 at Chestnut Street is anticipated to be replaced in the near future.

In 2009, BETA developed a Bridge/Culvert Management Plan for the Town, evaluating the condition of bridges and culverts throughout the Town. As part of the evaluation, bridges and culvert were prioritize in order of need of maintenance. The culverts over the Ten Mile River that were in this project area were ranked in the following order: Fisher Street (C4 – replaced in 2010), Chestnut Street (C11), Broad Street (North - C1), N. Washington Street (C3), Orne Street (C6), and Broad Street (South - C1).

6.2.3 Bridges

Two private bridges were identified as part of the field investigation. These bridges were located behind the Havana Café (#329) and Achin's Garage (#321) on N. Washington Street, as seen in **Figures 6-2A** and **6-2B**. The structures were noted for consideration in future river restoration. Bridge information collected can be found in **Table 6-4** in **Appendix E** and inspection reports in **Appendix F**.

6.2.4 Utility Crossings

During the field investigation, water, drain, sewer, and gas utilities crossing the river were encountered. Utilities crossed overhead, parallel to culverts, and well as along the river bottom. **Figures 6-2A** and **6-2B** show the location of each utility crossing. Information collected for these utilities is shown in **Table 6-5** in **Appendix E** as well as in inspection reports generated in **Appendix F**. Further utility research would be needed for design purposes.

6.3 Sediment Investigation

6.3.1 Approach

A sediment investigation was conducted to determine the amount and location of sediment in the Ten Mile River. The goal was to gather enough information to generate cross-sections of the river, calculate the amount of sediment, and determine the hydraulic capacity of the river in a later study.

In order to assess the sediment, the Whiting Pond dam was closed to lower the water level. Two BETA engineers hiked in and along the river, stopping approximately every 100 feet to collect a data point. Cross-sectional data was also collected at places where sediment deposits were uncharacteristic for the section of river. Information was recorded using an iPad and Utility Cloud software. A map of the Cross-Section data collection spots is shown in **Figures 6-3A** and **6-3B**.

10 Mile River Sediment Investigation
North Attleborough, MA

Figure 6-3A: Sediment Cross Section Locations

N
W E
S

1 inch equals 300 feet

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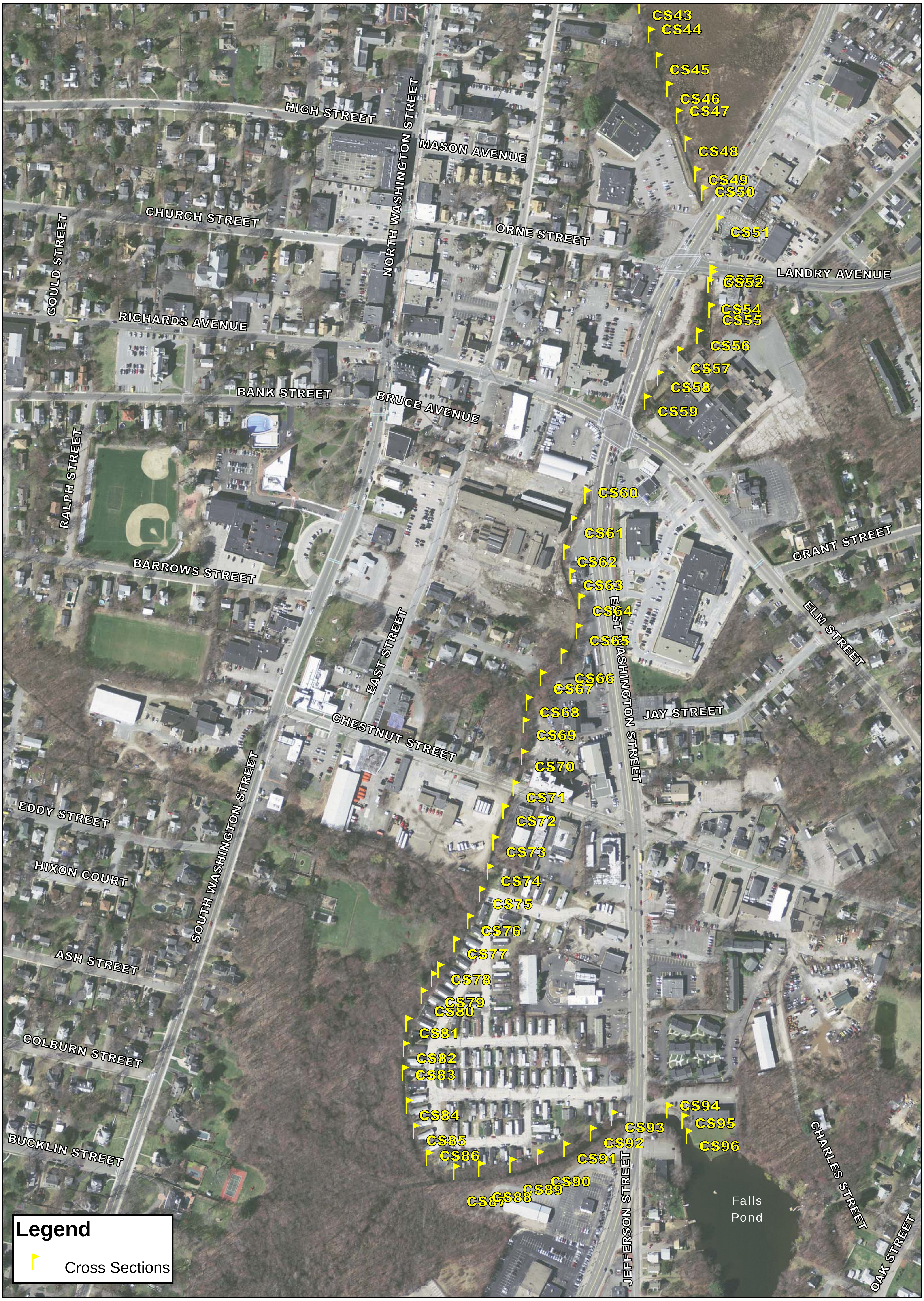

10 Mile River Sediment Investigation
North Attleborough, MA

Figure 6-3B: Sediment Cross Section Locations

N W E S

1 inch equals 300 feet

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Due to the high water levels and poor visibility in the water, it was not possible to dig holes in the bottom of the river to determine the depth of the sediment and to differentiate between sand and riverbed natural material. Instead, a metal rod was pushed into the river bottom until resistance was felt. The difference between the top of the riverbed to where the rod met resistance was the assumed depth of sediment.

As shown in **Figure 6-4**, at each cross-section point the sediment depth, water depth, bank height, bank material, and bank condition was collected for the left and right banks as well as the middle of the river. The depth of the sediment was measured, and photographs of the cross-section and of the sediment were taken. Data was collected orientated facing upstream. **Table 6-6** in **Appendix E** provides information collected during the investigation. Inspection reports can be found in **Appendix F**.

