RESTORATION PLAN

for

Stony Brook and Tussock Brook, Kingston, MA

submitted to

Mass Bays Program
251 Causeway St, Suite 800
Boston, MA 02114

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Jones River Watershed Association

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TABLE OF CONTENTS

1. Introduction 1
2. System Characterization 4
   2.1 Watershed Boundaries and Land Use 5
   2.2 Hydrology 6
   2.3 Flood Plains 7
   2.4 Dams, Structures, and Tidal Restrictions 7
      2.4.1 Landing Road Culvert 8
      2.4.2 Tussock Brook Tide Gate 10
      2.4.3 Stony Brook Dam 17
   2.5 Habitat Evaluations 22
   2.6 Wetlands 22
   2.7 Tidal Inundation, Topography, and Elevation 29
      2.7.1 Tidal Fluctuation Data 29
      2.7.2 Topography and Elevations 33
   2.8 Water Quality 35
   2.9 Historic 39
   2.10 Property Ownership 42
3. Restoration Goals 44
   3.1 Habitat Quality 44
   3.2 Anadromous and Native Fish Runs 44
   3.3 Water Quality 44
4. Restoration Solutions 45
   4.1 Stony Brook Dam 45
   4.2 Tussock Brook Tide Gate 46
   4.3 Stormwater 46
   4.4 Landing Road 46
5. Implementation 47
   5.1 Stony Brook Dam 47
   5.2 Tussock Brook Tide Gate 48
   5.3 Stormwater 49
   5.4 Water Quality 49
6. References 50

FIGURES

Figure 1. Project Site Locus Map....2
Figure 2. Satellite Photo of General Project Area....3
Figure 3. Project Area....4
Figure 4. Stony/Tussock Brook Watershed Boundaries (USGS StreamStats)....5
Figure 5. Stony/Tussock Brook Subbasin Water Budget for Average Precipitation Conditions....6
Figure 6. FEMA Flood Zone Designations for the Project Area....7
Figure 7. Atlas of Tidal Restrictions Description of Landing Road Bridge/Culvert....8
Figure 8. Culvert Under Landing Road (KIJR3) Looking Downstream....9
Figure 9. Culvert Under Landing Road (KIJR3) Upstream....9
Figure 10. Highway Plan Detail Showing Relocation of Tussock Brook....10
Figure 11. Atlas of Tidal Restrictions Description of the Tussock Brook Tide Gate....12
Figure 12. Tussock Brook tide Gate (KITB8). Looking Upstream at Low Tide....13
Figure 13. View of Tide Gate and "Sill" at Entrance....13
Figure 14. View of Upstream End of Tide Gate. Looking Downstream at Low Tide....14
Figure 15. Inside of Tussock Brook Culvert Looking Downstream....14
Figure 16. Spring Tide Passing Over the Downstream Side of the Tide Gate....15
Figure 17. Spring Tide Coming Through the Upstream Side of the Tide Gate....15
Figure 18. Spring Tide Flooding the Tussock Brook Marsh Above the Tide Gate....16
Figure 19. Atlas of Tidal Restrictions Description of the Stony Brook Dam....18
Figure 20. Stony Brook Dam (Sluice at left)....19
Figure 21. Stony Brook Dam Sluice (boards removed)....19
Figure 22. Stony Brook Impoundment (Bing Maps)....20
Figure 23. Atlas of Tidal Restrictions Prioritization of the Three Structures....21
Figure 24. Wetlands Inventory From USFWS (Consistent With Results of 2011 Field Survey)....24
Figure 25. Soil Map of Project Area (USDA, Consistent With 2011 Survey). Legend in Figure 26....25
Figure 26. Soil Type Legend for Figure 25....26
Figure 27. Typical of Tussock Brook, Dense *Phragmites* Surrounding Tidal Channel....27
Figure 28. Manmade Channels at the Toe of the Highway Embankment....27
Figure 29. Red Cedar Stands at Wetland Borders and Islands....28
Figure 30. Discharge Pipe from Manmade Headwater Pond to Upper Tussock Brook....28
Figure 31. Location of Water Level Logging Stations....30
Figure 32. Water Level Data from the Logging Stations....31
Figure 33. Water Levels During March 2010 Flood Event....32
Figure 34. Water Levels During April 2010 Spring Tides....33
Figure 35. Results of Topographic Survey....34
Figure 36. *MarineFisheries* Designated Shellfish Growing Area for Kingston Bay....36
Figure 37. Excerpt of Town of Kingston Stormwater Sampling Results 2011 (ATP 2011)....37
Figure 38. 17th Century Road Layout of Kingston with Notable Sites along Stony Brook (Drew 1876) 41
Figure 39. Property Boundaries in the Project Area (Kingston Maps 27, 28, 36, & 37)....43

TABLES

Table 1. Description and Elevation of Water Level Logging Stations....29
Table 2. Mass Balance of Bacterial and TSS Contributions From Kingston Outfalls (ATP 2011)....37
Table 3. Dry Weather Bacteria Data Jones River 2011 (DEP SERO-BST)....38
Table 4. Example of Goal Driven Decision Matrix for Stony Brook Dam....45

1. INTRODUCTION

The Jones River Estuary is a classic New England salt marsh. It is classic in its look and function, but unfortunately it is also classic in its impairments. Roads and rails crisscross the marsh restricting flows and disconnecting wildlife corridors. Invasive species such as *Phragmites* have taken hold – especially in areas of human alterations. Additionally, the water quality is impaired (303(d) category 5). Species diversity has declined and critical ecological function is degraded. These impairments are most readily seen today in the Stony Brook and Tussock Brook tributary system that drains into the Jones River. Figure 1-3 show the project area.

On Stony Brook (AKA Halls Brook)[1] a dam creates an artificial head of tide and complete obstacle to fish passage only 0.3 miles up from the mouth of Stony Brook. Even the mouth of this brook is subjected to a tidal restriction as it enters the Jones River under Landing Road. Each year anadromous fish including smelt and river herring work their way to the base of dam but find minimal suitable spawning habitat. Nearly the entire marsh from the mouth to the dam (~15 acres) is overtaken by *Phragmites*. On Tussock Brook a tide gate under the state highway (Route 3) limits tidal exchange in ~25 acres of former salt marsh. As a result there is heavy sedimentation and a near monoculture of *Phragmites*. Together these two tributary systems and their associated floodplains represent one of the largest areas on the South Shore for potential salt marsh migration and restoration. All three of these tidal restrictions – tide gate on Tussock Brook, dam on Stony Brook, and bridge at Landing Road and their associated marshes are identified in the 2001 Atlas of Tidal Restrictions on the South Shore of Massachusetts.

The Jones River Watershed Association (JRWA)is currently implementing a community-based restoration program for the main stem and sub-basins of the Jones River focused on fish passage, flow management, water quality, and habitat improvements with goals to benefit both diadromous and riverine fish including: alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*), tessellated darter (*Etheostoma olmstedi*), white perch (*Morone Americana*), redfin pickerel (*Esox americanus*), slimy sculpin (*Cottus cognatus*), and brook trout (*Salvelinus fontinalis*). Additionally, higher trophic level fish beyond the confines of the Jones River will benefit from the increase in productivity. There are more than a dozen state managed and federally managed marine fish species that directly benefit from feeding on anadromous fish in the Jones River system. JRWA has facilitated a number of land acquisitions throughout the estuary and river corridor in order to protect key habitats.

Sea level rise and other climate change factors are projected to significantly reduce existing salt marsh over the next several decades. Salt marshes are critical coastal buffers as well as highly productive habitats. As outer salt marshes are lost it is imperative to identify potential areas for inland migration and establishment of new marshlands. Unfortunately the Massachusetts coastline is highly developed. Private properties and hard infrastructure severely limit the available area for salt marsh migration. Stony Brook and Tussock Brook are an exception in that they are large areas of former salt marsh that appear to have only moderate infrastructure and ownership issues. In general, the land remains as open space and while the impairments related to infrastructure are significant they appear to be reversible and manageable.

Under the current project JRWA is developing a restoration, management, and maintenance plan for the Stony Brook and Tussock Brook areas. Although some of the improvements required in Stony and Tussock Brooks seem fairly obvious, JRWA understands that 'quick fix' approaches to restoration are not

[1] Note: Throughout historic and recent reporting there have been a number of renamed, misnamed, or multiple-named portions of the project area. 'Stony Brook', 'Stoney Brook', and 'Halls Brook' are used throughout to refer to the same water body. 'Landing Rd' is occasionally mistakenly referred to as 'Loring Rd'.

adequate when the goal is the enduring health of aquatic species and river systems. For this reason JRWA considers the development of a well formed, scientifically sound, restoration plan to be of absolute importance to the long-term health of Stony and Tussock Brooks. This restoration plan includes well defined performance measures for the implementation portion of the program and adaptive management strategies that will allow long-term functionality in the changing landscape.

Section 2 contains a detailed characterization of the project area. Section 3 sets restoration goals. Section 4 identifies solutions that will help to achieve those goals based on information described in the characterization. Section 5 outlines the implementation plan including adaptive management strategies that will allow long-term functionality in the changing landscape.

The current project is funded from the U.S. Environment Protection Agency (EPA) through the Massachusetts Bays Program (MBP) which is hosted by the Massachusetts Office of Coastal Zone Management (CZM).

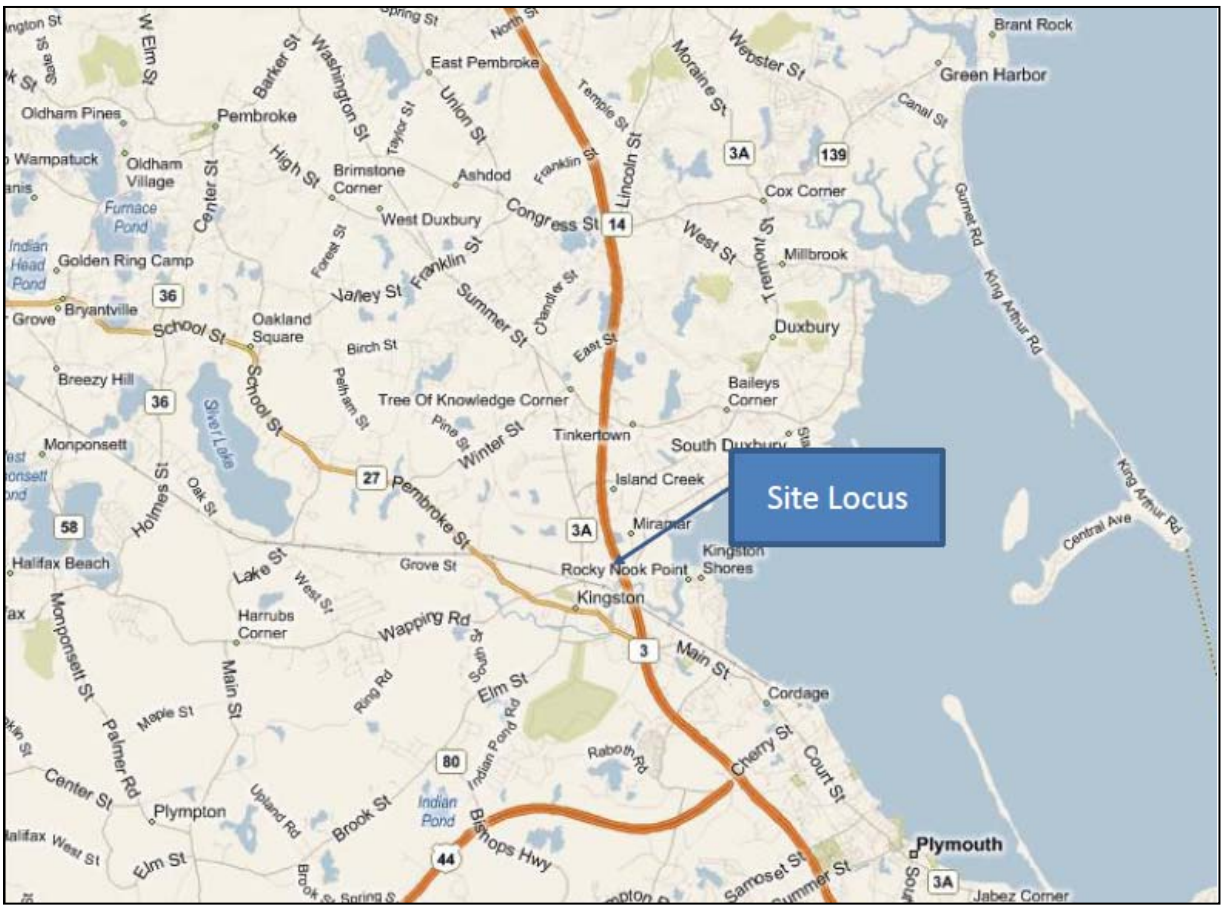


Figure 1. Project Site Locus Map

Figure 2. Satellite Photo of General Project Area

Figure 3. Project Area

2. SYSTEM CHARACTERIZATION

In order to develop solutions for restoring and managing the Stony and Tussock Brooks system we first characterized the watershed and identified key features and problems. Existing information was first compiled in order to identify data gaps. New data were collected to fill those gaps (where possible). Furthermore, we worked with several consecutive and complimentary programs to generate additional data relevant to the restoration planning. All of these sources have been combined to effectively characterize the watershed. The follow sections describe the natural and physical features; land use characteristics; current conditions including water quality and biology; and preliminary assessments of pollutants and their sources.

2.1 Watershed Boundaries and Land Use

The Stony Brook and Tussock Brook watersheds are sub-basins within the overall Jones River watershed. The total area of the sub-basins is approximately 4.91 square miles, including tidal portions within the estuary. Figure 4 shows the Stony/Tussock Brook sub-basin and data as taken from USGS MA Streamstats (http://water.usgs.gov/osw/streamstats/index.html). A large portion of this sub-watershed is in the upper reaches of Stony Brook where it drains from Blackwater Pond. JRWA has worked closely with the MA Division of Marine Fisheries (*MarineFisheries*) on habitat evaluations of Blackwater Pond. While Blackwater Pond is mentioned throughout this report as key habitat area and JRWA feels that it has future potential for restoration, it is not a targeted focus of this plan.

Land use in the sub-basin is predominately forest (42.8%) and residential (32.3%) with smaller contributions coming from cranberry bogs (3.8%), power lines (2.7%), cropland (2.4%), commercial (2.3%), and other uses (GZA 2003).

