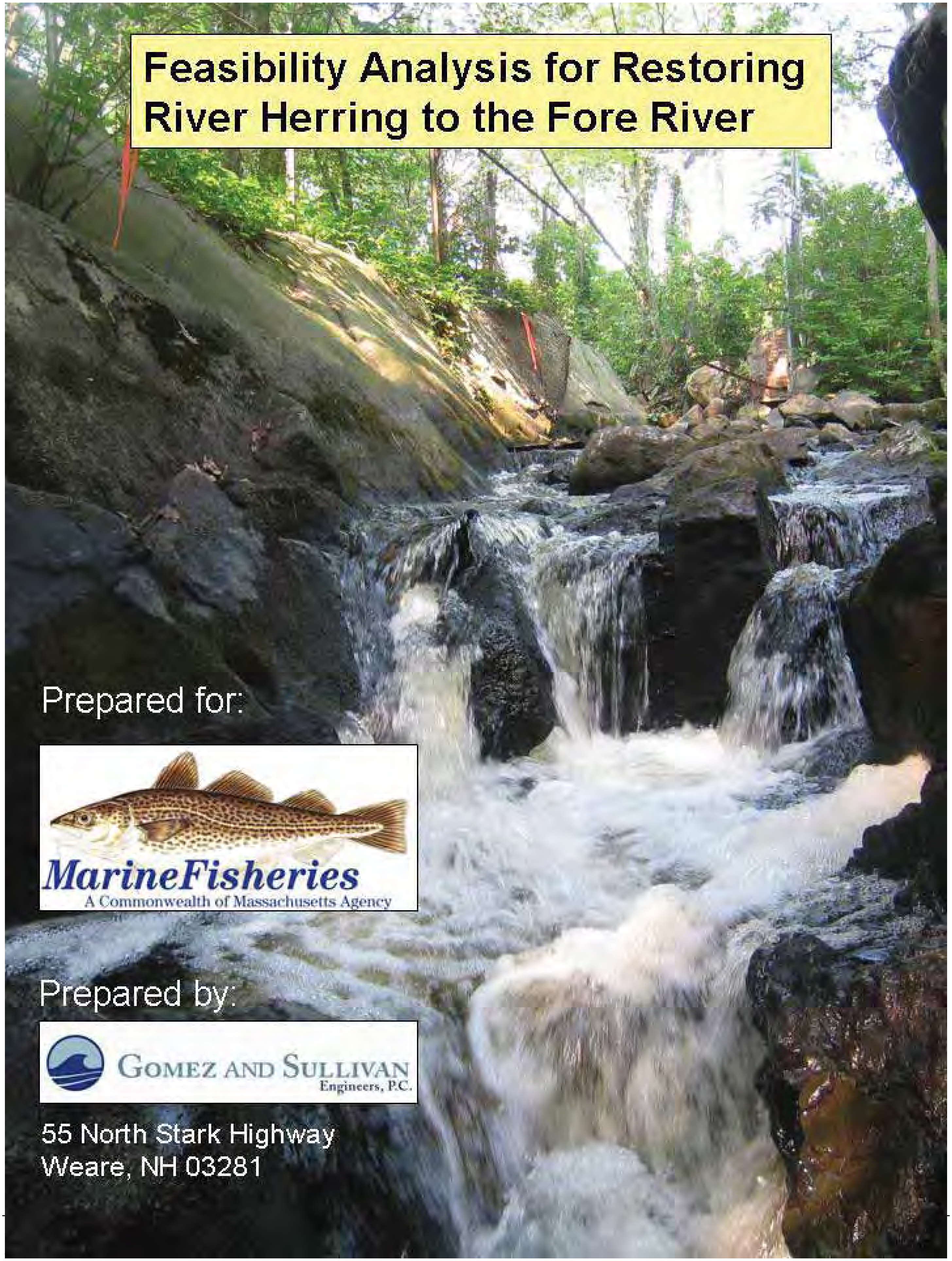
Feasibility Analysis for Restoring River Herring to the Fore River



Prepared for:

MarineFisheries
A Commonwealth of Massachusetts Agency

Prepared by:

Gomez and Sullivan
Engineers, P.C.