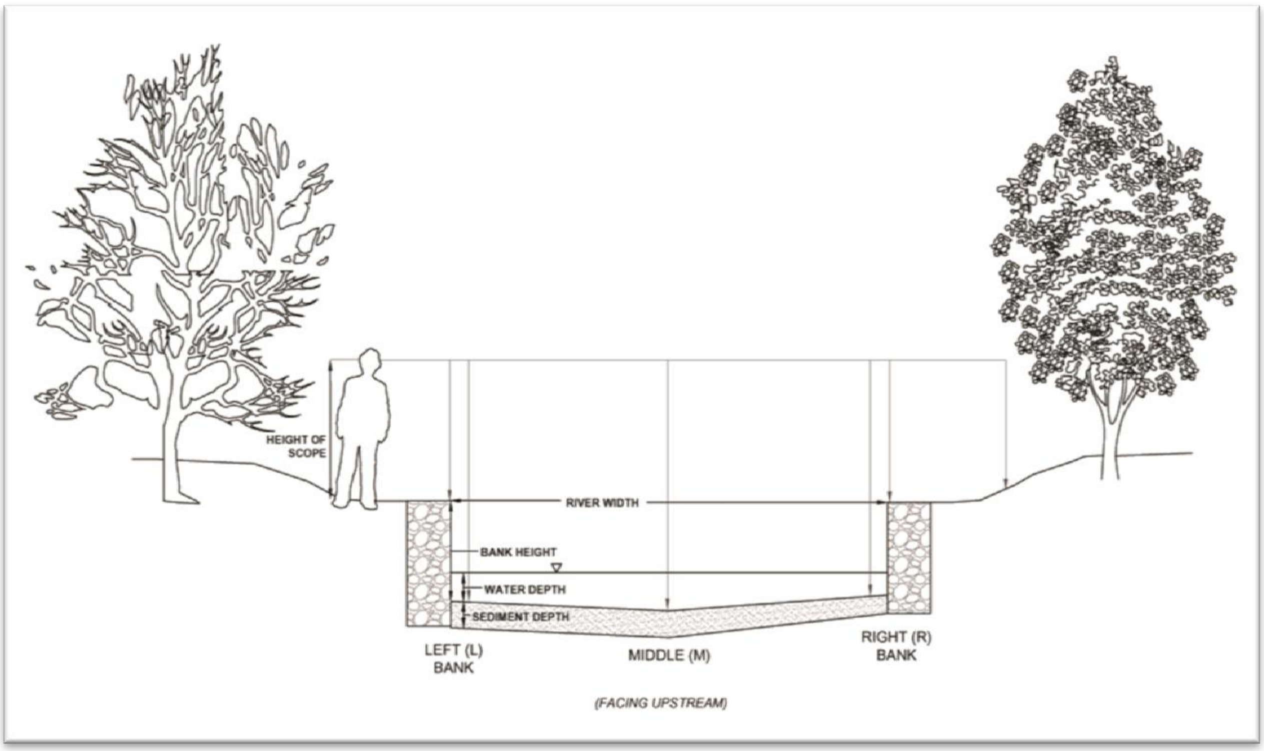

FIGURE 6-4: Field Survey Data Collection for Sediment Investigation

Also, at each cross-section, a handheld sight level and survey rod was used to generate a cross-section profile. As shown in **Figure 6-4**, the heights of the left, middle, and right portions of the river, retaining wells, as well as elevation changes on the bank were measured. Cross-section field notes and sketches can be found in **Appendix G**.

6.3.2 Sediment Estimate

The depth of sediment at the left, middle, right, and other locations (when needed), width of the river, as well as the distance between the cross-sections were used to determine the volume of sediment along the river assuming a linear correlation.

As shown in **Figure 6-5**, at each cross-section point, the area of sediment was determined by breaking each cross-section into 2-4 trapezoids, depending on the amount of data collection at each point. The areas of each trapezoid were calculated and summed together. The area was then multiplied by the distance to the next cross-section point to determine the sediment volume.

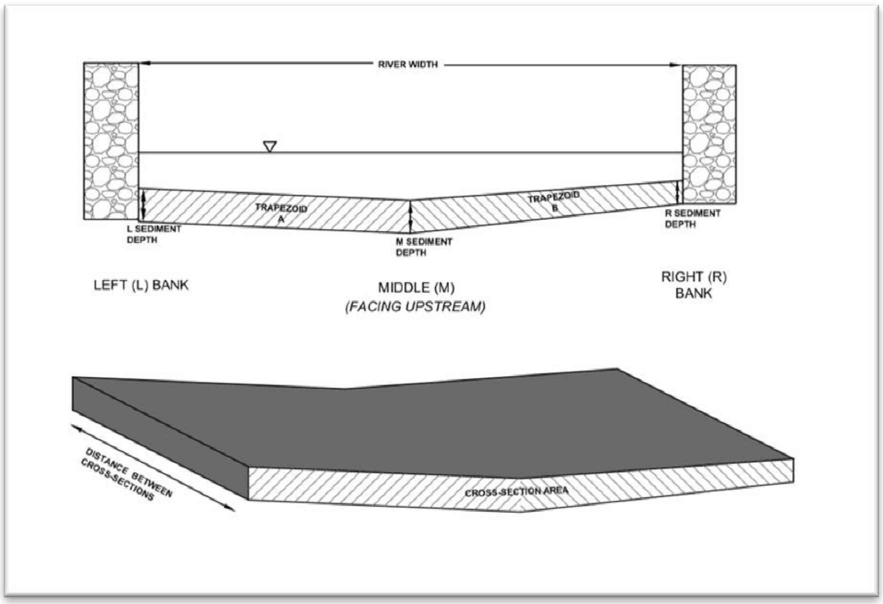

FIGURE 6-5: Sediment Estimate Calculations

Based on these calculations, an approximate total of 6,000 CY of sediment is along the bottom of the Ten Mile River from Whiting Pond to Falls Pond.

6.3.3 Findings

By incorporating elevations from GIS contours, an approximate profile of the Ten Mile River was created, illustrating areas with sediment concerns, as well as elevations along the river attached in **Appendix J**.

Figures 6-6A and **6-6B** illustrate the varied depth of sediment along the river. The middle sediment depth was used since it best depicts the overall sediment conditions at each section of the river.

10 Mile River Field Investigation
North Attleborough, MA

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Figure 6-6A: Sediments Depths (Middle of River)