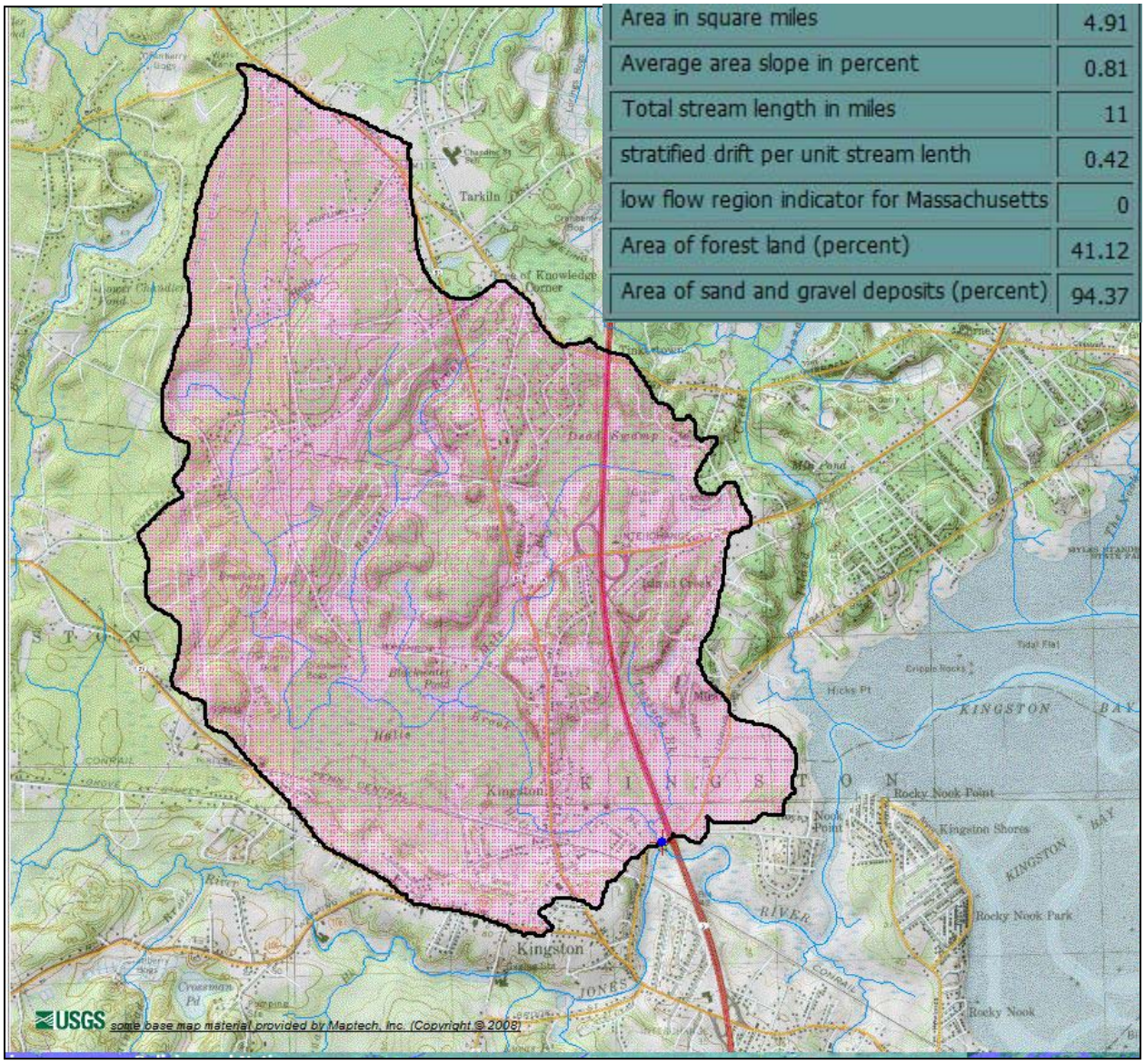


Figure 4. Stony/Tussock Brook Watershed Boundaries (USGS StreamStats)

2.2 Hydrology

In 2003 a study was conducted on the Jones River to prepare a water use inventory and an inflow/outflow analysis for the Jones River watershed and its subbasins. GZA GeoEnvironmental, Inc. conducted this study under contract with the Massachusetts Department of Environmental Management, Office of Water Resources, in conjunction with the Massachusetts Executive Office of Environmental Affairs Watershed Initiative. The following drainage and flow details are taken directly from the GZA report:

> *…estimated to have baseflow (cfsm) values typical of the average Jones River watershed to the USGS stream gage, peaking at 3.0 cfsm (12.4 cfs) in April and reaching a low of 1.0 cfsm (4.3 cfs) in September. Total streamflow peaks at 3.7 cfsm (15.2 cfs) in April and reaches a low of 1.3 cfsm (5.3 cfs) in September. There are no public water supplies in the watershed, but effects of other withdrawals are seen most clearly in summer and fall, reducing flows by up to about 0.6 cfs. Future predictions are identical to developed flow estimates, since there are no future anticipated additional water supply withdrawals. Dry-year conditions result in lower baseflow predictions between 0.7 cfsm (2.8 cfs) in September to 1.2 cfsm (4.9 cfs) in April. Streamflow estimates for dry conditions are also a bit lower: 0.8 cfsm (3.2 cfs) in September to 1.4 cfsm (5.8 cfs) in April. The low flow conditions estimated for natural conditions are again slightly reduced by developed conditions, approaching up to 0.7 cfs in the month of July.*

Figure 5 is reproduced from GZA Figure 5-13A and shows this water budget for this subbasin:

NATURAL CONDITIONS (CFSM)									Correction Factor =	1.13		
	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Corrected Baseflow (CFS)	6.0	6.0	7.5	9.4	10.8	12.0	12.4	11.2	8.2	6.3	5.1	4.3
Corrected Baseflow (CFSM)	1.45	1.46	1.82	2.28	2.63	2.93	3.02	2.74	1.99	1.53	1.24	1.04
Corrected Streamflow (CFS)	7.4	7.6	9.3	11.6	13.4	14.7	15.2	13.5	10.0	7.6	6.5	5.3
Corrected Streamflow (CFSM)	1.79	1.84	2.27	2.82	3.25	3.57	3.71	3.29	2.42	1.84	1.59	1.29
Predicted % Baseflow	0.81	0.79	0.80	0.81	0.81	0.82	0.81	0.83	0.82	0.83	0.78	0.81
CURRENT CONDITIONS (CFSM)												
	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Corrected Baseflow (CFS)	5.7	5.9	7.6	9.5	10.9	12.0	12.2	10.9	7.7	5.7	4.6	4.1
Corrected Baseflow (CFSM)	1.38	1.44	1.84	2.30	2.64	2.93	2.97	2.65	1.86	1.39	1.13	1.00
Corrected Streamflow (CFS)	7.0	7.5	9.4	11.7	13.4	14.7	15.0	13.1	9.3	6.9	5.9	5.0
Corrected Streamflow (CFSM)	1.71	1.82	2.29	2.84	3.27	3.57	3.66	3.19	2.27	1.68	1.44	1.23
Predicted % Baseflow	0.81	0.79	0.80	0.81	0.81	0.82	0.81	0.83	0.82	0.83	0.78	0.81
FUTURE CONDITIONS (CFSM)												
	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Corrected Baseflow (CFS)	5.7	5.9	7.6	9.5	10.9	12.0	12.2	10.9	7.7	5.7	4.6	4.1
Corrected Baseflow (CFSM)	1.38	1.44	1.84	2.30	2.64	2.93	2.97	2.65	1.86	1.39	1.13	1.00
Corrected Streamflow (CFS)	7.0	7.5	9.4	11.7	13.4	14.7	15.0	13.1	9.3	6.9	5.9	5.0
Corrected Streamflow (CFSM)	1.71	1.82	2.29	2.84	3.27	3.57	3.66	3.19	2.27	1.68	1.44	1.23
Predicted % Baseflow	0.81	0.79	0.80	0.81	0.81	0.82	0.81	0.83	0.82	0.83	0.78	0.81

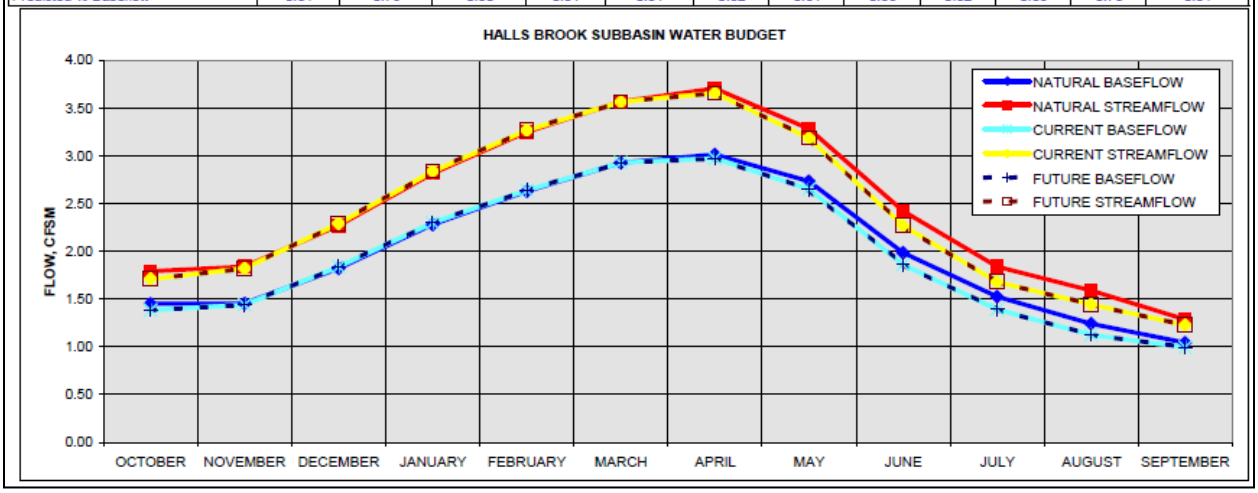


Figure 5. Stony/Tussock Brook Subbasin Water Budget for Average Precipitation Conditions

2.3 Flood Plains

The Federal Emergency Management Agency (FEMA) requires municipalities to perform floodplain mapping and develop management plans to receive federal flood insurance. This information is also relevant to water quality protection and restoration activities because floodplains, when inundated, serve many functions and provide important habitats for a variety of fish and wildlife. Floodplains are important for spawning and rearing areas. Floodplain wetlands act as nutrient and sediment sinks, which can improve water quality in streams. They also provide an area for water storage; helping to decrease the magnitude of floods downstream, which can benefit fish and riparian landowners. Figure 6 shows the FEMA floodplain maps for the project area. The FEMA maps are revealing in regards to Tussock Brook. Zone classifications are the same above and below the tide gate suggesting that the tide gate is not currently considered by FEMA to influence the flooding potential in areas above the gate.

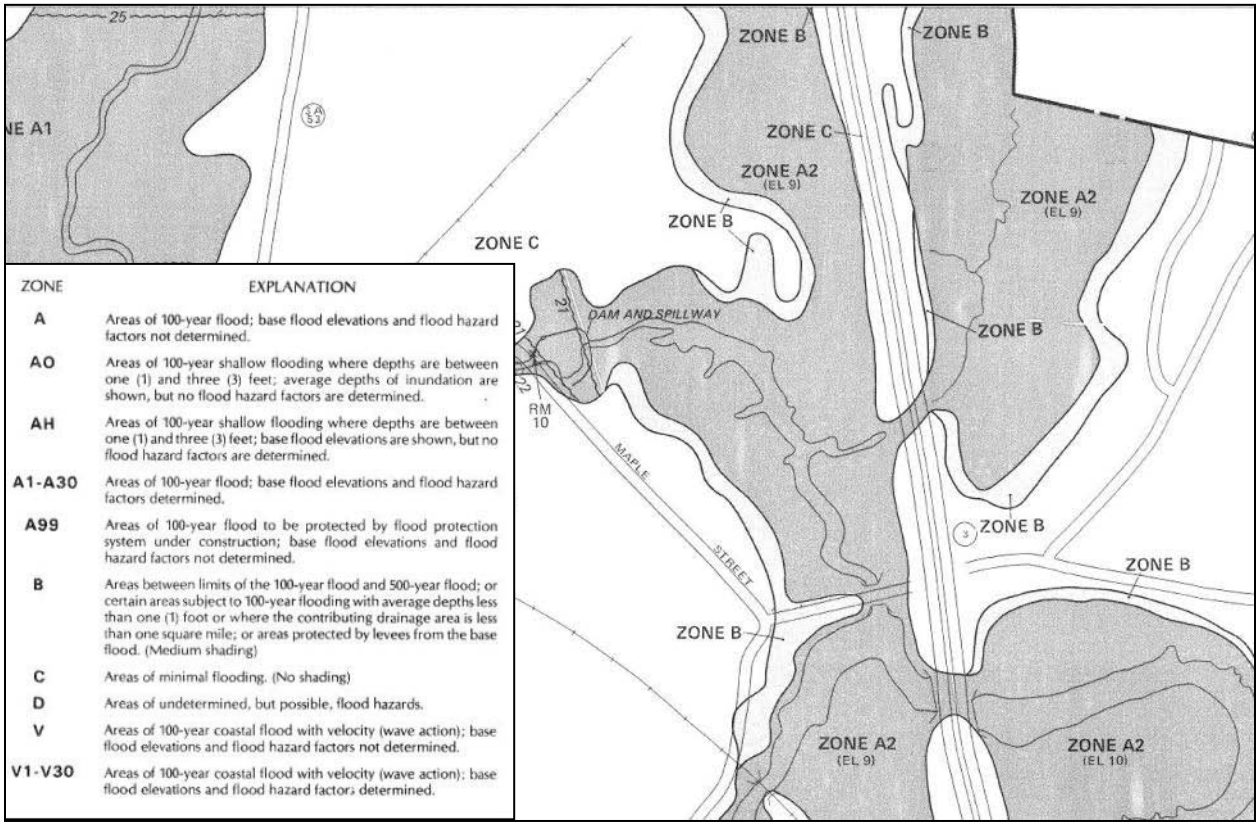


Figure 6. FEMA Flood Zone Designations for the Project Area

2.4 Dams, Structures, and Tidal Restrictions

The project largely revolves around a series of tidal restrictions in the project area. The *Atlas of Tidal Restrictions on the South Shore of Massachusetts* (2001) was prepared by the Metropolitan Area Planning Council and funded by the Executive Office of Environmental Affairs Massachusetts Wetlands Restoration Program. The Atlas "identifies, inventories, and prioritizes Massachusetts South Shore tidal restrictions that may adversely impact upstream tidal wetlands". All three of these tidal restrictions – tide gate on Tussock Brook, dam on Stony Brook, and the bridge at Landing Road and their associated marshes are identified in the Atlas.

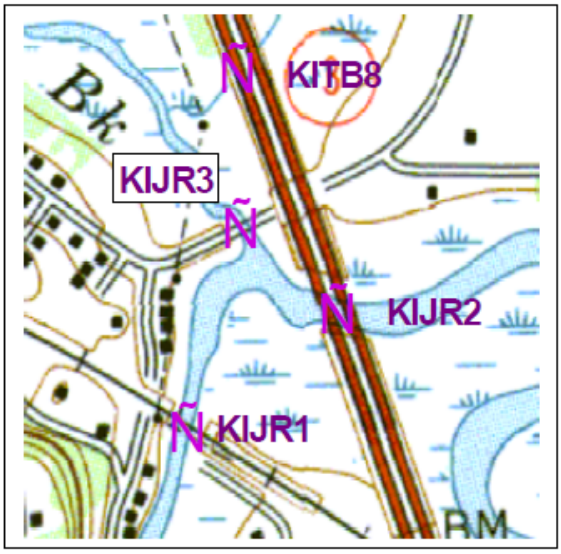
2.4.1 Landing Road Culvert

The bridge and culvert to pass Landing Road over Stony Brook were built in 1954. The Tidal Atlas identifies the culvert under Landing Road as KIJR 3. Figure 7 is an excerpt from the Tidal Atlas that describes the current conditions and potential remediation approaches. Figures 8 & 9 show photos of the upstream and downstream sides of the Landing Road culvert. The Tidal Atlas rates the Landing Road Culvert as a high priority for restoration efforts based on an area of impact (>20 acres), presence of anadromous fish, and potential upstream benefits (Figure 23). However, the Atlas rates the feasibility of restoration here as "low". This presumably based on the good condition of the present culvert and costs associated with expanding its size.

KINGSTON: Landing Road

Tidal Restriction Site KIJR 3

(See Town Overview Map for location)



Site Description

KIJR 3 is a box culvert under Loring Road at the confluence of Halls Brook and the Jones River. The culvert presently restricts the natural flow to Halls Brook and Tussock Brook. The roadway area and adjacent marina flood regularly during storm events and some astronomically high tides.
The upstream area is greatly impacted by *Phragmites* due to poor flushing and large amounts of fresh water input due to stormwater runoff.

Site Remediation

Potential remediation measures for this site could include:

- Enlarge the opening under Loring Road. Replacing the box culvert with a larger size culvert or a small bridge instead of a culvert would provide a much greater rate of flushing than is presently available. Further study of the upstream impacts of any increased flow to Halls Brook and Tussock Brook would need to be done

Site Summary

- Type of restriction: box culvert
- Culvert condition: good
- Culvert material: concrete
- Culvert size: 6' x 22' x 42'
- Wetland area size: 30+ acres

Figure 7. Atlas of Tidal Restrictions Description of Landing Road Bridge/Culvert

Figure 8. Culvert Under Landing Road (KIJR3) Looking Downstream

Figure 9. Culvert Under Landing Road (KIJR3) Upstream

2.4.2 Tussock Brook Tide Gate

Route 3 and the culvert passing Tussock Brook were built in 1954. Figure 10 shows a detail of the highway construction plans (MA Bridge No K-1-13, 1954). The detail shows the relocation of Tussock Brook as part of the highway construction. Based on these plans it appears that the brook was greatly reduced in width and that a significant meander was removed in order to channelize it through the culvert. The culvert is 145 ft long, 10 ft wide and 13 ft high.