55 North Stark Highway
Weare, NH 03281

Joseph C. Sullivan
Mayor

Office of the Mayor

One JFK Memorial Drive
Braintree, Massachusetts 02184

781-794-8100

January 26, 2009

Paul J. Diodati, Director
Massachusetts Division of Marine Fisheries
251 Causeway St., Suite 400
Boston, MA 02114

Re: Restoration of River Herring to Great Pond

Dear Mr. Diodati,

The Town of Braintree appreciated the Massachusetts Division of Marine Fisheries (DMF) meeting with us to summarize the feasibility study on restoring river herring to the Monatiquot River and specifically to Great Pond. DMF's presentations to Braintree town officials on December 17, 2008 and to the Tri-Town Water Board on January 9, 2009 were helpful in understanding the overall restoration objectives for the watershed. The Town of Braintree is supportive of the concept of restoring this valuable natural resource in the Fore River system and looks forward to working with your staff to develop a successful restoration plan that is compatible with existing water and land uses.

It is our understanding that river herring restoration is dependent on fish passage at the downstream Hollingsworth Dam, as well as at the Great Pond Dam in order for river herring to reach their native spawning habitat in Great Pond. In addition, DMF is seeking assistance from the Town of Braintree and the Tri-Town Board to coordinate a flow management plan to assist upstream and downstream fish passage when a ladder is constructed at Great Pond Dam

We are encouraged that the DMF has committed funds to work with the Town of Braintree and the Fore River Watershed Association on this project. In these uncertain economic times we do not see immediate opportunities for funding support from Braintree, but will keep potential opportunities in mind and work with the partnership on the challenges on fish passage and balancing our vital municipal water needs.

We look forward to evaluating the final feasibility report and considering options to move the project forward to the day when our citizens can witness herring running up towards

Great Pond. Please keep my staff informed of your activities. If you have any questions regarding this letter, please feel free to contact me.

Sincerely,

Joseph C. Sullivan
Mayor

cc: Tri-Town Water Board
Kristen Ferry, MA Division of Marine Fisheries
Brad Chase, MA Division of Marine Fisheries
Carl Pawlowski, Fore River Watershed Association
Kelly Phelan, Town of Braintree

Executive Summary

Background

The Massachusetts Division of Marine Fisheries (DMF) is evaluating the feasibility of restoring populations of river herring to the Fore River system. The Fore River Basin is located south of Boston and primarily includes the towns of Braintree, Randolph, Holbrook, Quincy, and Weymouth. The main river draining into the Fore River Bay is the Monatiquot River. The Monatiquot River is formed by two primary tributaries, the Farm and Cochato Rivers. Shown in Figure E-1 is a layout of the watershed and the proposed migration route for river herring. Shown in Figure E-2 are the Farm River, Cochato River and Monatiquot River drainage areas.

DMF is evaluating the feasibility of restoring river herring to Great Pond and Sunset Lake in Braintree. The Monatiquot River historically contained a large run of alewife that spawned in Great Pond; however successful spawning runs ceased after the construction of dams during the industrial revolution. Although river herring were believed to be absent from the river system, the DMF and the Fore River Watershed Association (FRWA) observed river herring at the natural falls[1] below Hollingsworth Dam in the 1990s (see Figure E-1 for location). The DMF believes that river herring are spawning in marginal habitat in the main stem Monatiquot River near Route 93. Given these observations and the amount of potential spawning habitat further upstream of Rock Falls in Great Pond and Sunset Lake, the Project Partners[2] evaluated the feasibility of restoring river herring to the upper watershed.

System Layout and Barriers

There are currently man-made and natural barriers that preclude upstream movement of river herring beyond the natural falls. Shown in Table E-1 in downstream to upstream order are a) the location of barriers, b) the approximate height of the barrier and c) the alternatives evaluated to mitigate the barrier. Refer to Figure E-1 for the specific locations.