N
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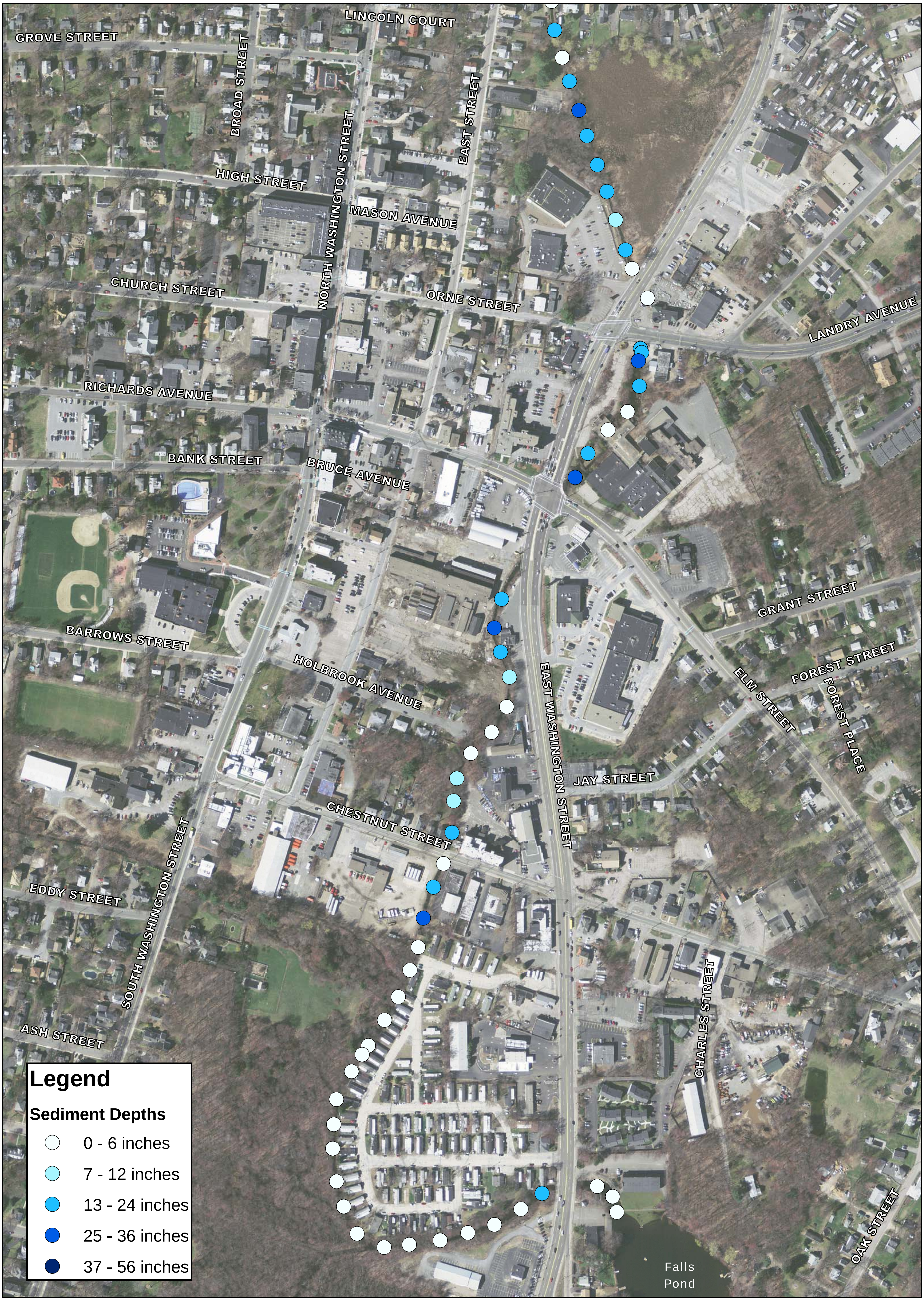
1 inch equals 300 feet



10 Mile River Field Investigation
North Attleborough, MA

N
W E
S

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Figure 6-6B: Sediments Depths (Middle of River)

1 inch equals 300 feet

The areas with the least amount of sediment were at the beginning and end by Whiting Pond and Falls Pond. The sediment in these areas was minimal and the gravel stream bed was visible.

The most significant sediment deposits were in the wetlands between North Washington Street and Fisher Street. The sediment in this area had been previously dredged, however, sediment has collected in these areas. Water and sediment depth totals for this area were 2-4 feet deeper than other areas of the river.

Another sediment issue was in Sections G and H between Chestnut Street and East Washington Street. Although there was little sediment deposit in the middle of the river, along the retaining walls, especially at the river bend, enough sediment has collected over the years that trees and plants have been able to grow in the sediment banks. **Figure 6-7** is a picture of the sediment deposits at the river's bend before East Washington Street.

FIGURE 6-7: Ten Mile River Bend before East Washington Street

Due to the bend in the river near Orne Street and Elm Street, sediment has built up near and inside of the culverts. Low water velocity and culverts has led to large sediment bars and deposits, obstructing the natural flow of the river. **Figures 6-8** through **6-10** are examples encountered during the field investigation. At CS-60 where **Figure 6-10** was taken, the sediment depth was measured to be 56 inches.

FIGURE 6-8: Sediment Buildup South Side of Orne Street Culvert

FIGURE 6-9: Sediment Deposits inside Orne Street Culvert

FIGURE 6-10: Sediment Deposits South Side of Elm Street Culvert

SECTION 7 – Preliminary Flood Storage Assessment

7.1 Purpose

The purpose of this section is to identify potential areas adjacent to the river within our study area that could be used to provide flood storage for large rain events. These areas would provide storage that would help increase the overall time of concentration, which would help in reduce the volume of water during storm events and help reduce the level of flooding.

7.2 Potential Flood Storage Areas

Two areas along the Ten Mile River were identified and investigated for potential flood storage that are currently filled with silt and inundated with a phragmites monoculture. As shown in **Figure 7-1**, potential storage area 1 is near River Street and East Washington Street (Route 1) and potential storage area 2 is located between Fisher Street and Orne Street, along East Washington Street (Route 1).

For either area to be used, sediment would need to be removed to provide storage volume. Prior to removing sediment, the material would need to be tested for possible contaminants, including heavy metals due to the areas historic industrial discharge.

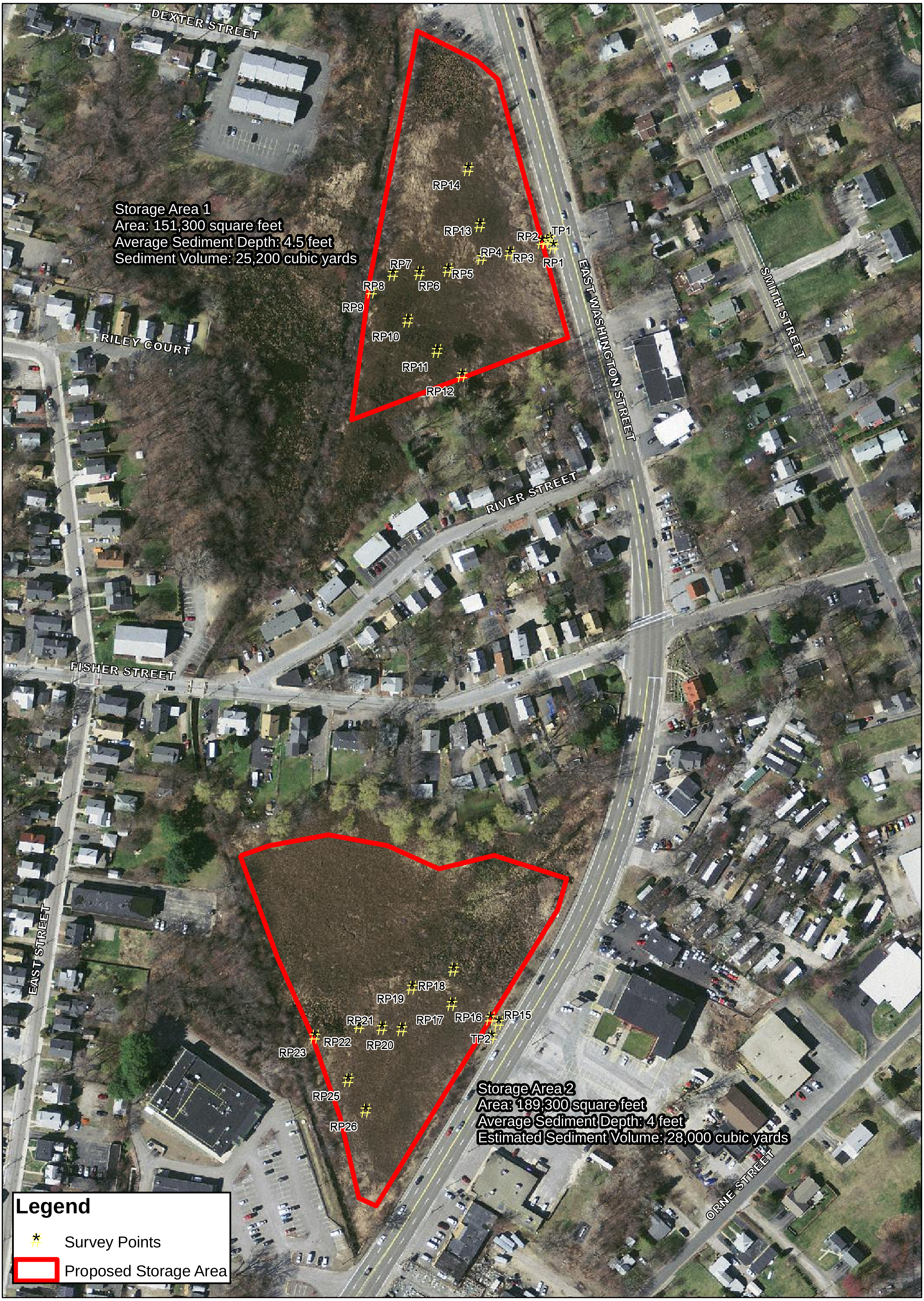
In May 2013, two BETA engineers surveyed each potential storage areas to approximate the depth of sediment and potential stormwater volume. A sub-meter GPS Trimble was used to locate each survey point horizontally and elevations at the top of sediment were taken at each point using survey level and rod. **Figure 7-1** depicts the GPS points. The depth of sediment was measured by inserting a rod into the sediment until resistance was felt. Data collected in the field was mapped using AutoCAD Civil 3D 2013. Profiles, provided in **Appendix H**, were generated for each area. Base elevations for the profiles were taken from MassGIS data.