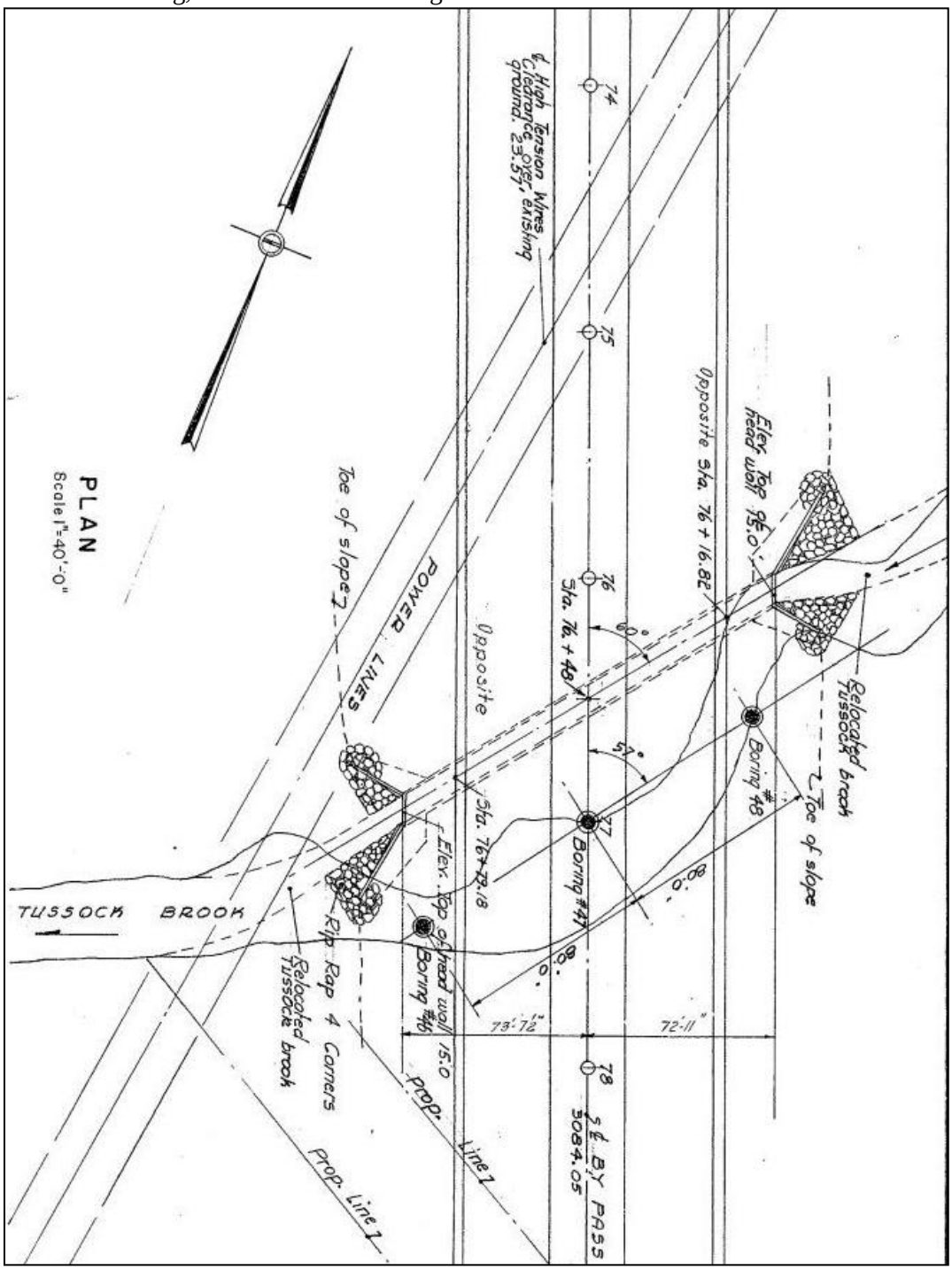


Figure 10. Highway Plan Detail Showing Relocation of Tussock Brook.

While the highway plans from 1954 provide precise details of the culvert construction they include no mention of the tide gate. We have been unable to find plans, records, permits, or any other mention of the installation of this structure. The Tidal Atlas identifies the culvert and tide gate on Tussock Brook as KITB 8. The Tidal Atlas rates the Tussock Brook gate as a high priority with high feasibility for restoration efforts based on an area of impact (>20 acres), potential for anadromous fish, and potential upstream benefits (Figure 23). Figure 11 is an excerpt from the Tidal Atlas that describes the current conditions and potential remediation approaches. Figure 12 - Figure 15 show photos of the upstream and downstream sides and inside of the culvert. The Tidal Atlas describes the structure as a "dam". It is not clear if this refers to the sill at the bottom of the culvert that serves as low (1-2 ft) dam or the "flapper" style tide gate. The significance of this description is important to understanding the design and function of this structure in several ways:

1. The gate is designed to pass water *under* the structure rather than *over* the structure.
2. The gate is designed to restrict the flow of water movement *upstream* rather than restricting *downstream* movement.
3. The gate does not serve any of the functions typically associated with a dam – water storage, power, etc.

Despite the semantics of "dam" versus "tide gate" the Tidal Atlas accurately describes the impacts of the structure on the physical and biological components of the system. Anadromous and resident fish species are certainly constrained in their passage by this structure. Tidal exchange is impacted in terms of extent, timing, and quality (see Section 2.7.1). There are other impacts not listed in Atlas. Natural sediment movement within the Tussock Brook system is greatly impaired by the tide gate structure. As seen is Figure 12 a large sediment delta has formed on the downstream side of the structure. Although it is difficult to see, Figure 15 also reveals a large sediment deposition area within the culvert near the downstream exit point. Adjacent to each of these areas of deposition are deep scour holes. Within the culvert there is a change of approximately 5 ft from the top of the deposited sediment to the bottom of the adjacent scour hole. Sediment transport and distribution is a critical aspect of healthy estuarine ecosystem function. Native salt marsh flora and fauna are highly sensitive to a delicate balance of organic sediment accretion and attrition.

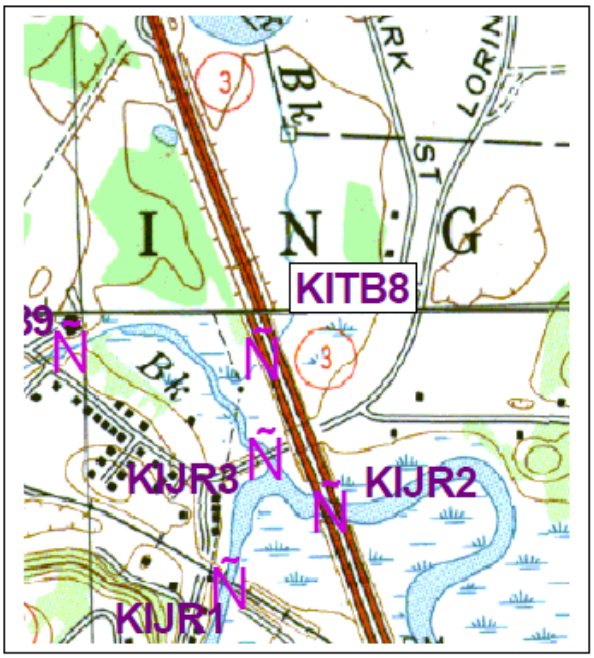
The tide gate and associated structures are in poor condition. The Tidal Atlas lists the condition as "good". However that assessment was conducted over a decade ago. Based on the access difficulties at Tussock Brook it is unlikely that the survey for the Atlas included an inspection of the interior of the culvert. During the project surveys the following notes were made about the condition of the tide gate and associated structures:

- The lower portion of the flapper gate is missing (Figure 13)
- The wood of the flapper is in very poor condition.
- There is an opening over the upper end of the gate. It is not clear if this was intended to be opened or closed. This is important to note since at the upper end of spring tides water passes over the top of the gate and into the upstream channel. This is counter the typical purpose of tide gates that are generally intended to keep extreme flooding events out of upper reaches. Figures 16 - 18 show spring tides at either end of the gate and into the upstream marsh. This is discussed further in Section 2.7.2.
- It is unlikely that the flapper is functioning as intended. Rusted hinges and waterlogged boards likely reduce the extent to which the gate can open on outgoing tides.
- There is steel sheeting covering the interior walls of the culvert as well as the wing walls on both the upstream and downstream sides. The steel is in very poor condition. It shows significant rust and flaking throughout and is detached from the concrete walls in a number of places.
- There has been significant separation of many of the concrete joints along the wing walls and headwalls.

KINGSTON: Tussock Brook

Tidal Restriction Site KITB 8

(See Town Overview Map for location)



Site Description

Tussock Brook is restricted as Route 3 South crosses over it. The foundation of Route 3 South is actually a dike across the marshes of the Jones River. The major restriction point is the box culvert under the roadway, however there is also a dam in the box culvert that further restricts water flow, and impedes the passage of anadromous fish. Access to this site is very difficult due to Route 3 and the surrounding marshes. The area is rich in wildlife with deer, raccoon and abundant bird life, all seen during the site visit.

Site Remediation

Potential remediation measures for this site could include:

- The removal of the dam at site KITB 8 could increase tidal flow to the upstream salt marsh. This could also benefit the spawning anadromous fish that use the stream, allowing an increased number of fish to pass upstream.

Site Summary

- Culvert condition: good
- Culvert material: concrete
- Culvert size: unknown (not accessible)
- Length of culvert: +/- 100'
- Area affected: 20+ acres

(No site pictures available)

Figure 11. Atlas of Tidal Restrictions Description of the Tussock Brook Tide Gate

Figure 12. Tussock Brook tide Gate (KITB8). Looking Upstream at Low Tide.

Figure 13. View of Tide Gate and "Sill" at Entrance

Figure 14. View of Upstream End of Tide Gate. Looking Downstream at Low Tide.

Figure 15. Inside of Tussock Brook Culvert Looking Downstream

Figure 16. Spring Tide Passing Over the Downstream Side of the Tide Gate

Figure 17. Spring Tide Coming Through the Upstream Side of the Tide Gate

Figure 18. Spring Tide Flooding the Tussock Brook Marsh Above the Tide Gate.

2.4.3 Stony Brook Dam

The Tidal Atlas identifies the dam on Stony Brook (referred to as Halls Brook) as KIHB 9. Figure 19 is an excerpt from the Tidal Atlas that describes the current conditions and potential remediation approaches. The Tidal Atlas rates the Tussock Brook gate as a high priority with high feasibility for restoration efforts based on an area of impact (>20 acres), potential for anadromous fish, and potential upstream benefits (Figure 23). The Stony Brook Dam is located on a 10.35 acre property at 20 Maple St, Kingston, MA. The dam is composed of an earth embankment and stone spillway (Figure 20). There is an adjacent headrace with dry stone masonry faces and a six- to eight-foot wide crest. The 300-foot long embankment is up to nine feet high. A series of dams, flumes, and related structures have been in place at the site since the 17th century (see Section 2.9). The existing dam was likely built in the 19th century with more modern components and repairs added. The dam does not have a current industrial use.

In 2004 American Rivers and the MA Riverways Program contracted a dam engineering specialist (Jim MacBroom) to conduct a reconnaissance survey and inspection of the site. Both MacBroom and the Tidal Atlas survey of 2001 rate the dam as in fair condition. MacBroom observed the spillway to be in “poor condition and could fail at any time.” The spillway has significant deterioration with displaced rock, one key stone being held in place only by a downstream tree. A concrete lined raceway to a former mill is located at the left (facing downstream) abutment. The allowable head is five feet. Tenants of the building had pulled boards from the six-foot wide stone spillway to relieve pressure on the failing sluiceboard frame. The upstream face along the pool has extensive tree and shrub growth plus displacement of the stone wave protection. The spillway is spanned by a footbridge in very poor condition.

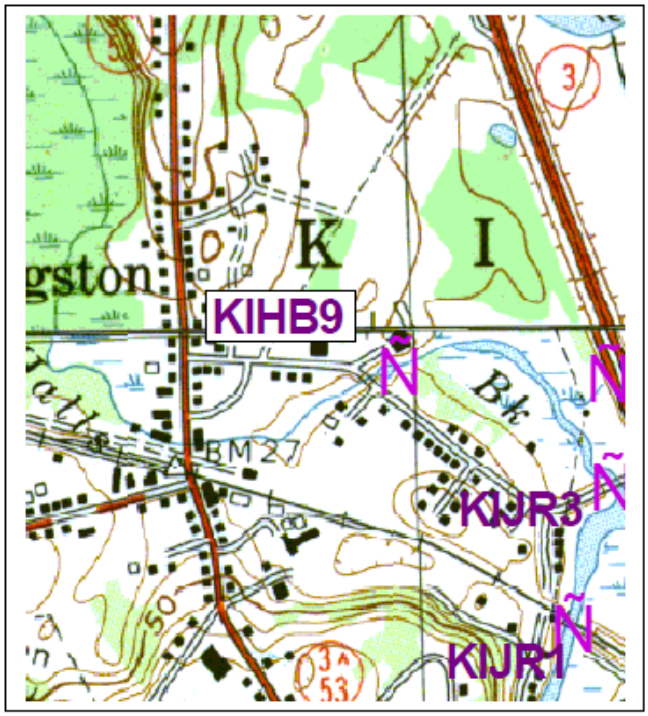
The pool above the dam is roughly square in shape, bordered by the dam on the south and east, by Maple Street on the west, and a driveway and retaining wall on the north (Figure 18). The ±1-acre pool is almost completely full of sediment with observed water depths of only one to two feet. The shallow water covered sediments support rooted aquatic plants, including wild rice and cattail. The dam is judged to be in the "small" category with a "low" hazard risk simply because there is little water volume. However, if the pool were to be dredged and its full depth and volume restored, it is possible that the hazard class could rise due to the mill building.

Upstream fish passage is completely blocked by the dam. Downstream fish passage over the spillway is challenging. The vertical drop terminates on exposed rocks without a scour pool or tailwater. Above the dam the next structure is the culvert under Maple Street. JRWA recently worked with the Town of Kingston to install a properly sized box culvert that would allow fish passage rather than a small pipe.

KINGSTON: Halls Brook

Tidal Restriction Site KIHB 9

(See Town Overview Map for location)



Site Description

The restriction at Site KIHB 9 consists of a channeled stream and a dam. The dam forms a small millpond. The tidal creek is called Halls Brook on the USGS maps but is known locally as Stony Brook. The Massachusetts Archives map # 1235 shows the site as that of a gristmill in 1795 (the name on the historic map is Stony Brook). KIHB 9 is upstream of KIJR 3, which is the key downstream restriction in the area.

Site Remediation

Potential site remediation measures could include:

- Increase the size of the box culvert under Landing Road, which would restore greater tidal flow and benefit salt marsh vegetation upstream of the site.
- The addition of a fish ladder or removal of the dam, which would enhance the stream's potential for use by anadromous fish.
- Redirect stormwater runoff away from the wetlands, which would reduce the input of fresh water and assist in the control of the *Phragmites* problem.

Site Summary

- Channel condition: needs cleaning
- Channeled streamlet size: 9' x 4' x +300'
- Dam condition: fair
- Spillway condition: needs maintenance
- Dam material: stacked granite block & boulders
- Dam size: 200' x 11'
- Dam spillway: 6'
- Wetland area affected: 2-3 acres

Figure 19. Atlas of Tidal Restrictions Description of the Stony Brook Dam

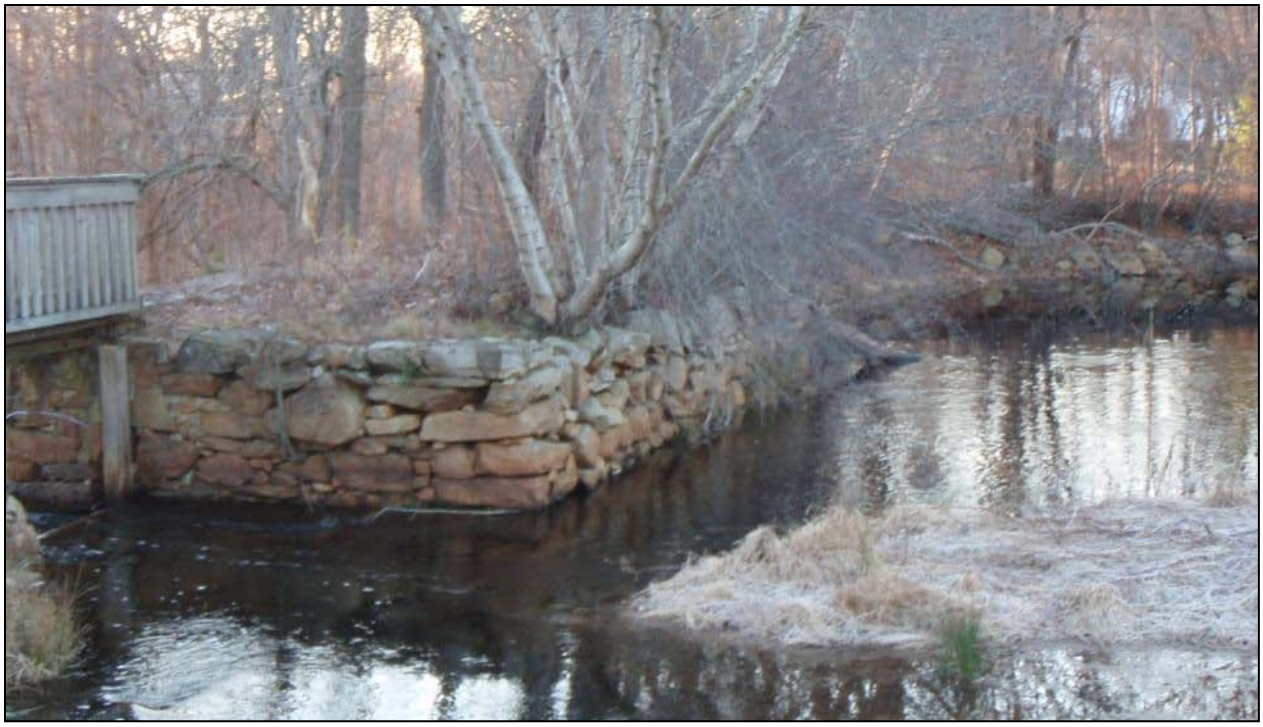


Figure 20. Stony Brook Dam (Sluice at left).