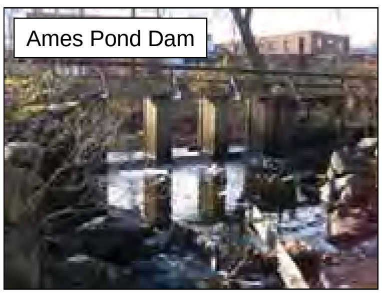
Table E-1: Barriers to River Herring Passage

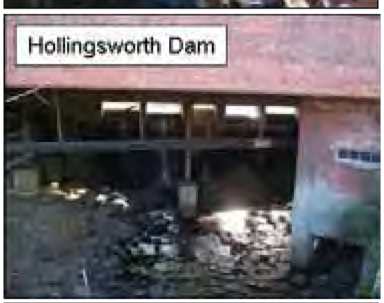
Barrier Location	Ownership	River	Approximate Barrier Height	Alternative(s) to Mitigate Barrier
Natural Falls – referred to as "Rock Falls"	Along shoreline- Hollingsworth Pond, LLC	Monatiquot River	4 feet- steep falls	Resurrect bypass channel around Rock Falls
Ames Pond Dam	Hollingsworth Pond, LLC	Monatiquot River	2-3 feet depending on flow	Lower the sill elevation of dam to mitigate vertical barrier
Hollingsworth Dam	Hollingsworth Pond, LLC	Monatiquot River	12.5 feet	Conventional fishway and dam removal
Richardi Reservoir- Diversion Dam	*Tri-Town Water Board	Farm River	Unknown- although appears to be minor	Based on a site visit does not appear to be a barrier. Slight modifications to stoplog operations may be necessary

[1] For purposes of this proposal we have referred to the natural falls as "Rock Falls" and its location is shown later in this report.
[2] Project Partners include DMF, FRWA, Hollingsworth Pond, LLC (c/o Messina Enterprise) who owns Hollingsworth Dam, and the Town of Braintree who owns Great Pond Dam.

Barrier Location	Ownership	River	Approximate Barrier Height	Alternative(s) to Mitigate Barrier
Sunset Lake Dam	Town of Braintree	Sunset Lake Canal, Tributary to Farm River	1-2 feet, depending on the number of weirboards	Modifications to weirboards, and potentially install cross vanes below dam to raise water surface elevation
Great Pond Dam	*Tri-Town Water Board	Tributary to Farm River	6.6 feet	Conventional fishway
* The Tri-Town Water Board consists of three towns- Braintree, Holbrook and Randolph				

As noted above, Rock Falls represents the current upstream extent of river herring migration. The steepness of the channel bed prohibits river herring from moving further upstream. There appears to be a historic bypass channel extending around the falls that may have been modified due to the construction of the MBTA railroad and adjacent parking lot. With some modifications to the bypass channel's upstream entrance and channel itself, it appears the bypass channel could be resurrected to permit river herring passage around the falls. In lieu of resurrecting the bypass channel it is also possible to reduce the slope of Rock Falls by removing bedrock to permit passage.


Ames Pond Dam


Hollingsworth Dam


Sunset Lake Dam


Great Pond Dam

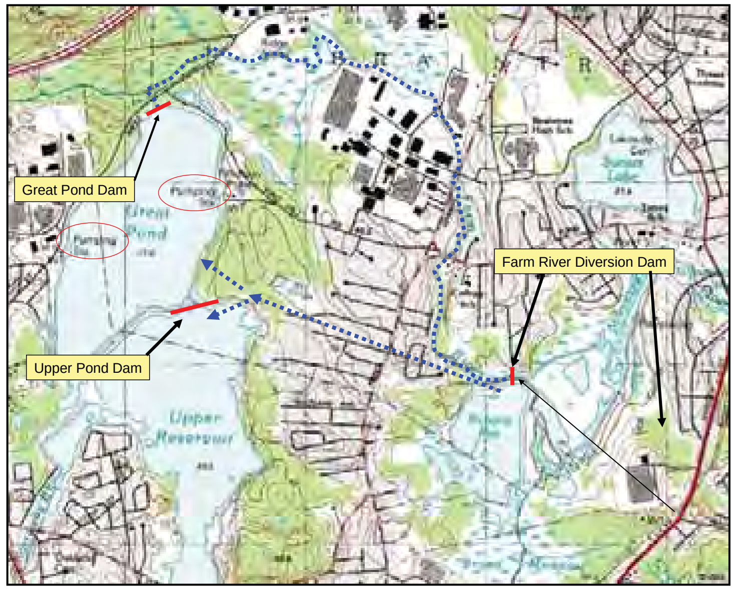
Approximately 50 feet upstream of Rock Falls is the 2 to 3-foot high Ames Pond Dam. To permit passage, the sill elevation of three center bays could be lowered to eliminate the vertical barrier while maintaining velocities in a reasonable range for passage. Approximately 560 feet upstream of Ames Pond Dam is Hollingsworth Dam, which represents the first major challenge for restoring river herring. A brick building sits atop the dam, and vertical columns or structural supports extend from the base of the building to the spillway crest. Two options were investigated to permit passage- removal of the dam, which would require further evaluation, and installation of a conventional fishway.