As shown in **Figure 7-1**, Area 1 has a surface area of approximately 151,300 square feet and an average sediment depth of 4.5 feet. The amount of sediment removal required would be approximately 25,200 cubic yards.

As noted **Figure 7-1**, Area 2 is a bit larger with an approximate surface area of 189,300 square feet and an average sediment depth of 4 feet. The amount of sediment removal required would be approximately 28,000 cubic yards.

7.3 Work Required for Use

To use either area as potential stormwater storage, several steps would need to be taken. **Figure 7-2** illustrates the areas are filled in with sediment and invasive phragmites. Due to the area's industrial discharge history, there is a potential for soil contamination, including heavy metals. Soil would need to be tested and if dredged, the materials for disposal would need to be permitted and likely disposed as hazardous, increasing restoration costs. Phragmites would also need to be eradicated. An added benefit to restoring the area is to bring back functioning natural wetlands.



10 Mile River Field Investigation
North Attleborough, MA

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Figure 7-1: Potential Stormwater Storage Areas

1 inch equals 150 feet

Furthermore, depending on the type of restoration efforts, several permits may need to be filed. Permits could include Environmental Notification Form, Environmental Impact Report, 401 Water Quality Certification, Notice of Intent and Stormwater Pollution Plan. Section 12 further explains the requirements for each permit.

FIGURE 7-2: Looking at Potential Storage Area 1 from Route 1

SECTION 8 – Steps to Finalize Hazardous Risk Assessment Report

8.1 Purpose

A Hazardous Mitigation Report was created for the Town by the Massachusetts Maritime Academy. The report was then forwarded to the regulators for review. Comments were received and have not yet been addressed. BETA was asked to review the existing draft Hazardous Mitigation Report and comments then compiled a list of necessary steps to direct the Town how to complete the Hazardous Mitigation Report.

The Hazardous Mitigation Report provides basis for future mitigation efforts. The Mitigation Report should identify and potential hazards, profile hazard events, inventory assets, and estimate losses. This process evaluates the vulnerability of people, buildings, and infrastructure to hazardous events.

8.2 Typical Hazard Mitigation Report

To best understand the intent of a Hazardous Mitigation Report, we have provided the following summary of information provided to the Town on FEMA's website.

According to the FEMA Website, a Hazard Mitigation Report can be broken down into four phases: Organize Resources, Assess Risks, Develop the Mitigation Plan, and Implement and Monitor Progress. The following sections describe FEMA recommendations to be included in each phase. Under Hazard Mitigation Planning Resources on FEMA's website (http://www.fema.gov/hazard-mitigation-planning-resources#1), there are how-to guides with worksheets to assist in developing each phase of a typical Hazard Mitigation Report.

8.2.1 Organize Resources

The first phase of the Hazard Mitigation Plan involves coordination with other agencies, integration with other planning efforts, and engaging with the community through the public process.

FEMA's website notes stakeholders should be included in the first phase of planning. Stakeholders are individuals or groups that will be affected in any way by a mitigation action or policy and include businesses, private organizations, and citizens. Stakeholders from the following groups should be included:

- Neighborhood groups and other non-profit organizations
- State, regional, and local government representatives
- Businesses and development organizations
- Elected officials
- Federal agency representatives
- Academic institutions

In order to involve the public, public participation activities are recommended. Activities can include meetings, questionnaires, an interactive website, hotline, and interviews. Steps taken to include the community as well as community comments should be included in the Hazard Mitigation Report.

8.2.2 Assess Risks

Risk assessment involves characterizing and determining likelihood and potential consequences of hazards. After completion, this section should state hazards to which the community is susceptible, what each hazard can do to physical, social, and economic assets, which areas are most vulnerable to damage, and the resulting cost of damage.

According to FEMA, the first step is to identify the hazards the community is most susceptible to. This can be accomplished by reviewing historic data, reports, and talking to experts such as the State Hazard Mitigation Officer.

After potential hazards have been identified, they must be profiled to determine how damaging each hazard can be to the community. In some cases such as flood and earthquakes, this can be achieved by mapping geographic extents. Other hazards, such as tornadoes are profiled by maximum potential wind speed.

Asset inventory is a critical part of assessing risks of each hazard by showing what can be affected by each hazard. HAZUS, software that uses models to estimate potential losses from hazards, can be used to assist with this step. Inventory of assets should include the number of structures, the value of structures, and the number of people located in each hazard area. A detailed inventory of structures listing building size, value, and replacement value should also be included.

The last step in assessing risks is estimating losses in terms of expected losses from hazard events to people, buildings, and other important assets. FEMA WORKSHEET can be used to estimate potential losses from hazards. Losses calculated are to the structure, content, structure use and function, and human losses.

FEMA states, hazards should be assessed individually and should take into account all possible hazard events. Hazards include floods, tropical storms and hurricanes, dam risks, nor'easters, thunderstorms, severe winter weather, extreme temperatures, tornados, pandemics, transportation and rails, fire, hazardous material pollution, hazmat, drought, earthquakes, and landslides.

8.2.3 Develop the Mitigation Plan

After assessing potential risks, the community should determine priorities and look at possible ways to avoid or minimize undesirable effects. The plan will develop goals and objectives that guide the identification of actions to address potential losses. Once goals have been established, mitigation actions can be determined.

Goals are general guidelines that explain what is trying to be achieved. They are usually broad policy-type statements, long term, and represent global visions. Objectives define strategies or implementation steps to attain the identified goals. Unlike goals, objectives are specific and measurable. Public input should also be included in the process.

FEMA states, mitigation actions can be grouped into six categories: prevention, property protection, public education and awareness, natural resource protection, emergency services, and structural projects. These actions form the core of the mitigation plan, and will be the most outward representation of the planning process to the general public and political leadership in the community. As part of this step, alternative mitigation actions should also be analyzed in order to evaluate and select proper mitigation actions.