Figure 21. Stony Brook Dam Sluice (boards removed)

Figure 22. Stony Brook Impoundment (Bing Maps)

TABLE 3 – Summary of Tidal Restriction Site Restoration Prioritization (Page 3 of 5)
(see page 9 for description of prioritization methodology)

Site #	Priority Code	Community	Subwatershed Name	Affected Area	Anadromous Fishway	Contiguous Open Space	Shellfish Area	Flood Structure	ACEC	Potential Upstream Benefits	Feasibility
KIJR1	Low	Kingston	Jones River	<5 acres	Y	N	N	N	N	Y	L
KIJR2	Low	Kingston	Jones River	<5 acres	Y	N	N	N	N	Y	L
KIJR3	High	Kingston	Jones River	> 20 acres	Y	N	N	N	N	Y	L
KIJR4	Med	Kingston	Jones River	<5 acres	Y	N	N	N	N	Y	M
KIJR5	Med	Kingston	Jones River	<5 acres	N	Y	N	N	N	Y	M
KIJR6	Low	Kingston	Jones River	<1 acre	N	Y	N	N	N	Y	L
KIJR7	Low	Kingston	Jones River	<1 acre	Y	N	N	N	N	Y	L
KITB8	High	Kingston	Tussock Brook	>20 acres	potential	Y	N	Y	N	Y	H
KIHB9	High	Kingston	Halls Brook	> 20 acres	potential	N	N	N	N	Y	H
MAGH3	High	Marshfield	Green Harbor	3-5acres	N	Y	N	N	N	Y	H
MAGH4A	High	Marshfield	Green Harbor	10-15 acres	N	Y	N	Y	N	Y	H
MAGH4B	High	Marshfield	Green Harbor	10-15 acres	N	Y	N	Y	N	Y	H
MAGH4C	Low	Marshfield	Green Harbor	<2 acres	N	Y	N	N	N	N	L
MAGH5	Med	Marshfield	Green Harbor	5-10 acres	N	Y	N	N	N	Y	H
MANR6	Med	Marshfield	North River	>50 acres	Y	N	Y	N	N	Y	M
MASR8	Low	Marshfield	South River	<1 acre	N	N	Y	N	N	Y	L
MASR9	Low	Marshfield	South River	1-2 acres	N	N	N	N	N	N	L
MASR10	Low	Marshfield	South River	<1 acre	N	Y	N	N	N	N	M
MASR12	Low	Marshfield	South River	2-3 acres	Y	Y	N	N	N	Y	L
MASR13	Low	Marshfield	South River	<1 acre	Y	N	N	N	N	Y	L
MASR15	Low	Marshfield	South River	<1 acre	Y	Y	N	N	N	N	L
MASR16	High	Marshfield	South River	5-10 acres	N	N	N	Y	N	Y	H

Atlas of Tidal Restrictions on the South Shore of Massachusetts 17

Figure 23. Atlas of Tidal Restrictions Prioritization of the Three Structures

2.5 Habitat Evaluations

MarineFisheries has been tracking smelt (*Osmerus mordax*) in the Jones River since at least the early 1970's (Reback and DiCarlo 1972) and has considered the Jones to be one of the largest smelt runs in Massachusetts. A more recent *MarineFisheries* study (Chase 2006) focused directly on habitat suitability and population estimates of smelt in a few of the larger Massachusetts runs. The following are direct excerpts from Chase 2006 in regards to the project area:

> *Four tributaries to the Jones River also contained known smelt spawning habitat. Halls Brook joins the Jones River estuary on the north side of the river slightly west*
>
> ***Halls Brook.*** *Halls Brook (also called Stoney Brook) flows from Blackwater Pond through a Mill Pond to meet the main stem Jones River in the estuary west of Rt. 3. A dam at the Mill Pond prevents upstream passage. Smelt eggs were found from the base of the dam downstream for 66 m to the intertidal marsh. The substrate area of spawning habitat was 260 m2. This stretch had suitable depth, flow and substrate for smelt spawning habitat, and moderate to high densities of smelt eggs were observed here in 1995. This brook was not monitored routinely; however, smelt eggs were seen during four visits from April 17th through May 18th at densities that exceeded those seen at Smelt Brook. Two discharge measurements were taken at Halls Brook: 0.274 m3/s on May 2nd and 0.199 m3/s on May 18th. Although the area of spawning habitat was less at Halls Brook than Smelt Brook, there was higher quality habitat, and the discharge was larger. A full season of monitoring would have been appropriate for this brook.*
>
> *The tributaries to the Jones River continue to attract spawning adult smelt. Halls Brook and Smelt Brook feed directly to the Jones River estuary and probably receive annual recruitment from smelt hatched in the main stem. Viewing the geography of the region, it is likely that all the smelt runs (including Island Creek, Town Brook, and Eel River) within the coastal embayment of Duxbury Bay, Kingston Bay and Plymouth Harbor receive recruitment from the main stem spawning habitat. Despite the small size of the Halls Brook, the spawning habitat is very suitable for smelt, and relatively large numbers of eggs were seen in 1995.*
>
> ***Halls Brook Riparian Buffer.*** *The former mill property along the smelt spawning habitat in Halls Brook does not offer sufficient canopy or riparian buffer to provide shading and erosion protection. It is recommended that the riparian bank on that side of Hall Brook be landscaped to improve shading and erosion control along the spawning habitat.*

The 2006 Chase report also contains several tables that provide details on the extent and quality of spawning habitat in the study sites. For Halls/Stony Brook: length and area of spawning habitat where smelt egg deposition was observed were 66m and 260m^2 respectively. Discharge was measured at 0.237m^3/s, and the drainage area is 10.3 km^2. In terms of habitat quality river segments were scored based on sediment, eutrophication, passage, channel flow, storm, tidal, buffer, and acidity. Stony Brook scored 5th highest in quality out of 42 spawning areas assessed in the study. The poorest scoring categories for Stony Brook were fish passage and acidity.

2.6 Wetlands

On August 23, 2011 a wetland delineation and wetland field assessment was conducted in the study area. The Survey was conducted by Joseph Grady (Duxbury Conservation Agent) and Alex Mansfield (JRWA). Vegetation, soils and hydrology were evaluated in the field to identify wetland resources located within the defined project limits and then the upper boundaries of wetland resources were flagged in the field. On November 18th wetland flag locations were surveyed using a Leica Smart Rover Real

Time Kinematic Global Positioning System (RTK GPS). Field survey reports were compared against the Natural Resources Conservation Service (NRCS) web Soil Survey (WSS) database and the National Wetlands Inventory (NWI) operated by the U.S. Fish and Wildlife Service (USFWS). Field results correlated very well with these existing data sets. Figure 24 - Figure 26 show the wetland type and soil inventory for the project area. Figure 27 - Figure 30 are photos of representative portions of the project area.

Tussock Brook

Wetland vegetation on the east side of Route 3 (i.e. upstream of the tide gate) consists of a mix of tidal and brackish communities. Expansive monotypic communities of *Phragmites australis* have outcompeted native communities throughout nearly all of the wetlands. In portions of the upper reaches pockets of cattails (*Typha spp.*) are interspersed with the *Phragmites*. Very few, if any, estuarine marsh species (e.g. *Spartina sp.*) were observed upstream of the tide gate. Towards the upper reaches of Tussock Brook the vegetation transitions from brackish marsh to palustrine shrub swamp mixed with rushes and grasses. Wetland areas transition quickly over to a forest woodland community of pine, Eastern red cedar (*Juniper virginiana*), Atlantic white cedar (*Chamaecyparis thyoides*), and intermittent deciduous trees (primarily Oak) with an understory dominated by common greenbriar (*Smilax rotundifolia*). This transition takes place around the mapped borders of the wetland as well as on a few “islands” with the marsh. The western edge of the wetland is sharply defined by a manmade, stone-lined channel and the steep forested bank of the elevated highway (Route 3). At the northern end of the project area there is a rapid grade change of approximately 15 ft where a manmade berm creates a pond from the Tussock Brook headwater. Additional wetlands exist in and around the pond but were not targeted as part of this survey.

Stony Brook

The wetland communities on the west side of Route 3 are also dominated by a near monotypic community of *Phragmites australis*. However, small appearances of salt marsh cordgrass (*Spartina alterniflora*) and salt marsh hay (*Spartina patens*) are interspersed throughout the marsh. As on the east side, the wetland border is fairly well-defined and transitions quickly to the forested woodland community described above. The eastern edge of the wetland is sharply defined by the steep forested bank of the elevated highway (Route 3).

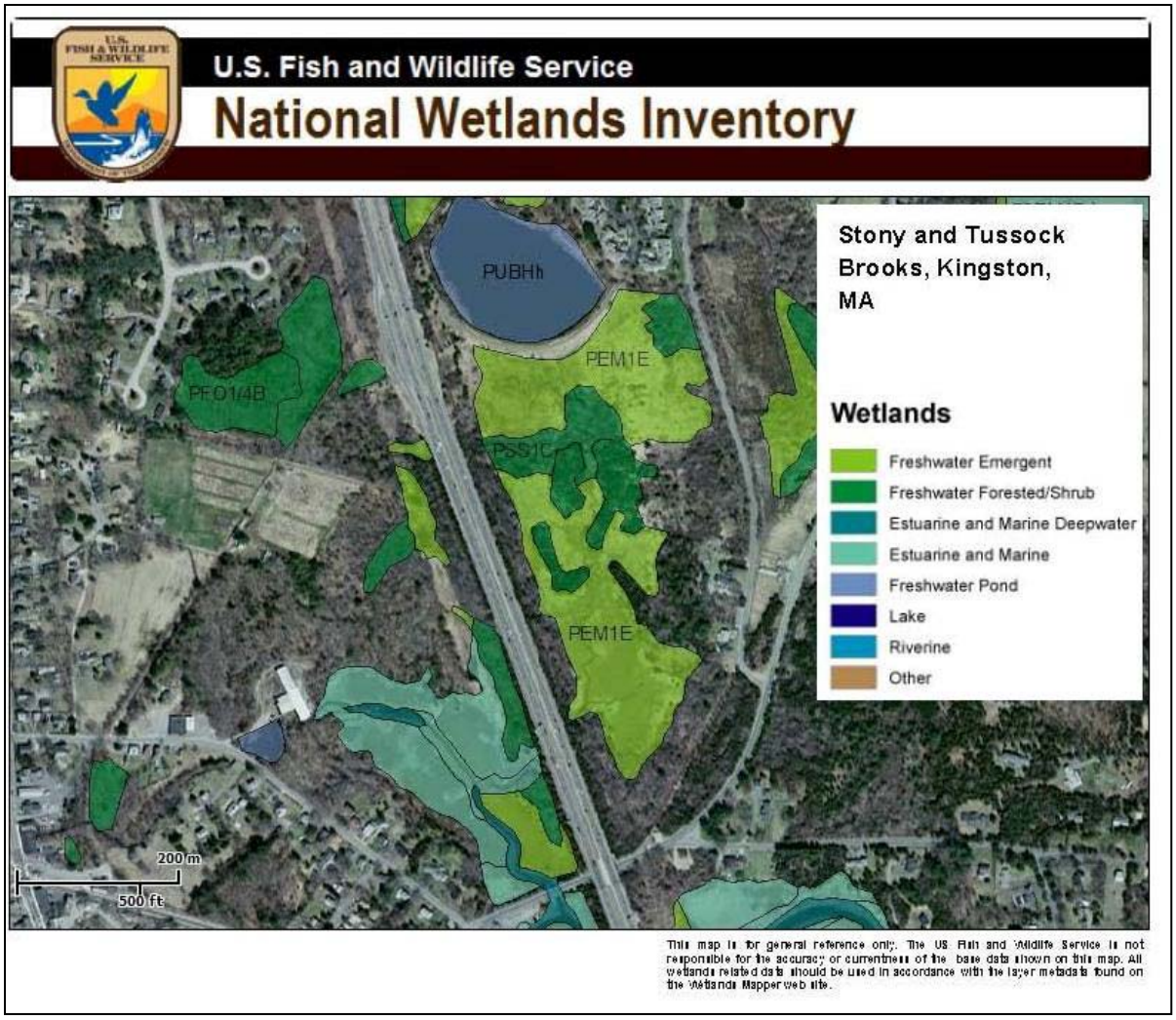


Figure 24. Wetlands Inventory From USFWS (Consistent With Results of 2011 Field Survey)

Figure 25. Soil Map of Project Area (USDA, Consistent With 2011 Survey). Legend in Figure 26.

Plymouth County, Massachusetts (MA023)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Water	2.1	1.5%
9A	Birdsall silt loam, 0 to 3 percent slopes	11.1	7.7%
30A	Raynham silt loam, 0 to 3 percent slopes	16.0	11.2%
37A	Massasoit - Mashpee complex, 0 to 3 percent slopes	8.9	6.2%
49A	Norwell mucky fine sandy loam, 0 to 3 percent slopes, extremely stony	17.6	12.3%
66A	Ipswich - Pawcatuck - Matunuck complex, 0 to 1 percent slopes	21.5	15.0%
69A	Mattapoisett loamy sand, 0 to 3 percent slopes, extremely stony	3.3	2.3%
200A	Squamscott fine sandy loam, 0 to 3 percent slopes	1.5	1.1%
223A	Scio very fine sandy loam, 0 to 3 percent slopes	14.8	10.3%
252B	Carver coarse sand, 3 to 8 percent slopes	8.8	6.1%
252C	Carver coarse sand, 8 to 15 percent slopes	0.0	0.0%
254B	Merrimac sandy loam, 3 to 8 percent slopes	2.5	1.7%
255B	Windsor loamy sand, 3 to 8 percent slopes	3.0	2.1%
256A	Deerfield fine sand, 0 to 3 percent slopes	1.4	1.0%
256B	Deerfield fine sand, 3 to 8 percent slopes	3.9	2.7%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	4.1	2.9%
276A	Ninigret fine sandy loam, 0 to 3 percent slopes	1.3	0.9%
320A	Birchwood sand, 0 to 3 percent slopes	7.7	5.4%
602B	Urban land, 0 to 8 percent slopes	2.6	1.8%
607	Water, saline	0.8	0.6%
608	Water, ocean	0.2	0.1%
656B	Udorthents - Urban land complex, 0 to 8 percent slopes	7.0	4.9%
657A	Aquepts, 0 to 3 percent slopes	1.4	1.0%
659B	Udorthents, 0 to 8 percent slopes, gravelly	0.1	0.1%
700A	Udipsamments, wet substratum, 0 to 3 percent slopes	1.6	1.1%
Totals for Area of Interest		**143.2**	**100.0%**

USDA **Natural Resources Conservation Service** Web Soil Survey National Cooperative Soil Survey

Figure 26. Soil Type Legend for Figure 25.

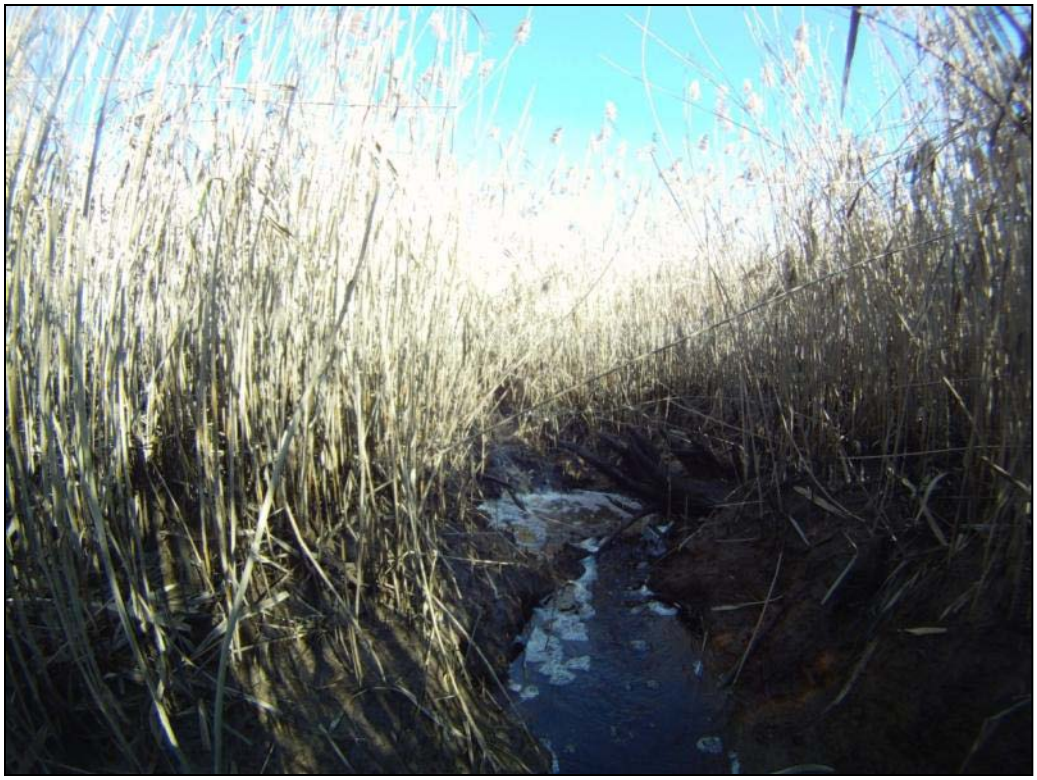


Figure 27. Typical of Tussock Brook, Dense *Phragmites* Surrounding Tidal Channel

Figure 28. Manmade Channels at the Toe of the Highway Embankment.