Moving upstream, the next barrier is the Diversion Dam located on Farm River that diverts flow into Richardi Reservoir. A detailed investigation of the Diversion Dam was not conducted as part of this study; however, it appears that minor modifications may be needed to facilitate fish passage. Continuing upstream, Sunset Lake canal connects Sunset Lake Dam to the Farm River. Sunset Lake Dam is a small dam and would require modifications to weirboards and potentially modifications to the channel directly below the dam to facilitate passage. Finally, the 6.6-foot-high Great Pond Dam is a barrier to passage. A conventional fish ladder was evaluated at this site.

Water Supply

River flows on the Farm and Monatiquot Rivers are heavily impacted by water supply withdrawals occurring within the Farm River watershed. There are two water supply intakes located in Great Pond that provide potable water. The two intakes are maintained and operated by the Braintree Water and Sewer Commission (BWSC) and the Randolph/Holbrook Joint Water Board. Only on rare occasions is water spilled below Great Pond Dam; most of the watershed runoff is used for water supply. In addition to Great Pond, further downstream in the watershed is Richardi Reservoir. Water from the Farm River can be diverted at the Diversion Dam into Richardi Reservoir for water supply. Water retained in Richardi Reservoir is pumped to either Great Pond or Upper Reservoir to further supplement water supply demands (see schematic).

Eighteen years (1989-2006) of water withdrawals records for Great Pond were analyzed. Shown in Figure E-3 and E-4 is the annual and average monthly water withdrawals, respectively, from Great Pond based on the period 1989-2006 (18 years). The average annual withdrawal rate is 11.2 cfs. With a drainage area of 6.1 square miles at Great Pond Dam, 11.2 cfs represents 1.8 cfs per square mile of drainage area (cfsm). To put the average annual withdrawal rate into context, the estimated average annual flow at Great Pond Dam is approximately 11.5 cfs. Thus, virtually all of the runoff in the watershed above Great Pond Dam is used for water supply.



Great Pond water levels are also fluctuated seasonally to meet water supply demands. Shown in Figure E-5 are the Great Pond water levels from August 2005 through February 2008. When full, the pond level is maintained near the top of the steel lift plates at the dam. However, during the summer when runoff into the ponds subsides, water levels are drawn down to supplement water supply demand. Generally water levels are fluctuated between 2 to 3 feet annually as shown in Figure E-5.

Hydrology

A major challenge to restoring river herring is the timing and magnitude of streamflow at key locations in the basin. A US Geological Survey (USGS) gage was installed on the Monatiquot River on March 31, 2006; approximately 2+ years of flow data are available. Because the period of record is so short, it was placed into context with another USGS gage having a longer period of record, a similar size drainage area and similar basin characteristics. As described in the report, the East Branch Neponset River was selected as it has a long period of record, is in relatively close proximity to the Monatiquot River, and a regression analysis showed a relatively close relationship between flows on each river for the common period of record. It is recognized that both the East Branch Neponset and Monatiquot Rivers are subject to regulation (water withdrawals, etc); however, there are no unregulated USGS gages in close proximity to the project, thus it represents the best available data. The drainage areas of the Monatiquot and East Branch Neponset River gages are 28.7 and 27.2 square miles, respectively. The flows on the East Branch Neponset River were adjusted by a ratio of drainage areas to estimate the flow at the USGS gage on the Monatiquot River.