After mitigation actions are determined, an implementation strategy must be developed. Necessary resources, parties involved, and time frames should be reviewed and documented. The strategy clearly lays out who will be responsible for undertaking the identified actions, what funding sources are available, and the time frame for completing these actions.

8.2.4 Monitor Progress

This step focuses on the actions necessary to establish and maintain plan effectiveness as a fundamental tool for risk reduction. This section must describe the method and schedule of monitoring, evaluating, and updating the mitigation plan with a 5-year period.

According to FEMA's website, the plan must state how, when, and by which department or agency it will be monitored. Monitoring can involve periodic reports, site visits, phone calls, and meetings.

The plan must also include how, when, and by which department of agency it will be evaluated. The evaluation should assess whether:

- The goals and objectives address current conditions.
- The nature, magnitude, and type of risks have changed.
- The current resources are appropriate.
- There are implementation problems.
- The outcomes have occurred as expected.
- The agencies and other partners participated as originally proposed.

The plan must describe how, when, and by which department or agency it will be updated. FEMA recommends the plan be reviewed and updated annually or after a hazard occurrence to determine effectiveness and reflect changes in land development. The plan is required to be updated within five years from the date of FEMA approval.

8.3 Steps to Finalize Town of North Attleborough Hazardous Risk Assessment Report

Sarah White, Hazard Mitigation Planner of MEMA, reviewed a preliminary draft plan created by Massachusetts Maritime Academy. Ms. White noted that several items must be completed in order to finalize the Hazardous Mitigation Report for North Attleborough. These items are listed in **Figure 8-1**.

Work should be divided among departments best suited to complete each task. Suggested departments and tasks are further explained below. More detailed information can be found in "Understanding your Risks Identifying Hazardous and Estimating Losses" on the FEMA website (http://www.fema.gov/media-library-data/20130726-1521-20490-4917/howto2.pdf).

FIGURE 8-1: Summary of Steps to Finalize Hazardous Mitigation Plan

1. Public Process

Make available to residents, stakeholders, businesses, environmental groups

Departments: Building Dept., Zoning Board, Board of Selectmen, DPW, Conservation Commission, Business and Industrial Commission

<u>Option 1</u>
Include in Public Meeting
(Board of Selectmen, Planning Board)

<u>Option 2</u>
Online Survey
(Mention on Town Website, Water Bills, Newspaper)

<u>Option 3</u>
Make Draft Available for Comment
(Town Website, Library)

2. Infrastructure Assessment

Expand on which infrastructure, buildings, and homes, are impacted by each hazard and the estimated losses of those structures for each possible hazard

Departments: Building Dept, Zoning Board, Assessor's Office

3. Effects of Development

How development or growth may add to the hazards identified

Departments: Building Dept., Zoning Board, Assessor's Office, DPW, Fire Dept., Police Dept.

4. Mitigation Goals and Actions

Develop and prioritize a list of mitigation goals and actions based on the risks identified.
-Who and when are responsible for implementation?
-What resources are needed?
-What are the benefits of the actions?
-What is priority for implementing the action?
Departments: Building Dept., Zoning Board, Assessor's Office, DPW, Fire Dept., Police Dept.

5. Analyze the National Flood Insurance Program

-Discuss the rep loss structures by type and location
-How does the Town comply with the NFIP?
-What are some actions the town will do in the next 5 years to continue to comply with the NFIP?
Departments: Building Dept., Zoning Board, Assessor's Office, DPW, Fire Dept., Police Dept.

6. Five Year Plan

How will the community maintain, review, and update this plan over the next 5 years?

Departments: Building Dept., Zoning Board, Assessor's Office, DPW, Fire Dept., Police Dept.

A public process is required for the Hazardous Mitigation. A public meeting can be held to present the risk assessment and findings, followed by a second public meeting to share the final draft before it is sent to Massachusetts Emergency Management Agency (MEMA). A draft of the document can be posted on the town website, in the library, or town hall for comments. Another option is through an internet survey with a link on the town website, local paper, or water bills.

Public process allows for the general public to present concerns that can be included in the final plans. The final plan should state how the public was involved. More information regarding public process of the Hazardous Mitigation Plan can be found in the report "Getting Started: Building Support for Mitigation Planning" on FEMA's website.

The general public and other stake holders such as, major businesses, civic organizations, and environmental activities groups must also be included. These groups can also assist with the public process portion of the report.

Step 2: Infrastructure Assessment
Infrastructure, buildings, and homes impacted must be elaborated upon by estimating structural losses for each possible hazard. Each hazard must include details regarding effects to infrastructure. FEMA has a guide to complete this item.

Infrastructure impact must include the proportion of buildings, value of buildings, and population in the community located in hazard areas. Information can be found using local figures or data, tax assessment values, CENSUS data, and HAZUS. Location of expected growth should also be included in the analysis.

Building and hazard specific information about assets such as lowest floor elevation and base flood elevation must also be included.

Departments in charge of each hazard section are recommended to work in conjunction with the building department to finalize analysis.

Step 3: Effectiveness of Development
This section should expand upon development or growth which may add to the identified hazard. Incorporate details on how much the development or growth increases the potential effects of hazard and where in Town development or growth occurs.

Step 4: Mitigation Goals and Actions
Following the risk assessment mitigation goals and actions must be developed. It is a vision for long-term mitigation and loss reduction. Risk assessments should be reviewed and from these findings problem statements should be developed. Then goals can be formulated and finally objectives can be determined. Each goal and action must address the following criteria:

- Who is responsible for the implementation and when will the action be implemented?
- What resources are needed to complete the action?
  - Funding, staff time, new equipment, etc.
- What are the benefits of the action?
  - Flooding minimization, public awareness, reduce annual repair costs, etc.

- What is the Town's priority for implementing the action?

Step 5: Analyze the National Flood Insurance Program

The Hazardous Risk Assessment Report must analyze the National Flood Insurance Program in the following ways:

- Discuss the loss structures by type and location. This information will be provided by the Massachusetts Emergency Management Agency.
- How the Town complies with the National Flood Insurance Program. This includes but is not limited to zoning codes and floodplain regulations.
- Actions the Town will take in the next 5 years to continue to comply with the National Flood Insurance Program.

Step 6: Five Year Plan

Under the code of federal regulations, local jurisdiction is required to review and revise the Hazard Mitigation Plan within 5 years in order to continue to be eligible for mitigation project grant funding. The Hazard Mitigation Plan must include how the community will maintain, review, and update the Plan over the next 5 years. It also includes an explanation of how local governments will incorporate the mitigation strategies into existing planning. Public participation must also continue throughout the plan maintenance process.

SECTION 9 – Summary, Recommendations and Costs

9.1 Summary

Based on the information collected in the field, as well as concerns discussed with the Town, the following is a summary and evaluation of existing conditions to alleviate flooding along the Ten Mile River.

9.1.1 Retaining Walls

Reviewing the finding of the field investigation, most retaining walls along the Ten Mile River are in need of some level of repair. **Table 9-1** prioritizes the need for retaining wall repair; 1 being highest priority (poor condition and missing walls) to 8 being lowest priority (good condition). Locations can be found in **Figures 6-1A** and **6-1B**. Future retaining wall designs should allow for increased flow capacity. Depending on available funds, sections with a repair priority of 3 or less should be considered for immediate repair; however, a hydraulic analysis of the study area should be conducted prior to allow for development of recommendations for potentially increasing the width and/or depth of the river in these locations. Ownership needs to be determined for the various reaches of wall sections to be rehabilitated prior to conducting work.