Figure 29. Red Cedar Stands at Wetland Borders and Islands.

Figure 30. Discharge Pipe from Manmade Headwater Pond to Upper Tussock Brook.

2.7 Tidal Inundation, Topography, and Elevation

In addition to the wetland delineation survey a focused topographic survey was conducted throughout the project area. Tidal fluctuation data were also collected in order to assess the current conditions in Tussock Brook. The purpose of these studies was to identify the extent of tidal fluctuation and inundation under current conditions and identify critical elevation points that would inform decision-making in terms of modifications to existing structures. In particular, a goal was to identify whether changes to the Tussock Brook tide gate would increase the risk of flooding at upstream properties. The data were collected in two phases:

2.7.1 Tidal Fluctuation Data

In 2010 JRWA and CZM installed four survey stations in the Jones River, Stony Brook, and Tussock Brook. At all four stations continuous water level data were collected. The data collection sondes were deployed for approximately six weeks, spanning a period of astronomically high spring tides. The primary goals of this data collection were to track tidal heights above and below the Tussock Brook tide gate during both typical and astronomically high tidal cycles in order to understand the functionality of the tide gate and the potential for flooding at upstream properties. As part of the topographic survey, the elevations of each of the data collection stations were surveyed using a Real-Time Kinematic (RTK) GPS system. The water level data were then corrected using the true elevation for each logging station.

Figure 31 shows the location and elevation of each of the four logging station. The stations are summarized in Table 1.

Table 1. Description and Elevation of Water Level Logging Stations.

Station	Elevation (NAVD 88)	Description
Jones River	-4.4	Mainstem. Baseline of (mostly) unrestricted tidal exchange
Stony Brook	-3.7	Confluence of Stony and Tussock Brooks
Tussock Brook	-2.0	Just upstream of tide gate. Shows direct influence of gate on tidal fluctuation
Parks Street Creek	NA*	Located at upper portion of Tussock Brook marsh in channel that drains from Parks Street and runs along the edge of upland on private property. Intended to show current extent of tidal influence and potential flooding of private property.

*Data from the Parks Street Creek station is not included in this plan.

Figure 32 shows the full two month corrected data set from the four water level logging stations. Significant features of the data set include:

- A major precipitation and flooding event was captured in late March 2010. This was the second of two major events in March 2010. The first event occurred just prior to installation of the loggers.
- Astronomically high tides around the full moon of April 28, 2010.

Both of these features represent typical high water conditions and were further evaluated.

Figure 31. Location of Water Level Logging Stations.

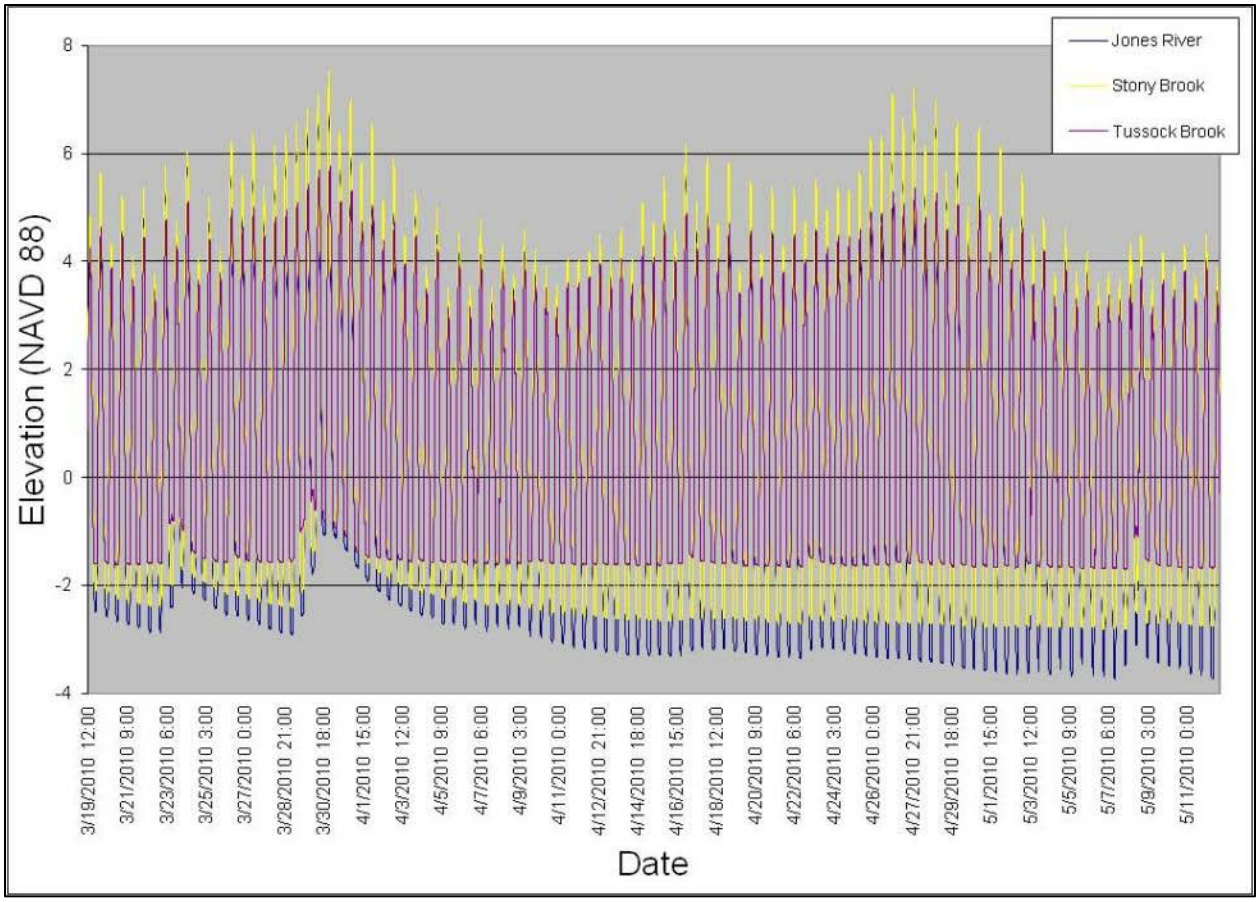


Figure 32. Water Level Data from the Logging Stations.

The extreme precipitation events in March 2010 resulted in increased freshwater flow through the Jones River and its tributaries. Figure 33 shows selected water level data from this time period. At each station the increased flow resulted in increased water elevations at both high and low tides. The amount of increase was proportional to the size of the system and watershed. The Jones River Station showed low tide water depth increases of as much as 2 ft, while the Tussock Brook station showed approximately a 1 ft increase and the Parks Street Creek showed an increase of approximately 0.5 ft (not shown). Increases in the high tide elevations (over tidal influence) as a result of the freshwater contribution were comparable to the low tide increases. In general the time of tidal fluctuations and freshwater influence were the same at all stations. There is a slight lag in time of peak tide at upstream stations (discussed in more detail below) but there does not appear to be significant blockage of the amount of tidal flow nor backwater on outgoing tides at upstream stations. The return to non-flood conditions occurred at nearly the same time at all of the stations.

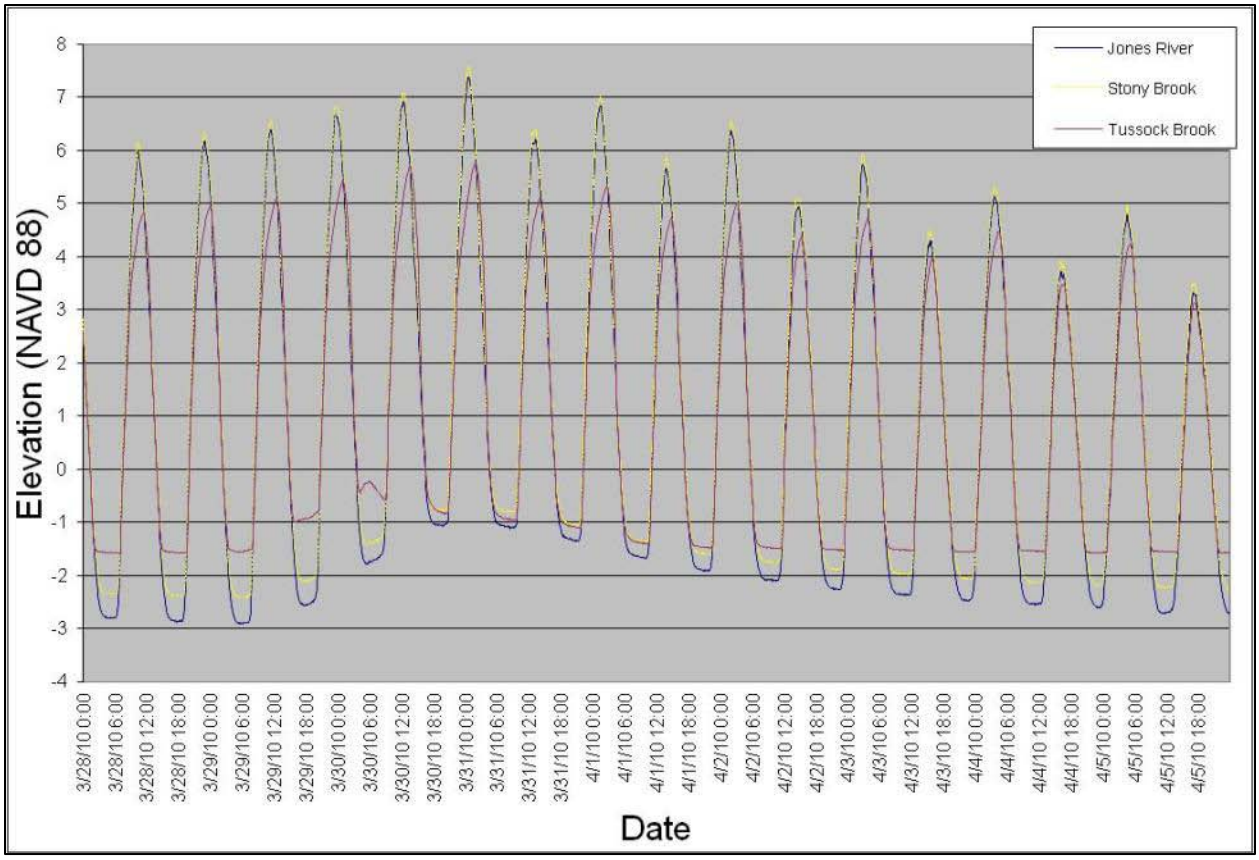


Figure 33. Water Levels During March 2010 Flood Event.

The astronomically high spring tides recorded during the survey (April 2010) provide a good measure of the extent of tidal intrusion to upper Tussock Brook marsh. Spring tides occur with each full and new moon and bring increased tidal range and increased tidal height. The spring tide period of the data record was used in this evaluation as an example of the higher end of typical conditions for tidal inundation. Figure 34 shows selected water level data from this time period.

At all each station the low water levels represent 100% freshwater flow with zero tidal influence. At each station the influence of each tidal cycle can be clearly seen and the high tide water elevations are higher for each station as compared to neap conditions. The dashed line in the center of Figure 34 is a visual aid to compare the timing of tidal cycles at the various stations. The Jones River and Stony Brook stations show nearly identical elevations and timing at the high tide. This suggests that there is virtually no influence of the Landing Road culvert on the tidal fluctuations in Stony Brook. There is a noticeable difference in both the timing and height of tides between Stony Brook and Tussock Brook upstream of the gate. The tide gate creates a lag in the upstream timing of the high tide. This lag begins to occur at approximately elevation 3.0 ft and does not appear at all during neap tide events. The gate also appears to reduce the height of the peak tides. As compared the Stony Brook, peak water elevations were as much as 1.7 ft lower just upstream of the tide gate on Tussock Brook. It appears that the lag occurs as the tide gate and culvert restricts volume from entering upstream areas and the elevation reduction occurs because the tide turns and begins dropping before the lagged elevation can catch up to the full height of the tide. The culvert itself would likely serve as a restriction to some extent but it is assumed that the gate is the primary driver in these upstream tidal features.

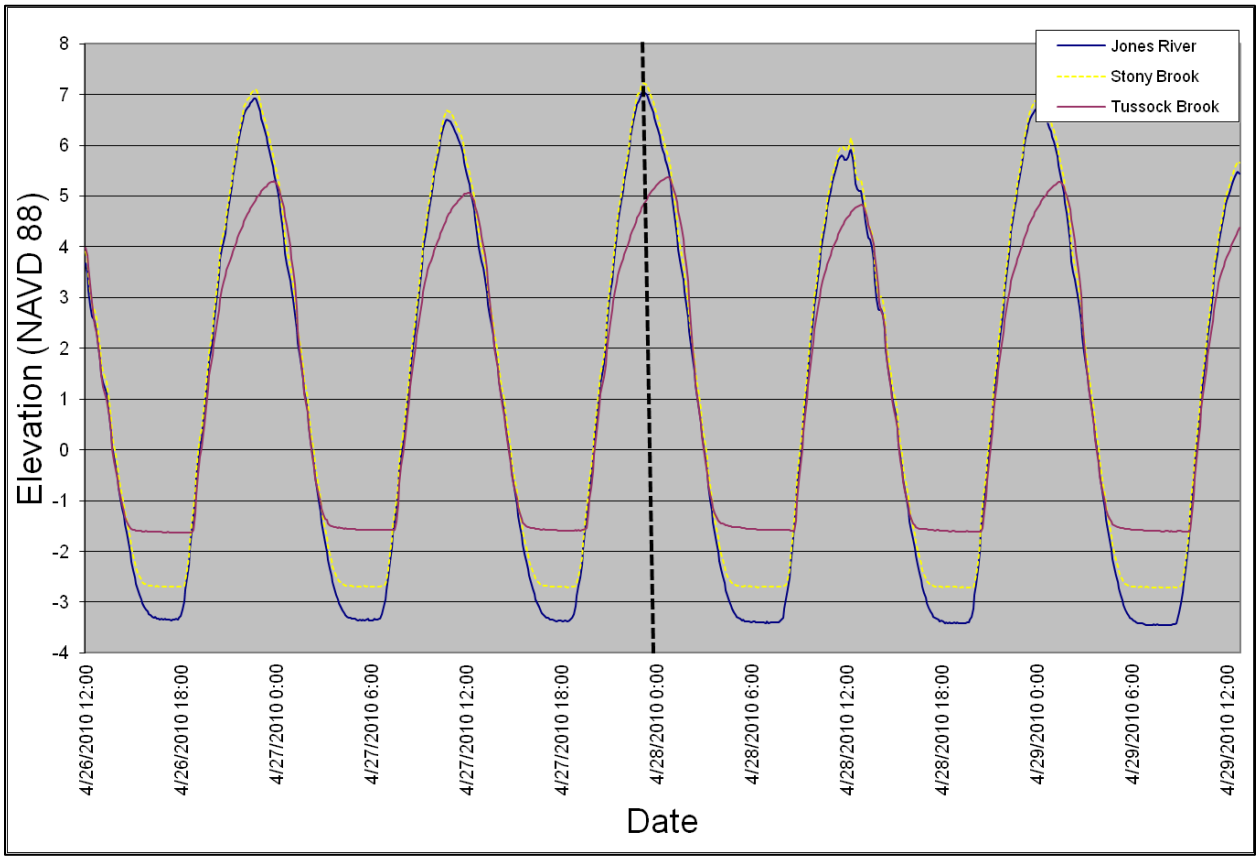


Figure 34. Water Levels During April 2010 Spring Tides.