Flows were subsequently estimated at key locations in the basin using a) the adjusted East Branch Neponset River gage flows (57 years of data) and b) the observed Monatiquot River gage flows (2 years of data). Flows at locations other than at the USGS gage were estimated by a ratio of drainage areas. Shown in Table E-2 is the estimated average annual flow at key locations in the basin.

Table E-2: Estimated *Average* Annual Flow at Key Locations in Fore River Watershed

Location	Drainage Area (mi^2)	Monatiquot River 03/31/2006-05/06/2008	Adjusted East Branch Neponset River flow 10/01/1952-05/06/08
Great Pond Dam outlet	6.1	11.2 cfs	11.7 cfs
Sunset Lake Dam outlet	0.5	0.9 cfs	1.0 cfs
Farm River at confluence with Monatiquot River	12.9	23.7 cfs	24.8 cfs
Cochato River at former diversion location to Richardi Reservoir	10.7	19.7 cfs	20.6 cfs
Cochato River at confluence with Monatiquot River	11.1	20.4 cfs	21.4 cfs
Monatiquot River at Hollingsworth Dam	25.9	47.6 cfs	49.9 cfs

Although Table E-2 shows an average annual flow of approximately 11 cfs at Great Pond Dam, in reality virtually no flow is passed below the dam. Thus, one of the major challenges to restoring river herring to Great Pond is maintaining a flow below the dam during the migration season to attract fish without impacting water supply withdrawals.

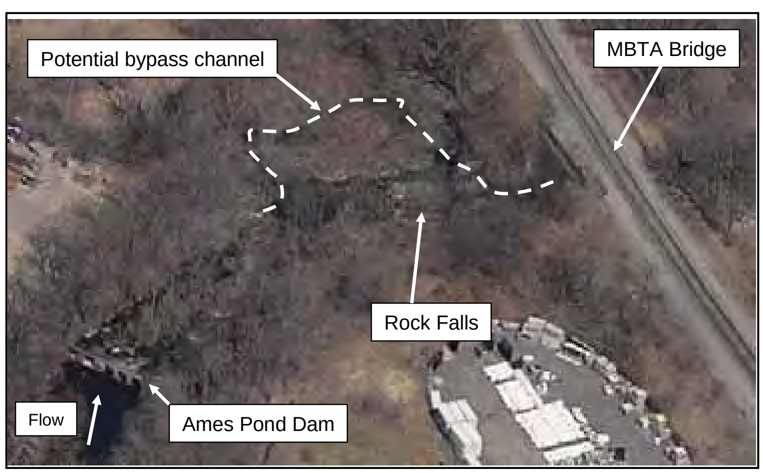
Options to Mitigate Barriers

A hydraulic model of the Monatiquot River was developed from just below Rock Falls and extended upstream to Jefferson Bridge (see Figure E-6, Pages 1 and 2). This reach of the river includes Rock Falls, Ames Pond Dam and Hollingsworth Dam. The purpose for developing the hydraulic model was to determine:

- If the bypass channel around Rock Falls could be restored to provide fish passage;
- If lowering the sill elevation of Ames Pond Dam would permit passage;
- How removal of the Hollingsworth Dam would impact depths and velocities upstream of the dam.

The hydraulic model simulated flows likely to occur during the river herring upstream and downstream migration seasons as well as flood flows. The findings were as follows:

Bypass Reach



River herring can not ascend Rock Falls as it is too steep. However, an approximate 140-long bypass channel extends around the falls as shown in the inset. Based on hydraulic modeling the bypass channel could be restored and function to pass river herring upstream. Currently, only when stream flows are exceptionally high is water conveyed to the bypass channel. Modifications would be required at the upper bypass/mainstem intersection to direct flow into the bypass channel. This would require moving stones and potentially demolishing some bedrock such that the bypass conveys the majority of flow. In addition, some modifications to the bypass channel are required to ensure that water depths and velocities are acceptable for passage. In short, the bypass channel, with some modifications, is feasible to pass river herring. Although not evaluated in the hydraulic model at this time, another potential option in lieu of resurrecting the bypass channel is reducing the slope of Rock Falls to permit passage. This would require removal of bedrock to lessen the channel slope such that depths and velocities are in the range to permit fish passage.