Table 9-1: Retaining Walls Repairs Ranking

Repair Priority	Section	Start	Finish	Retaining Wall IDs	Retaining Walls Condition
1	C	N. Washington Street	Fisher Street	RW22-RW46	poor
2	D	Fisher Street	E. Washington Street (at Orne Street)	RW47-RW50	poor
3	A	Whiting Pond Dam	Broad Street	RW7–RW15	fair-poor
4	F	E. Washington Street (at Elm Street)	Chestnut Street	RW55-RW61	fair-poor
5	H	Stream Inlet	Falls Pond	RW69-RW75	fair-poor
6	B	Broad Street	N. Washington Street	RW1-RW6, RW16-RW21	fair
7	E	Landry Avenue	Elm Street	RW51-RW54	good-fair
8	G	Chestnut Street	Stream Inlet	RW62-RW68	good

9.1.2 Culverts/Bridges

The field investigation concluded that the culvert at Chestnut Street and the two culverts at Orne Street and East Washington Street are most in need of repair. Chestnut

Street culvert is scheduled to be repaired in the near future. FEMA flood insurance study maps indicate that the two culverts at Orne Street (C5 and C6 in Figure 6-2B) limit the amount of flow during extreme storm events, resulting in flooding upstream. Evidence of this can be seen in the amount of sediment deposits of on either end of the culverts. These two culverts should be further evaluated for capacity issues through hydraulic modeling. Modeling should evaluate the effects of increased culverts capacity and downstream water levels.

Also, according to the 2009 Bridge/Culvert Management Plan by BETA, the repair of spalls and delamination on the underside of the bridge beams at Orne Street is high priority. These repairs should be completed in conjunction with any future recommendations. It should be noted that culvert C5 is State owned and the north side of C6 is located on private property.

9.1.3 Sediment Removal and Reestablishing River Invert

Sediment depths along the Ten Mile River are of greatest concern between the intersections of North Washington Street and Fisher Street, the south side of the Orne Street culvert, and both sides of the Elm Street culvert. The sediment deposits near the culverts should be carefully removed to increase flow capacities.

A consistent invert should be established along the river from STA 1+00 to STA 78+00. An estimated proposed grade is illustrated in **Appendix J**. Currently the river's invert is not consistent, which accounts for part of the sediment deposition issue. For river sections listed in **Table 9-3**, sediment should be removed and replaced with clean, suitable fill to establish a natural river bottom at the appropriate slope to provide an optimal hydraulic grade.

9.1.4 Potential Flood Storage

The two potential stormwater storage areas identified in Section 7 of this report, that are currently inundated with sediment, could be restored to temporarily impound some of the flow during small to moderate rain events. It is recommended that restoring these areas should be evaluated as part of a subsequent hydraulic analysis of the study area to determine the benefit vs. the cost of this work.

9.1.5 Whiting Pond Bypass

In a meeting with the Town, it has been noted that the Whiting Pond bypass located behind 49 Whiting Street contributes large volumes of unregulated stormwater due to the altering of an upstream dam in Plainville and a "homemade" dam for easier river crossing constructed by local children. It is recommended that a low maintenance weir be installed in the pond bypass to regulate flow and redirect base flows back to Whiting Pond.

As discussed at the Ten Mile River Committee meeting on June 25, 2013, another flood mitigation idea was to re-route the large drainage line discharging to the Ten Mile River near North Washington Street to an outlet further downstream in one of the potential stormwater storage areas. The re-routing of the drain line will not help mitigate flooding upstream until capacity of the culvert at Orne Street is increased.

9.1.6 Modeling

To better understand how the Falls Pond dam operation affects flooding upstream along with how the river reacts during various rain events, it is recommended that a HEC-RAS hydraulic model should be created of the study area. This model can be then used to test recommendations to determine their efficiency in reducing river flooding events.

Currently, the United States Geological Survey (USGS) is developing a HEC-RAS model of the entire Ten Mile River from Plainville, Massachusetts to East Providence, Rhode Island. The model includes new LIDAR elevation data, survey of structures, and new hydrology peak flows. The model will be available for Town use in Spring 2014.

The HEC-RAS model created by USGS will not eliminate the need for a model developed specifically for the study area, but will be used in developing the boundary conditions since the study area is located in the middle of the overall river. Up and downstream boundary conditions will be critical for the successful calibration and operation of a model focused solely on the study area.

9.1.7 Hazardous Mitigation Report

It is recommended that the various Town departments collaborate together to develop the information required by MEMA to finalize the Hazardous Mitigation Report. Finalizing this report may provide opportunity for additional funding sources.