2.7.2 Topography and Elevations

A RTK GPS system was used to conduct surveys throughout the project area. The land survey was focused on identifying elevations around private property where flooding could be a concern, and to identifying the potential horizontal extent of tidal inundation under a range of tidal conditions. Dense *Phragmites* stands in the area prevent full topographic coverage. However, target locations were selected to identify key elevations throughout the area. In general, periodic cross-sections across the upstream channels were conducted to identify stream channel bottom elevation and the elevations of both bank tops. Upland transects were conducted to identify elevations subject to normal and periodic flooding under existing and proposed conditions. The results of the survey are shown in Figure 35.

There was typical topographic variability and typical elevation increase with distance from the river channels. However, there were some notable results from the survey that relate to restoration planning. There were essentially three vertical zones to the overall topography:

- **Channels:** Center channel elevations were less than 0.0 ft (NAVD 88) throughout the entire area
- **Marsh Surface:** The marsh surface was hummocky but showed overall elevation consistency in a range of approximately 2.5-4.5 ft throughout.
- **Upland:** As described in Section 2.6 the wetland areas transitioned very quickly to upland. Upland elevations immediately adjacent to the marsh ranged from approximately 7.0-12.0 ft.

These results are highly informative when paired with the water level logging data. In the unimpeded areas of Stony Brook and the Jones River peak recorded water elevations were approximately 7.0 ft during both the flood event and the spring tides. This is below the level of the surrounding uplands of Tussock Brook. As a result it is assumed that unrestricted tidal exchange above Route 3 would be unlikely to result in flooding of the surrounding properties during typical spring tide cycles

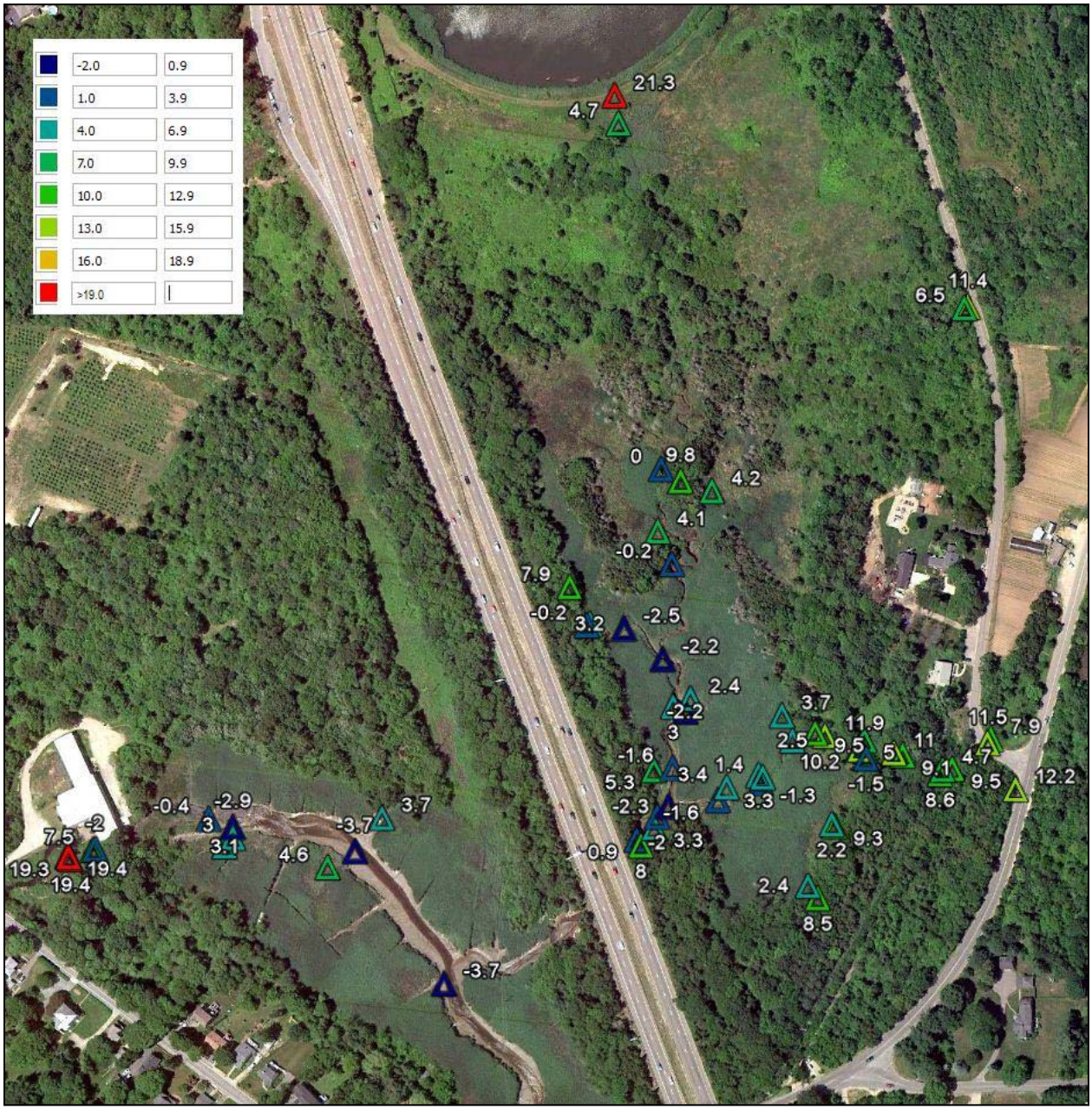


Figure 35. Results of Topographic Survey

2.8 Water Quality

A number of state agencies have conducted water quality sampling in the lower Jones. Massachusetts Department of Environmental Protection (DEP) 2010 Integrated List of Waters includes a listing of Jones River (9457650, segment MA94-14) as impaired for Pathogens (i.e. bacteria) and requiring a TMDL. *MarineFisheries* conducts periodic sampling in the lower Jones as part of their shellfish monitoring program. High bacteria counts in the lower Jones from *MarineFisheries'* sampling program have contributed to the long-term closure of shellfish beds in Kingston Bay. Recent infrastructure improvements in Duxbury and Kingston (i.e. stormwater, sewer) have improved conditions in the bay to some extent and new areas have been opened to commercial and recreational shellfishing. However, prohibited and conditionally approved areas are still present. As clearly seen in the *MarineFisheries* Designated Shellfish Growing Area map (Figure 37), restrictions are related to proximity to the mouth of the Jones River.

Until recently there have been limited water quality data available specifically for Stony Brook and Tussock Brook. In 2011 two bacterial tracking programs were initiated that worked in cooperation with the present restoration planning project. The first is the *Jones River Estuary and Kingston Bay Stormwater Assessment Project*. This project is also funded by the Massachusetts Bays Program and is the initial phase of a multi-phase endeavor that will establish baseline water quality conditions and develop preliminary design plans from which the Town of Kingston will prioritize and implement stormwater remediation projects. The ultimate goal is to open and/or improve shellfish growing areas in Kingston Bay (*MarineFisheries* growing area CCB43) encompassing 1,294 acres). The project conducted storm event sampling at a number of outfalls within the watershed to identify pollution sources. Figure 37 and Table 2 provide bacterial and Total Suspended Solid (TSS) data from the 2011 Kingston stormwater sampling program (excerpt taken from ATP 2011). The full data set is provided for relative comparison to the two stations of interest to this program: Maple St. and Parks Street. Both sites show fairly high levels of input. In particular, the Maple St. site is a large contributor of TSS. However, compared to the other sites sampled as part of the Kingston program they are not major contributors and do not rank as top priority for stormwater remediation.

A complementary program was initiated by DEP's Southeast Regional Office (SERO). Previous monitoring plans applied by the Division of Watershed Management (DWM) to evaluate surface water quality conditions in Massachusetts have often been found to be particularly unsuccessful in 1) identifying the specific locations of sources of bacterial contamination and 2) implementing follow-up actions for remediation. To begin to rectify this situation, a Bacteria Source Tracking (BST) program was initiated in 2006 in the southeast region. The overall goal of this program is to improve the water quality of rivers and streams in the southeast region that are impaired due to bacterial contamination. Steps towards achieving this goal will be made by locating sources of bacterial contamination within selected sub-watersheds and recommending appropriate action to initiate remediation. Table 3 provides data collected through this program in 2011. The full data set is provided for relative comparison to the stations of interest to this program. Samples collected just downstream of the Tussock Brook tide gate had by far the highest bacterial counts measured in the program. Peak *E. coli* reached 7,270 MPN/100ml in August year. Elevated levels were also measured in the lower portions of Stony (Halls) Brook and are presumed to be the result of contributions from Tussock Brook. Based on these elevated levels DEP decided to collect and analyze samples for Human Indicator bacteria. The results showed no evidence of human sources.

Results from the two sampling programs show elevated bacterial levels in both Stony and Tussock Brook. The negative results from the human indicator samples are first step in addressing potential sources. It is likely that bacterial contributions come from either wild or domestic animals in the Tussock Brook watershed. Further studies would be required to identify and mitigate actual sources.

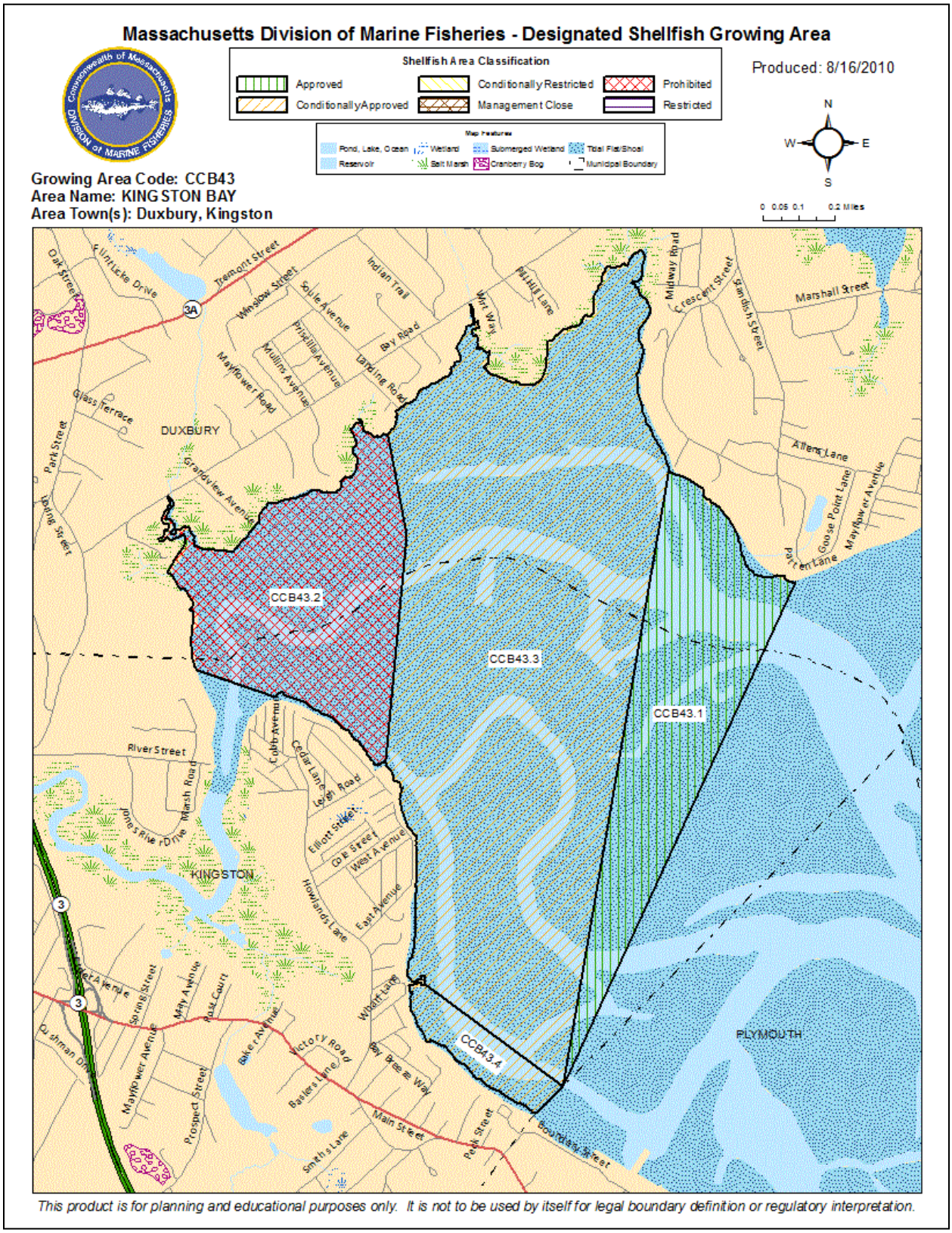


Figure 36. ***MarineFisheries*** **Designated Shellfish Growing Area for Kingston Bay**

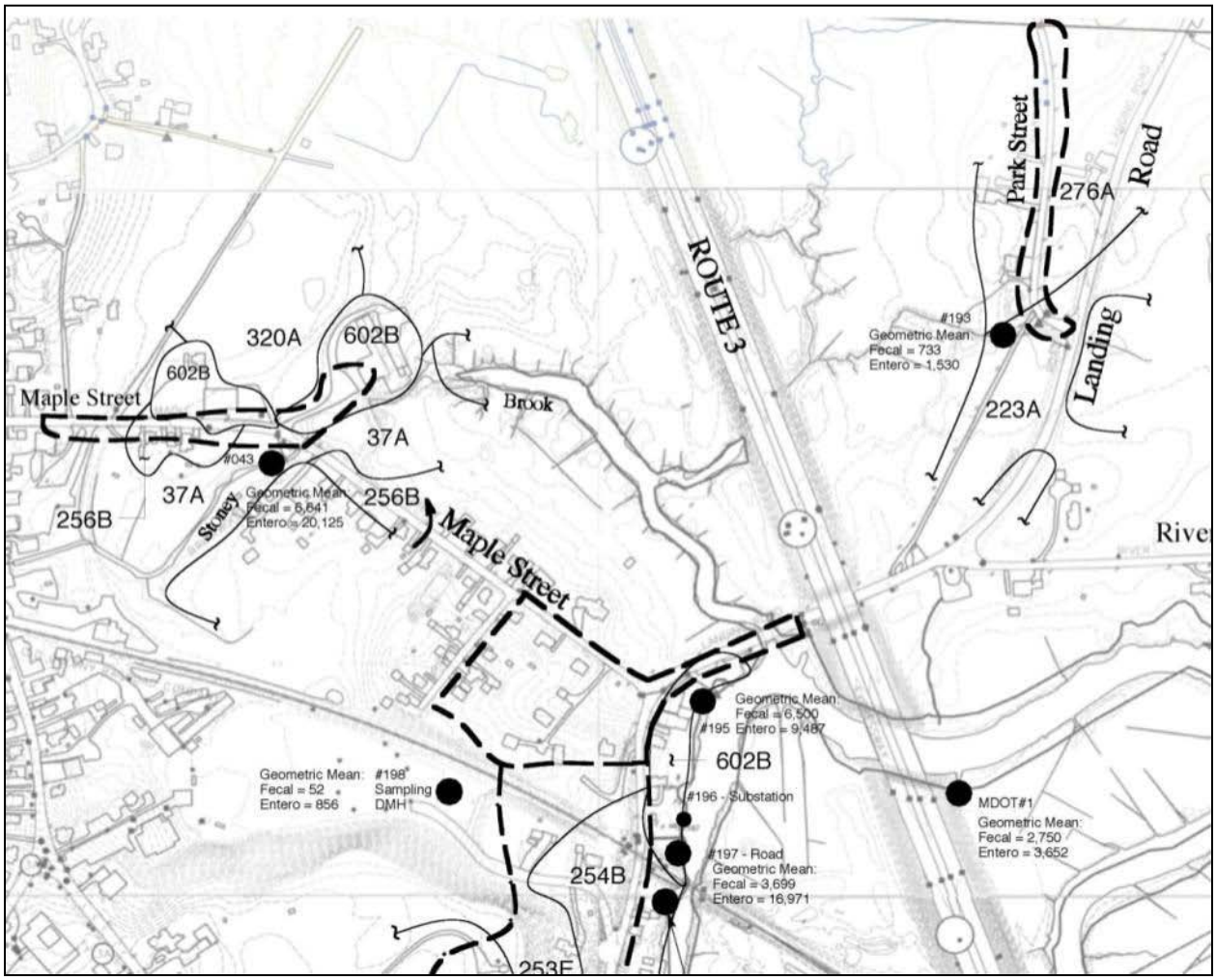


Figure 37. Excerpt of Town of Kingston Stormwater Sampling Results 2011 (ATP 2011)