Ames Pond Dam

The hydraulic model at Ames Pond Dam showed a barrier at Ames Pond Dam due to a vertical drop between the bay opening sill elevation and plunge pool. To facilitate passage, lowering the sill elevation of the dam by approximately one foot at the three center bays appears to eliminate the barrier, while maintaining velocities in an acceptable range during the passage season. In short, with some minor modifications, it is feasible to pass fish at Ames Pond Dam.

Hollingsworth Dam

Hollingsworth Dam currently creates a backwater that extends upstream through four bridge openings- Plain Street Bridge, MBTA Bridge, Route 37 Bridge and Jefferson Street Bridge. It is unclear the construction dates of the bridges relative to the construction date of dam. If the bridges were constructed or modified after the dam was constructed, the bridges were designed for negligible velocity as the dam creates a backwater through the bridge openings. The hydraulic modeling showed that with the dam removed the water velocities through the bridge openings increase.

Note that no analysis was conducted to determine the geographic extent and volume of accumulated sediment within the impoundment. However, it is suspected that under the dam removal scenario accumulated sediments within the impoundment may be transported downstream unless other measures such as dredging or stabilizing some of the sediments in place are taken. If sediments near the bridge openings become eroded, it could lead to scour. Further analysis is recommended relative to bridge abutment and pier scour.

Removal of the Hollingsworth Dam will permit river herring passage; however, there are several more feasibility related studies that are necessary before moving forward with this alternative. A detailed description of additional feasibility related studies is outlined in the report; however, two investigations are recommended prior to moving forward with further feasibility work. Specifically, we recommend testing of accumulated sediment in Hollingsworth Pond and conducting a structural stability analysis. We suggest collecting at least two sediment samples within the impoundment and testing the sediment for a suite of contaminants. If high levels of contaminants are present and depending on the geographic extent and volume of sediment, the cost for the dam removal alternative could increase considerably.

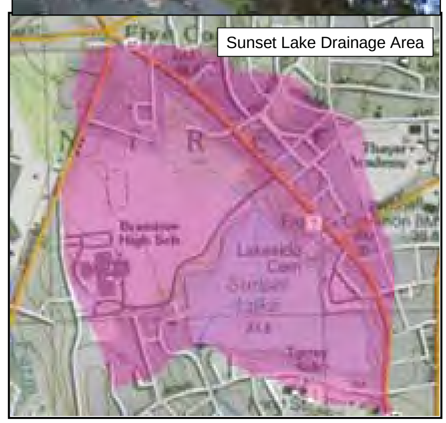
The other issue that must be addressed is related to the building sitting above the dam as shown in the picture. The building and dam are owned by Hollingsworth Pond, LLC. There are concrete vertical columns that transfer the load (weight) from the building to the concrete spillway. Removal of the concrete spillway will result in removing the structural support for the building. We recommend a structural stability analysis to determine potential options that satisfy both removal of the dam to restore fish passage while providing structural support for the building. Clearly, increased communications are needed with

Hollingsworth Pond, LLC if the dam removal alternative is considered further.

In addition to dam removal, the other alternative evaluated for fish passage at Hollingsworth Dam was a conventional fishway. While evaluating this alternative, an investigation was conducted relative to the spillway capacity of the dam. The Hollingsworth Dam is classified as a high-hazard dam according to Massachusetts Dam Safety and because of the dam's height and storage volume it is required to pass what is termed the ½ Probable Maximum Flood (PMF)- this is a flow higher than the 100-year flood. A research of Massachusetts Dam Safety files and discussion with the dam owner did not uncover any studies that a) estimated the ½ PMF and b) determined whether the dam can safely pass the ½ PMF. The reason for mentioning this is that the conceptual fish passage plan calls for installing an Alaska Steeppass (ASP) fishway that would have an exit through one of the bay openings. Installing a fishway within the bay opening will further reduce the dam's spillway capacity. If the fishway alternative is carried further, it will likely trigger investigation into the dam's ability to pass the ½ PMF. Given this, prior to moving forward with the fishway option, we recommend consultation with Hollingsworth Pond LLC, Massachusetts Dam Safety, and other parties.