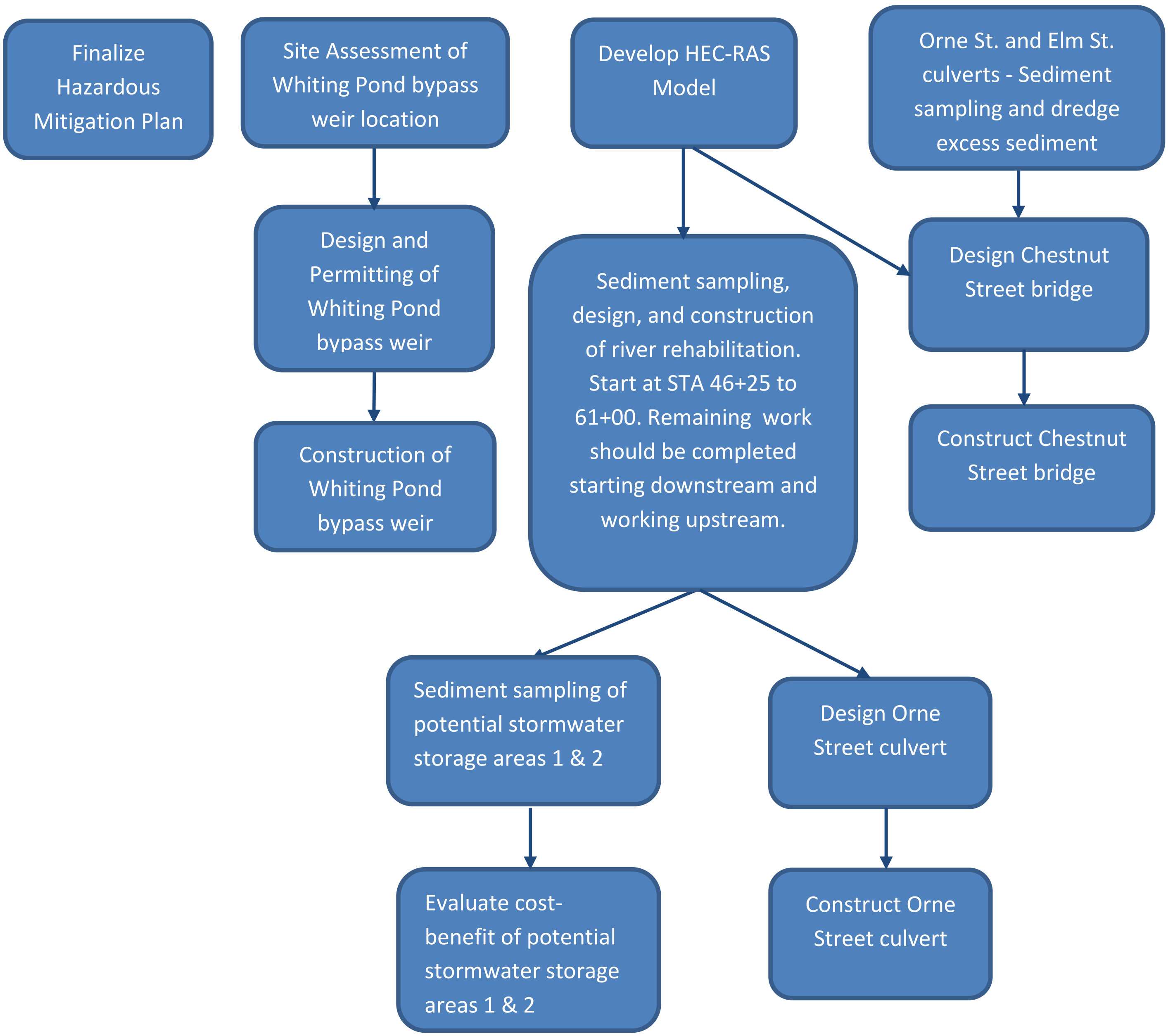
9.2 Recommendations

BETA presented a preliminary schedule and prioritized recommendation to the 10 Mile River Committee on March 5, 2014 for review and comment. At that meeting the Committee indicated that they agreed with the general approach to the recommendation breakdown but wanted to see the projects broken into more manageable, affordable sizes. The Committee suggested that these projects would be affordable at a cost of $250,000 per year. Following this directive, BETA reworked the recommendation and broke the river into projects that fit within the recommended annual project funding level. This results in a 56 year program. These costs along with a detailed breakdown of the river segments are discussed below.

It was also recommended by the Committee that while there may be segments in upstream portions of the river that could, for relatively short amounts of money, be reconfigured/cleaned, it would be most prudent to start at the most downstream reach of the river and work upstream. As such, BETA has adjusted the recommendations to comply with this suggestion. Sediment sampling is recommended prior to rehabilitation of any river segments. We recommend only sampling the particular segment for immediate rehabilitation.

Below is Figure 9-1 that illustrates the recommended approach for advancing the overall project.

Figure 9-1: Recommended Plan



9.3 Costs

Table 9-2 is a further breakdown of recommendations and estimated costs, in order of priority, related to recommendations provided above. Engineering costs will vary depending on geotechnical, survey, bidding or construction phase services that may be required. Sediment removal costs do not include lab testing, permitting, LSP services, or contaminate removal which will vary in price depending on quantity and type of contaminate, if any, identified.

Table 9-2 : Costs

Priority	Recommendations	Description of Work	Engineering Cost	Construction Cost
1	Finalize Hazardous Mitigation Report	Provide additional engineering services to finalize Hazardous Mitigation Report	$10,000	
2	River Restoration – STA 46+25 to 61+00	Dredge excess sediment from Orne and Elm Street culverts.	See Table 9-3	See Table 9-3
3	HEC - RAS Modeling	Develop a HEC - RAS model for the 10 Mile River from Whiting Pond to Falls Pond	$50,000	
4	Chestnut Street Bridge	Replace Chestnut Street Bridge	Separate funding source	Separate funding source
5	Weir System Installation	Install a weir system installation along the Whiting Pond bypass	$25,000 – $50,000	$60,000
6	River Restoration – STA 46+25 to 61+00	Replace retaining walls, remove remaining sediment, and establish new grade	See Table 9-3	See Table 9-3
7	River Restoration – STA 61+00 to 69+00	Replace retaining walls, remove sediment, and establish new grade	See Table 9-3	See Table 9-3
8	River Restoration – STA 1+50 to 61+00	Replace retaining walls, remove sediment, and establish new grade	See Table 9-3	See Table 9-3
9	Replace Culvert	Design and replace the Orne Street culvert	Unknown	Unknown
10	Sediment Removal	Remove sediment from potential stormwater storage area 1 (See Figure 7-1)	$100,000 – $160,000	$1,675,000 - $4,125,000
11	Sediment Removal	Remove sediment from potential stormwater storage area 2 (See Figure 7-1)	$100,000 – $160,000	$1,864,000 - $4,608,000

Based on the direction provided by the 10 Mile River Committee, **Table 9-3** was created. The Committee asked that an affordable recommendation be developed and broken into reasonably sized portions. $250,000 projects were suggested. As such, **Table 9-3** was developed following this criterion. A detailed version of Table 9-3 can be found in **Appendix I**. The table factors sediment depth, a range of sediment removal costs, retaining wall construction, river bottom restoration, and engineering. The river was then broken into logical segments for restoration. A price per segment and a time duration was then established using the $250,000 per year budget. This table provides a first cut at what the long term plan might be along with a potential magnitude of cost. Please note that the number of years to complete is based on the highest potential sediment disposal cost. It is likely that this cost may be lower for many areas of the river. As noted above, we are recommending that only the particular area of the river that will be rehabilitated be sampled to determine the estimated disposal cost. This potential disposal cost change will affect the overall project implementation schedule.

Table 9-3: River Restoration Cost Breakdown

River Section	Sediment Removal and Construction Cost Range		10% Contingency Range		10% Design Contingency Range		15% Engineering Cost Range		Total Cost Range (Sediment, Construction, Contingencies, Engineering)		No. Years to Finish *
STA 1+50 to STA 4+00	$345,800	$351,500	$34,580	$35,150	$35,150	$35,150	$51,870	$52,725	$467,400	$474,600	2
STA 4+00 to STA 11+25	$1,035,300	$1,084,600	$103,530	$108,460	$108,460	$108,460	$155,295	$162,690	$1,402,600	$1,464,300	6
STA 11+25 to STA 16+00	$678,300	$710,200	$67,830	$71,020	$71,020	$71,020	$101,745	$106,530	$918,900	$958,800	4
STA 16+00 to STA 21+00	$717,000	$754,500	$71,700	$75,450	$75,450	$75,450	$107,550	$113,175	$971,700	$1,018,600	4
STA 21+00 to STA 26+00	$721,500	$762,500	$72,150	$76,250	$76,250	$76,250	$108,225	$114,375	$978,200	$1,029,400	4
STA 26+00 to STA 31+00	$726,500	$773,500	$72,650	$77,350	$77,350	$77,350	$108,975	$116,025	$985,500	$1,044,300	4
STA 31+00 to STA 36+00	$728,000	$777,000	$72,800	$77,700	$77,700	$77,700	$109,200	$116,550	$987,700	$1,049,000	4
STA 36+00 to STA 46+25	$1,453,500	$1,511,900	$145,350	$151,190	$151,190	$151,190	$218,025	$226,785	$1,968,100	$2,041,100	8
STA 46+25 to STA 55+00	$1,312,500	$1,435,900	$131,250	$143,590	$143,590	$143,590	$196,875	$215,385	$1,784,300	$1,938,500	8
STA 55+00 to STA 61+00	$973,200	$1,131,600	$97,320	$113,160	$113,160	$113,160	$145,980	$169,740	$1,329,700	$1,527,700	6
STA 61+00 to STA 69+00	$1,122,400	$1,156,000	$112,240	$115,600	$115,600	$115,600	$168,360	$173,400	$1,518,600	$1,560,600	6
								Total	**$13,312,700**	**$14,106,900**	**56**

*Assuming $250,000 funding source available per year, highest total cost

9.4 First 5 Years

Based on the information above, the first 5 years of the program have been detailed below showing the year, recommendation, and cost.