Table 2. Mass Balance of Bacterial and TSS Contributions From Kingston Outfalls (ATP 2011)

x10^6	x10^6	x10^3	
Fecal Units	**Entero Units**	**TSS: mg**	**SAMPLE ID**
2,912	7,705	11,889	#59
6,039	18,249	7,309	Paved Swale #4
6,773	10,996	7,426	#041A
219	1,206	6,270	#041B
9,995	16,321	12,262	#041
530	5,381	1,980	#047
7,883	**25,193**	6,545	#047B
6,264	9,143	**22,166**	#195
2,520	11,563	4,770	#197
4,295	13,017	**21,345**	#043 (Maple Street)
330	689	7,655	#193 (Parks Street)
4,437	**49,311**	20,105	#051A

Table 3. Dry Weather Bacteria Data Jones River 2011 (DEP SERO-BST)

		6/28/2011	8/23/11	8/23/11	8/31/11	8/31/11
Station ID	DESCRIPTOR	**E.coli MPN/100ml**	**E.coli MPN/100ml**	**Enterococcus MPN/100ml**	**Enterococcus MPN/100ml**	**Human Marker Analysis**
JR01	Mainstem at harbor master dock at end of River Street, left bank	279	538	52		
JR02	Mainstem at Rt.3 crossing	292	2014	703		
JR03	At bottom of Halls Brook, approximately 30 ft upstream of confluence with Jones River and downstream of Landing Rd	213	2481	529		
JR04	Mainstem at railroad bridge	211	213	10		
JR05	Route 3A (Main Street) crossing	No sample	145	62		
JR06	Tussock Brook, downstream of tidegate and Rt.3	884	7270	3076	3200	Evidence of Human Sewage Source = **None**
JR07	Halls Brook, approximately 130ft downstream of Maple Street and downstream of dam, Kingston, MA	410.6	187	216		
JR08	Halls Brook approximately 90ft downstream of Rt.3A, at endwall	159.7	238	350		
JR09	Outlet from pond at headwaters of Tussock Brook	183	<10	10		
JR10	Smelt Brook, approximately 120ft downstream of Rt.3A	22.8	10	109		
JR11	At bottom of Smelt brook, just upstream of confluence with Jones River	No sample	243	10		
JR13	1st Brook, approximately 50ft downstream of Brook Street (Rt.80), Kingston, MA	No sample	41	259		
JR14	2nd Brook, approximately 25ft downstream of Brook Street (Rt.80	No sample	20	20		
JR15	3rd Brook, immediately downstream of Brook Street (Rt.80)	No sample	52	185		

2.9 Historic

Archaeologists have documented 12,000 years of pre-contact Native American occupation of the region. With easy access to plentiful resources (soils, wood, fish, etc) the Jones River drainage has been a focal point for human occupation. Isolated archeological find spots in the Kingston and Plymouth areas reveal evidence of at least some human presence as far back as the PaleoIndian Period (12,500–10,000 B.P.) and it has been suggested that this presence has been largely underestimated (Bradley and Boudreau, 2008).

The archeological evidence of human presence in Southeastern Massachusetts is spotty from the PaleoIndian Period through the Transitional Archaic Period (3600–2500 B.P.). However, by the Early Woodland Period (3000–1600 B.P.) human presence in the coastal zone of Plymouth County is well documented by archaeological finds. These sites are primarily located in estuarine settings surrounding the lower Jones River, Kingston Bay, and along the shores of Massachusetts Bay. The Bay Farm Site is a large site located immediately to the southeast of the project area and adjacent to Kingston Bay. The site has yielded a wide variety of projectile points diagnostic of the Middle Archaic, Late, Archaic, and Woodland Periods along with ground-stone tools, steatite, and pottery. A recent investigation conducted as part of the Kinston sewer project recovered Large Triangle/Levanna projectile points adjacent to Stony Brook in Kingston which establish a Late Woodland component at the site (Dudek 1999).

Throughout the “Contact Period” (450–300 B.P./A.D. 1500–1620) the presence of large populations of native people in Southeastern MA was well documented by European explorers and settlers including William Bradford, Thomas Morton, Samuel Champlain, and others. What would eventually become the Kingston area was inhabited by the native Wampanoags. Wampanoag populations at the time of European contact were concentrated around the Jones River and at Rocky Nook where they had a successful community based on hunting, gathering, and horticulture. Fish weirs were in use on the Jones River, attesting to the presence of a strong anadromous fish run. The coastal villages in the Kingston area were seasonal – being used in the summer to cultivate crops and harvest marine resources and the spring to exploit seasonal runs of anadromous fish. Contact came at a price for the native inhabitants. Disease and warfare devastated native populations. The survivors were dispersed throughout the region. A significant epidemic occurred from 1616–1617 that drastically reduced native populations. This reduction in native populations may have been a large reason for the selection and success of Plymouth by early settlers.

During the early settlement period (1620’s) many settlers left Plymouth for the productive agricultural lands of the lower Jones River. Throughout the Colonial Period most settlers in Kingston were involved in agriculture, animal husbandry, commercial fishing, and lumbering. Kingston continued to grow and by the mid-1700’s the town was a center for shipbuilding, iron production, and other industrial activity. Shipbuilding began with the establishment of two shipyards – one on Stony Brook and the second on Landing Road, both ca. 1713. The Town of Kingston is fortunate to have been the home of the passionate local historian and photographer Emily Fuller Drew. Drew wrote highly detailed histories about the industries of Kingston which naturally included chronicles of the various mills and other industrial uses of Kingston waterways. These accounts are critical to understanding human alterations to the natural environment as industries reshaped the river with dams, sluices, roads, etc. Included in Drew’s works are several descriptions of the industries along Stony Brook:

> *There was a sawmill here very early . . . The sawmill, which is mentioned in a deed of 1730, had been removed by 1746 when a group of Kingston men bought of John Brewster "innholder," the right to establish a gristmill on the site. The grist-mill served the community until about 1866, when it was removed by Caleb Bates to allow for the enlargement of the pond. The machinery was put in a building on the lower dam and continued to grind for many years longer. In 1805, the grist-mill and privilege and a blacksmith shop which had been built close by were bought by Seth Washburn and Deacon Seth Drew. They took into partnership Thomas Cushman and started*

> *the Stony Brook Iron Works, making augers and doing ships' blacksmithing in one building, and grinding corn in the other when there was grist to grind* (Bailey and Drew 1926).

The 1805 iron works started by Washburn and Drew were in large part created to serve the needs of the shipyard operated on Stony Brook by the Drews since about 1713 (MHC 1981). Even by 1875 the site had gone through a number of changes with buildings, dams, flumes, and other structures built, rebuilt, and moved:

> *The old buildings, the Stony Brook Iron Works, stood in the midst of what is now the pond, close to or on the present dam and not far from the present factory building. They were on an island formed by the natural stream and the flume leading to the new shop, and the foundations still show in the bottom of the pond when the water is low. They stood until Mr. Bates made extensive changes about 1875.* (Drew 1937)

The length of the industrial history at the site can be easily recognized when considering that the following statement was made nearly ninety years ago,

> "*Two hundred and more years of constant service is the story of the water privilege; one hundred and twenty-one years, the story of the Stony Brook iron works; eighty-nine years, the story of C. Drew & Company as a firm, the senior firm in the Town of Kingston today."* (Drew 1926)

In addition to historical buildings and industries the Stony Brook area was part of a well traveled route. Figure 38 shows a 17th century trail and road layout. The map includes the "Massachusetts path" which connected Kingston and Duxbury to Boston. It likely crossed the Stony Brook near the present site of the dam (Drew 1937, MHC 1981). The map also shows the location of an early shipyard and brickworks on Stony Brook.

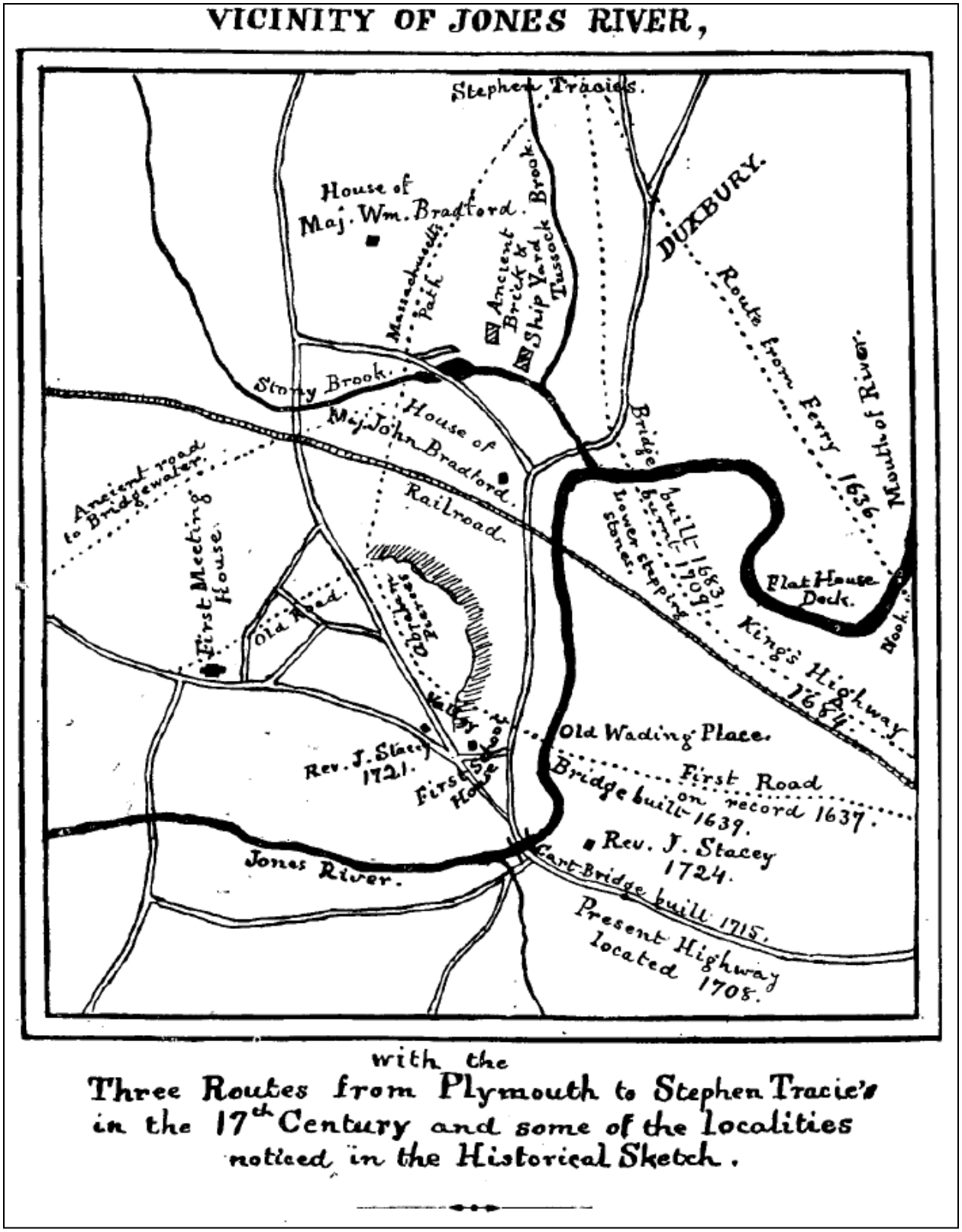


Figure 38. 17th Century Road Layout of Kingston with Notable Sites along Stony Brook (Drew 1876)

2.10 Property Ownership

Any restoration program must be sensitive to property ownerships and potential changes that will occur as a result of modifications. The first step for this program was identifying the property boundaries and ownerships in the immediate project area. Figure 39 shows the property boundaries in the project area (combined from Kingston assessors Maps 27, 28, 36 &37). There are 14 properties, owned by ten individual entities, which abut the project area including the Massachusetts Department of Transportation (DOT) ownership of Route 3. JRWA has compiled the names and addresses of all property owners (not included here). Some of the property owners were contacted throughout the development of this restoration plan.

In particular, JRWA met with the primary residential property owner on the upstream side of Tussock Brook on several occasions. The owner is supportive of the restoration project in concept as long as impacts to his property are avoided. The results of the surveys and data collection will be shared with this owner to explain the value of restoration and the limits of the potential impacts. JRWA has also worked closely with the property owner at Stony Brook dam. The dam owner is aware of the condition and associated liabilities of the dam. During previous plans for site development the owner was pursuing fish passage and river restoration options as part of the project. While development of the site has been indefinitely postponed JRWA feels that the property owner will continue to be amenable to river restoration at the site. JRWA has also spoken with MA DOT about the Tussock Brook tide gate. During these conversations MA DOT indicated that the department did not have any official plans or records of the tide gate. Conversations with agents of the Towns of Kingston and Duxbury also uncovered no plans of the tide gate. JRWA will continue to pursue information about the tide gate.

JRWA has met with the conservation agents of both the Towns of Kingston and Duxbury to discuss the restoration goals and potential in the project area. Both agents are highly supportive of the project as it suits towns' goals to improve water quality, protect wildlife habitats, and protect coastline. Several of the properties are owned as conservation land by non-profits (e.g. Boys & Girls Scouts) or are absentee owners. JRWA is preparing a letter that summarizes the results and goals of this project. The letter will be distributed to property owners with a request for input, partnership, and cooperation.

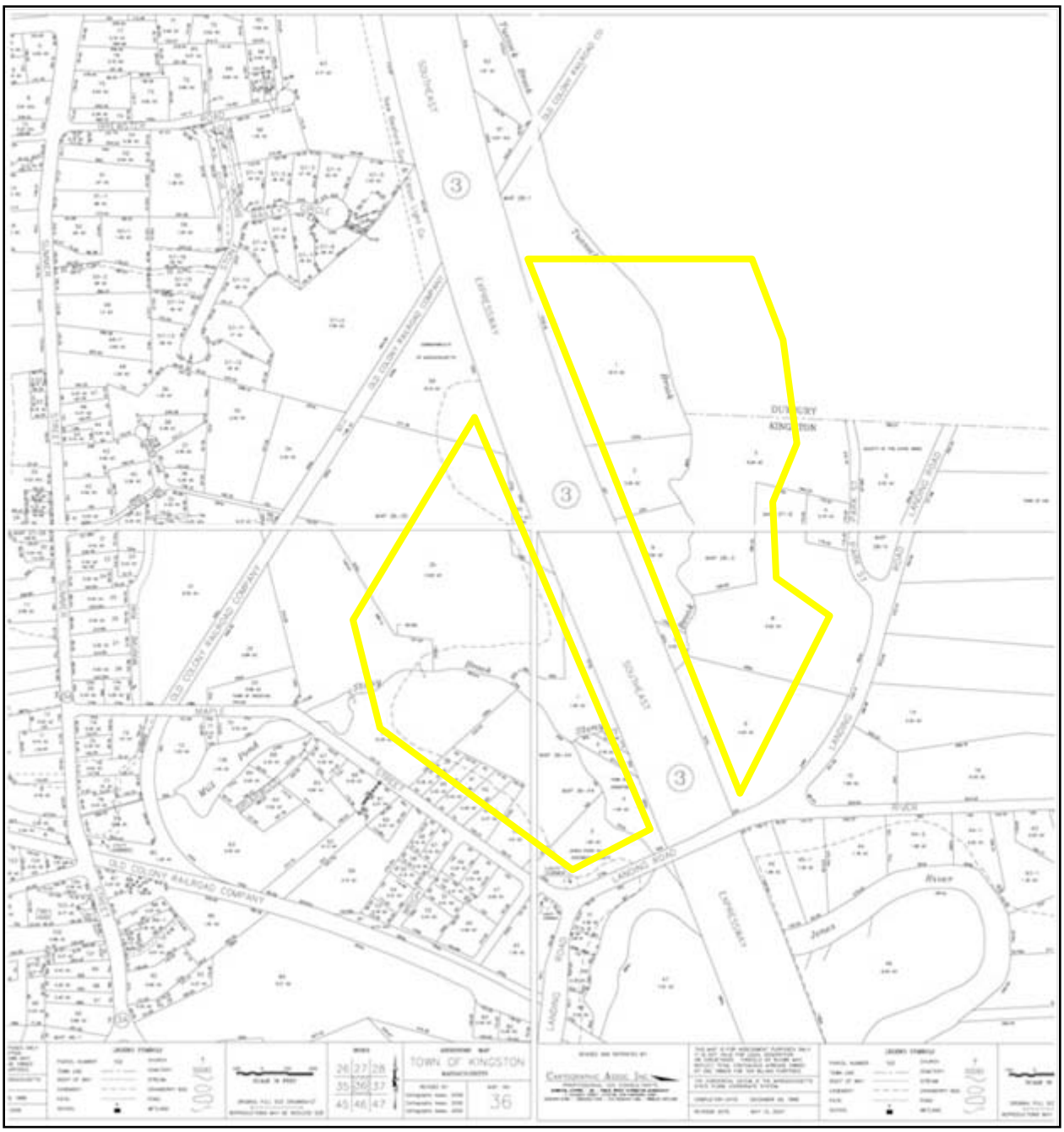


Figure 39. Property Boundaries in the Project Area (Kingston Maps 27, 28, 36, & 37)

3. RESTORATION GOALS

There are three primary restoration goals as part of this program: 1) improve habitat quality, 2) improve anadromous and native fish runs, and 3) improve water quality. These goals and the solutions required to achieve them are described in greater detail in the following sections

3.1 Habitat Quality

In both Stony and Tussock Brooks habitat quality has been significantly degraded by the presence of manmade structures and inputs. In both Stony Brook and Tussock Brook there is extensive monoculture of the invasive *Phragmites australis.* Restricted saltwater inputs, physical disturbance, and disruption of natural sediment transport pathways have all been implicated in *Phragmites* invasions. *Phragmites* stands provide poor habitat for birds and other wildlife, supporting low species diversity. Habitat degradation continues as natural sediment transport is disrupted by the dam, tide gate, and presence of *Phragmites.*

Upstream of the Stony Brook dam the impoundment has reached a near steady state of sediment deposition. Despite a 5-7 ft head height at the dam, the impoundment is generally less than 1 ft deep. Sediment accumulation is driven by both the presence of the dam and by high loading rates from stormwater outfalls on Maple St and route 3A in the town center. In warmer months nearly the entire impoundment is vegetated. High temperatures and low dissolved oxygen are typical of such impoundments. Habitat quality in the impoundment is low.

Restoration goals for habitat include:

- ☐ Stopping the further invasion of *Phragmites*
- ☐ Restoring natural plant communities
- ☐ Restoring connectivity throughout Stony and Tussock Brooks
- ☐ Allowing healthy natural habitat changes to occur over time (i.e. salt marsh migrations, climate change, sea level rise, etc)

3.2 Anadromous and Native Fish Runs

Although dams have been present on Stony Brook since the 17th century, full obstruction to fish passage may have occurred only recently. Configurations of the site prior to the 1970s appear to have provided passage. *MarineFisheries* has identified Stony Brook as a priority anadromous fish run. Herring and smelt presently spawn at the base of the dam for lack of access to better upstream spawning habitats. ; *MarineFisheries* has conducted spawning habitat assessments of Blackwater Pond at the headwater of Stony Brook and identified potential restoration targets for the anadromous run. Other anadromous and native fish such as American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*), tessellated darter (*Etheostoma olmstedi*), white perch (*Morone americana*), Atlantic tomcod (*Microgadus tomcod*), and others are known to inhabit the Jones River Estuary. Habitats in Stony Brook are discretely limited by the dam. Access to Tussock Brook is greatly reduced by the presence of the tide gate.

Restoration goals for fish runs include:

- ☐ Restoring connectivity throughout Stony and Tussock Brooks
- ☐ Providing access to suitable spawning habitats

3.3 Water Quality

Water quality is poor throughout the project area. Extremely high dry weather bacterial counts were found in both Tussock and Stony Brooks. Wet weather sampling revealed high levels of bacterial and TSS contributions from stormwater systems. Although it was not specifically monitored, the impoundment on Stony Brook is assumed to be typical of similar impoundments that usually have low dissolved oxygen and high temperature.

Restoration goals for water quality include:

- ☐ Reducing bacterial levels
- ☐ Improving sediment loading and transport
- ☐ Improving tidal exchange and flushing

4. RESTORATION SOLUTIONS

The majority of impairments described in Section 2 and all the restoration goals defined in Section 3 are closely linked to manmade features in the project area. The Stony Brook dam and Tussock Brook tide gate are the most significant, though stormwater outfalls and the Landing Road culvert are also implicated.

4.1 Stony Brook Dam

Dams have been a feature on Stony Brook since the 17th century. Throughout that time they served a series of critical industrial purposes for the community. The remnant dam that exists on the site today has long outlived its function. While there are historical attachments to the site and the structures, from an ecological and community standpoint it is a liability, a safety hazard, and a break in the natural connectivity of the ecosystem. In this sense it is typical of remnant dams throughout New England. Communities throughout the region are tackling the challenging problem of remnant dams and their long term disposition. Removal, modification, and repair have all been employed as solutions at dam sites – each meeting a specific set of goals. Goal driven decision-making is key to selecting the best alternative at dam sites. Revisiting the restoration goals listed in Section 3 and including other non-restoration goals, we can begin to develop a decision-making matrix for solutions at the site. Many of the economic, historic, and physical factors affecting the site are beyond the scope of this plan. A feasibility study would be required to adequately address these issues. However, based on the available data an informed example of the decision-making criteria and results is provided in Table 4. Based on this preliminary decision matrix dam removal meets the greatest number of restoration (and other) goals. Section 5 describes the path forward to implementation of restoration at Stony Brook.

Table 4. Example of Goal Driven Decision Matrix for Stony Brook Dam

Action:	**Removal**	**Modification**	**Repair**	**No Action**
Restoration Goals				
Stopping the further invasion of *Phragmites*	M	M	N	N
Restoring natural plant communities	M	M	N	N
Restoring connectivity	Y	M	N	N
Allowing healthy natural habitat changes	Y	M	N	N
Providing access to suitable spawning habitats	Y	M	N	N
Reducing bacterial levels	M	N	N	N
Improving sediment loading and transport	M	N	N	N
Improving tidal exchange and flushing	Y	N	N	N
Other Goals				
Reduce operation and maintenance requirements	Y	N	N	N
Promote long-term sustainability of site and river	Y	N	N	N
Create a condition compatible with site use	M	M	Y	M
Promote recreational use of the river	Y	N	N	N
Preserve/Enhance Historic Site	M	M	M	N
Improve safety	Y	M	Y	N

Y = Yes, M = Maybe, N = No

4.2 Tussock Brook Tide Gate

The Tussock Brook tide gate appears to be 'low hanging fruit' in terms of restoration potential. MA DOT and the Towns of Kingston and Duxbury do seem to have records of its original installation. Based on typical tide gate installations it is assumed that the Tussock Brook gate was installed to reduce flooding and/or saltwater intrusion into the upper portions of Tussock Brook Marsh. This may have been intended to protect upstream properties as they exist today. However, anecdotal information from local residents suggests that the development of upstream areas as farmland had been proposed at one time. The tide gate may have been intended to protect that use. The area was never developed as farmland and current property ownership and wetland regulations would restrict that use in the future.

Although the original intent of this gate is unknown, based on the typical purposes of similar structures it does not appear that the gate is currently functioning properly or serving a purpose. Missing boards at the bottom of the gate allow exchange of water at most tides. A large gap over the top of the gate allows peak tides to flow over. Rusted hinges and water logged boards reduce the extent to which the gate opens. Increased water velocities from these malfunctions are scouring the base of the structure and depositing large volumes of course sediment. While it is not serving a typical function, it is creating impairments typical of tide gates. Reductions in tidal flushing, unnatural sediment transport, and blockage of wildlife corridors are all features of this structure. Since ownership is unclear, function is ineffective, and impacts are observed, removal of this structure is a clear restoration solution. Revisiting the restoration goals of Section 3 we see that most would benefit from removal:

- ☑ Stopping the further invasion of *Phragmites*
- ☑ Restoring natural plant communities
- ☑ Restoring connectivity throughout Stony and Tussock Brooks
- ☑ Allowing healthy natural habitat changes to occur over time (i.e. salt marsh migrations, climate change, sea level rise, etc)
- ☑ Providing access to suitable spawning habitats
- ☑ Reducing bacterial levels
- ☑ Improving sediment loading and transport
- ☑ Improving tidal exchange and flushing

4.3 Stormwater

Stormwater runoff in urban areas has been cited as the largest source of water quality impairments to estuaries. Sediments, nutrients, bacteria and other pollutants are discharged into coastal system through stormwater runoff. A number of best management practices (BMPs) are available that can reduce the impact of stormwater to coastal areas. These include BMP designs that incorporate Low Impact Development (LID) techniques, infiltration, pretreatment to remove TSS, oil and grease, floatables and high bacterial removal efficiency. Potential BMP designs for bacterial removal include: constructed wetlands, bioretention areas, subsurface infiltration and water quality swales, while designs specific to TSS removal may include: settling tanks, settling basins, vegetated swales, etc. Such solutions would have effective and immediate impact on the water quality goals outlined in Section 3.

4.4 Landing Road

The Atlas of Tidal Restrictions cites the Landing Road culvert as restriction to natural flow and contributor to *Phragmites* invasion as a result of reduced flushing. Potential solutions mentioned in the Atlas include enlarging the culvert size to improve flushing. The water level logging study (Section 2.7.1) does not support this assessment. During that study the height and timing of tides in Stony Brook as compared to Jones River were not impacted. This suggests that under the conditions tested the Landing Road culvert did not noticeably restrict tidal movement and flushing. However, a goal of the project is to 'Allow healthy natural habitat changes to occur over time (i.e. salt marsh migrations, climate change, sea level rise, etc)'. While the Landing Road culvert appears to be suitably constructed for

current conditions it may not be suitable for future conditions. Periodic monitoring of the site at time scales consist with coastal change should be conducted. Keeping these long term restoration goals in mind may allow modifications at Landing Road to be conducted by opportunity rather than urgent necessity thus keeping costs low and sustainability high.

5. IMPLEMENTATION

5.1 Stony Brook Dam

The information collected to date on the Stony Brook dam identifies it as having high value for restoration potential. However, a comprehensive feasibility study will be required to evaluate the details of methods required for river restoration at the site. Implementation of a restoration program at Stony Brook should be pursued in the following sequence:

1. **Conduct a feasibility study:**
    a. **Review of Existing Materials:** Review and document the available existing data and resource information regarding the dam and dam site such as aerial photographs, dam inspection reports, past studies of the dam, watershed history and potential contamination information, information regarding abutting property owners, as well as any information on historical diadromous fish runs and/or fisheries. Contaminant testing, potential threatened or endangered species issues, existing archaeology and historical reports should also be included. This restoration plan should be considered a starting point but not a comprehensive source for the review.
    b. **Base Map.** The existing site conditions for the dam and the associated stretch of river should be documented through on-site field investigation and data collection. A detailed base map should be prepared (based upon actual ground survey data or combined aerial photogrammetry with supplemental ground data). The survey should cover all areas potentially impacted by all of the alternatives. The base map should include all features below including those required for all local, state and federal permits including, but not limited to:
        - Biological benchmarks (wetland extent, stream channel, etc.)
        - Major structures including, but not limited to roadways, culverts, bridges culvert inverts, residential and commercial structures within floodplain, well heads, septic, utilities (power lines, waterlines, sewer lines, phone/cable, etc.)
        - Channel cross-section survey data and drawings sufficient for hydrologic/hydraulic calculations necessary for all viable restoration alternatives.
        - Delineated wetland resource areas
        - Bathymetry, including longitudinal profiles
        - Locations of the 100-year, 500-year, and regulatory floodway boundaries as shown on the National Flood Insurance map
        - Property boundaries based on assessor’s information
        - Extent of major vegetation types, including extent of non-native invasive species, suitable for post-project monitoring of major vegetation changes
    c. **Hydraulics and Hydrology.** The hydrological component should discuss how dam removal (or other alternatives) will alter the hydrological equilibrium imposed by the dam (such as flood impacts, floodplain impacts, spillway capacity, etc). This analysis will address the anticipated alterations to the riparian wetlands to a different hydrologic type and/or plant community due to the lowered river water level. A preliminary hydraulic analysis to assess the feasibility of fish passage for target fish species should be conducted. The analysis should provide recommendations regarding channel cross-sections and channel modifications associated with dam removal.

d. **Preliminary Sediment Management Plan.** Sediment management can be one of the most challenging parts of a restoration project. A plan should be developed to identify options for managing the impounded sediments based on levels of contaminants and the appropriate regulatory requirements (E.g. DEP and US ACOE). This should include (but not be limited to):
   - An assessment of sediment volume and regulatory need for testing.
   - A proposed sediment sampling scheme appropriate for the volume and distribution of sediment.
   - Optional tasks which define analytical costs for any required testing.
   - Other tasks deemed necessary for development of sediment management options

2. **Public outreach.** Public outreach should be a key component at all phases of the restoration program. However, it is critical to conduct effective public outreach around the feasibility stage. Setting the stage for partnership and support prior to design and permitting can make the difference between successful or failed restoration.
3. **Design and permitting.** The preferred alternative selected in the feasibility study will require significant design details prior to actual restoration. Additionally, there are a significant number of permits that may be required for such an undertaking. Given the size, location, and history of Stony Brook Dam the following permits may be required:

   Local:
   - Wetlands Protection Act: Determination of Applicability from the Kingston Conservation Commission
   - Notice of Intent (NOI) under Town of Kingston Wetland Protective By-law
   - Kingston Building Permit
   - The building permit will trigger review by the local Kingston Historical Commission which will assess any perceived threat to local historical resources.

   State:
   - Chapter 253 Massachusetts Dam Safety
   - Massachusetts Environmental Policy Act
   - Chapter 91 Waterways License
   - Section 106 Historical Certificate (if federal funding)
   - Section 401 Water Quality Certificate (MDEP)

   Federal:
   - Section 404 CWA (U.S. Army Corps of Engineers).
   - CZM Federal Consistency Review.
   - NPDES (EPA)
4. **Conduct restoration.** With design plans and permits in place site restoration can proceed.
5. **Monitoring and adaptive management.** Long-term sustainability of restoration projects depends on monitoring conditions and adaptively managing to maintain consistency with restoration and goals and endpoints.

5.2 Tussock Brook Tide Gate

JRWA is currently working towards removal of the Tussock Brook tide gate under funding from the Massachusetts Environmental Trust.

JRWA will prepare all permit applications and presentations in early 2012. Removal of the gate may require permitting at the local, state, and federal levels. Potential permits include:

Local:
- Notice of Intent (NOI) under Town of Kingston Wetland Protective By-law

State:

- MA DOT Access Permit
- MEPA EIR or EIR waiver
- MA DEP Chapter 91

Federal

- Army Corps of Engineers Programmatic General Permit II (for restoration)

Removal is expected to occur over time through an adaptive management approach. By removing individual sections of the gate, from the bottom up, we will be able to watch the response in the marsh over several tidal cycles before continuing with the removal of another section. The final result will be a full or partial removal that meets the restoration goals without the need for physical or automatic tide gate controls. The final outcome will not require long-term maintenance costs or efforts.

The location of Tussock Brook makes it ideal for educational opportunities. It is within easy reach by walking or paddling from Jones River Landing and the Bay Farm Montessori School that has recently developed an innovative curriculum using hands-on application of real world problems to teach core principles to the students. The restoration project will be an opportunity to connect with the ecology program elements of the curriculum. JRWA continues its work with local school systems to bring children to the site or the Landing, or bring presentations to the schools. Additionally, JRWA uses its Landing site for public outreach to the local community. With Tussock Brook located only a short walk or paddle from the Landing it is a perfect opportunity to show people how tidal systems function and the purposes of restoration projects. JRWA will guide paddling trips up to the site prior to removal and beyond the site and into the marsh once the removal is implemented.

5.3 Stormwater

Implementation of stormwater improvements follows a multi-phase path starting with 1) the establishment of baseline water quality conditions, 2) identification of pollution contributions, 3) prioritization of sites, 4) development of design plans for the appropriate BMPs, and 5) final installation of those BMPs. This program is currently underway in the Town of Kingston. Kingston has conducted the first three phases of the project. The stormwater outfalls on Stony Brook and Tussock Brook were not assigned highest priority. The overall goal of Kingston's program is to open and/or improve shellfish growing areas in Kingston Bay (*MarineFisheries* growing area CCB43) encompassing 1,294 acres). Once the top priority sites have been addressed, the town will move on to subsequent rounds of prioritization. The outfalls in the project area will fall under these subsequent rounds and will be slated for eventual improvements through BMPs.

5.4 Water Quality

In addition to stormwater contributions the 2011 DEP SERO sampling program identified high bacterial levels in Tussock and Stony Brooks during dry weather. Based on preliminary screening tests it does not appear that the high levels are from human sources. It is suspected that wild or domestic animals in the Tussock Brook watershed are contributing to the issue. This may include wildlife directly in the marsh (deer, raccoon, otter, etc), wildlife in the headwaters (waterfowl), or domestic animals on adjacent properties (horses, goats, sheep, birds, etc). Identification of sources is the first step of implementation of water quality restoration. Continued targeted sampling should occur within Tussock Brook to identify the location of sources. Once the sources are identified a remediation program can be established to improve water quality through the use of BMPs. Depending on the source(s) BMPs may include education, enforcement, wildlife management, etc. Removal of the tide gate is expected to result in water quality improvements through increased flushing. However, source control is a critical component to the restoration program.

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