<table>
<tr><th colspan="3">Table 9-4: Recommendation for Years 1 - 5</th></tr>
<tr><th>Year</th><th>Recommendation</th><th>Cost</th></tr>
<tr><td rowspan="2">Year 1</td><td>Finalize Hazardous Mitigation Report</td><td>$10,000</td></tr>
<tr><td>Start Restoration STA 55+00 to 61+00
Phase I - Sediment testing</td><td rowspan="2">$270,000</td></tr>
<tr><td>Year 2</td><td>River Restoration STA 55+00 to 61+00
Phase II – Sediment removal</td></tr>
<tr><td>Years 3</td><td>River Restoration - STA 46+25 to 55+00
Phase I - Sediment testing
Phase II - Sediment removal</td><td>$210,000</td></tr>
<tr><td rowspan="3">Years 4</td><td>Develop HEC-RAS Model</td><td rowspan="2">$160,000</td></tr>
<tr><td>Weir Design and Construction</td></tr>
<tr><td>Design for River Restoration 55+00 to 61+00</td><td rowspan="2">$1,257,700*</td></tr>
<tr><td>Year 5</td><td>Start River Restoration STA 55+00 to 61+00
Phase III – Establish new grade and retaining wall restoration</td></tr>
</table>

*With a funding source of $250,000 per year, it will take 5 years to complete Phase III

SECTION 10 – Funding

10.1 Funding Sources

Table 10-1 lists potential sources of funding, the agency in charge, eligible applicants, previous application deadlines, and previous average funding amounts awarded. Recommended funding sources are described in detail below. Four recommended funding sources were determined based on this project's scope, funding's description, and complexity of funding application.

Table 10-1: Funding Sources

Funding Program	Agency	Eligible Applicants	Previous Application Deadline	Average Funding Awarded
Federal 319 Nonpoint Source Grant Program	DEP	MA public or private organizations	May 31	$191,000
Federal 604b Water Quality Management Planning Grant Program	DEP	Regional planning agencies, conservation districts, cities, and towns	November	$50,000
Flood Mitigation Assistance Program	FEMA	Municipalities, state agencies, certain nonprofits	December 4	Unknown
Massachusetts Environmental Trust	Executive Office of Energy and Environmental Affairs	501(c)(3) nonprofit organizations, municipalities, and academic organizations	October 12	$5,000-$50,000
Native Plant Conservation Initiative	Bureau of Land Management, Forest Service, Fish and Wildlife Service, and National Park Service	501(c)(3) nonprofit organizations, municipalities, and academic organizations	May 25	$50,000-$100,000
Natural Resource Damages Assessment and Restoration	MassDEP	All public and private entities	Unknown	Unknown
Pre Disaster Mitigation Grant Program	FEMA	States, territories, Indian tribal governments, communities, and universities	December 4	Unknown
Pulling Together Initiative	National Fish and Wildlife Foundation (NFWF)	State and local agencies, private landowners, and other interested parties	May 17	$60,000-$100,000
Rivers and Harbors Grant Program	DCR	Federal agencies, municipalities, and non-profits	Rolling deadline	Unknown

10.1.1 Rivers and Harbors Grant Program

The purpose of this grant program is to provide matching funds towards studies, surveys, design and engineering, environmental permitting, and construction activities that address problems on coastal and inland waterways. Grants are given to projects that focus on erosion control, flood mitigation, wildlife habitat, and water quality.

10.1.2 Federal 319 Nonpoint Source Grant Program

The EPA administers funds under Section 319 of the Clean Water Act to states yearly. The amount each state receives is based on an allocation formula. From this, funding decisions are made by the state. Projects that attempt to prevent, control, and abate nonpoint source pollution through structural and nonstructural best management practices are eligible for this grant. 40% nonfederal match is required.

10.1.3 Massachusetts Environmental Trust

The trust supports cooperative efforts to restore, protect, and improve water and water-related resources of Massachusetts. Typical projects funded are those that improve water quality or quantity, conserve aquatic habitat and species, reduce runoff pollution, mitigate the effects of climate change on water resources, and promote human health as it relates to water resources

10.1.4 Pre-Disaster Mitigation Program

Hazard mitigation planning and implementation of mitigation projects prior to a disaster event are eligible for funding under the program. Funds are awarded on a competitive basis without reference to formula base funding allocations.

SECTION 11 – Permitting

11.1 Permits

Current environmental permits required for implementation of this project are listed below. Reasons necessitating the specified permit as well as what should be included in the permit application are described. Permits should be acquired prior to start of construction.

11.1.1 Environmental Notification Form

An Environmental Notification Form (ENF) is required if the project results in altering 5,000 square feet or more of Bordering Vegetated Wetlands (BVW) or altering half an acre or more of any wetland. This permit requires a 30 day review period and copies of the form sent to all designated agencies, as well as a public comment period. The awarding authority is Massachusetts Environmental Policy Act (MEPA). Other MEPA review may be required by the Secretary.

11.1.2 Environmental Impact Report

After the public comment period for the ENF, the Massachusetts Secretary of Environmental Affairs will determine if an Environmental Impact Report (EIR) is required and what the scope will be. If more than one acre of BVW is altered and/or ten or more acres of any other wetlands are altered, an EIR is mandatory. The EIR must include a detailed status of project planning and design, the type and size of the Project, the requirements of any Agency Action, the availability and analysis of reasonable alternatives including a discussion of any alternatives no longer under consideration, and methods to avoid or minimize potential environmental impacts. The EIR must also include responses to comments posed during the review period of the previous draft. This permit requires a 37 day review period with a notice published in *Environmental Monitor*. Following the end of the EIR public comment period, the Secretary will determine if the EIR is adequate and complies with MEPA regulations.

11.1.3 401 Water Quality Certification

This permit applies to activities in wetlands and waters to ensure the project will comply with state water quality standards. Projects with over 100 cubic yards of dredging are required to file a 401 Water Quality Certificate (WQC). The application should include a description and plans of the proposed dredging area, the proposed method of dredging, a description of the material to be dredged, and the proposed disposal site. The application should also include a comprehensive analysis of practicable alternatives to dredging. Copies of the application must be sent to the local Conservation Commission and Department of Environmental Protection (DEP).

Permit reviews are divided into two separate categories: Major Projects and Minor Projects. Major Projects are categorized as projects that call for 5,000 or more square feet of dredging. Minor Projects are those with less than 5,000 square feet of dredging.

11.1.4 Notice of Intent

Under the Wetlands Protection Act (WPA), a Notice of Intent (NOI) is required when direct activity occurs in a resource under protection including BVW, Land Under Water (LUW), River Front Area (RFA) and Banks. The application should include a description of the site including type and boundaries of resource areas. It should also describe proposed work, including measures and designs proposed to meet performance standards described in WPA regulations for each applicable resource area. A copy of the Notice must be sent to the local Conservation Commission and DEP.

11.1.5 Stormwater Pollution Prevention Plan

Any construction project resulting in earth disturbance of one or more acres must file a NOI and a Stormwater Pollution Prevention Plan (SWPP) concurrently with EPA in accordance with the National Pollutant Discharge Elimination System (NPDES) Program requirements. The SWPPP is generally a list of best management practices to be used during construction in order to control erosion and sediment transport.