Farm River Diversion Dam

The Farm River Diversion Dam was not heavily investigated as part of this project; however, based on our site inspection, it is a relatively low-head dam. Fish passage above the Diversion Dam may require some slight modifications to the use of stoplogs at the dam.



Sunset Lake Dam

Connecting Sunset Lake dam to the Farm River is the Sunset Lake "canal", which passes beneath Pond Street. The two challenges to moving river herring into Sunset Lake are flow availability and negotiating the Pond Street culverts (see photo). It is unknown if the depth and velocity through the culvert will permit passage as it appears that the culverts are partially silted in. Second and most importantly, is the ability to maintain flow below the dam during the upstream and downstream passage seasons. With only a 0.5 square mile drainage area (see inset), and an estimated spring flow of 1.5 cfs, there does not appear to be enough water to facilitate passage. In addition, an estimated flow of 0.5 cfs occurs during the fall emigration. We have offered potential options to increase passage flows by adjusting weirboards at the dam; however, it is unknown if this is truly feasible.

Great Pond Dam

The alternative evaluated for fish passage at Great Pond Dam was a conventional fishway. There are a few challenges of maintaining fish passage at Great Pond. First, similar to Hollingsworth Dam, the Great Pond Dam is classified as a high-hazard dam that must pass the ½ PMF without overtopping the earthen portion of the dam. Braintree Water and Sewer Commission commissioned a study to determine if Great Pond Dam can safely pass the ½ PMF. The results of the study indicated that the dam can not pass the ½ PMF and the following options were offered:

- raising the earthen embankments so as to not overtop,
- widening the spillway, and

- a combination of raising the embankment and widening the spillway.

It is our understanding that no corrective measures have been implemented to date. In addition, it is unknown if the results of the consultant's study were shared with Massachusetts Dam Safety. Again, we mention this only because any potential fishway at the dam would likely trigger consultation with Massachusetts Dam Safety. Given this, prior to moving forward with the fishway option, we recommend consultation with the Tri-Town Water Board, Massachusetts Dam Safety, and other parties.

The other major challenge of maintaining fish passage at Great Pond Dam is flow availability. Based on historic data and discussions with BWSC, essentially no water is passed below the dam. Only under rare conditions, when there is no reservoir storage capacity remaining, does spillage occur. Maintaining a flow through the fishway will directly impact water supply withdrawals.

In considering fishway alternatives, we focused on an Alaska Steeppass (ASP) fishway primarily because it requires less water than similar fishways such as a Denil. The ASP flow requirements can range between approximately 3 to 4 cfs. What does maintaining 3 cfs to 4 cfs in a fishway during the upstream passage season mean to water supply withdrawals? The peak of the spawning run typically occurs between April 15 and May 31 for river herring- a total of 46 days. Note that although the duration of upstream migration may be from April 15 to May 31, monitoring of river herring movement- as has been done in the past by the Fore River Watershed Association—could result in reducing the duration of time in which flows are maintained in the fishway for upstream passage. However, for purposes of the analysis below we assumed the fishway would operate from April 15 to May 31. Assuming 3 to 4 cfs is maintained in the fishway during the upstream migration period, the total volume of water needed (in MG) is summarized in Table E-3. Also shown in Table E-3 is the percentage of the fishway flow volume relative to the water supply withdrawal volume.

Table E-3: Flow Range Needed to Operate Upstream Fishway Relative to Water Withdrawals

Fishway Flow	Fishway Flow converted to MG for the period April 15-May 31	*Average Total Water Withdrawal for the period April 15-May 31 (MG)	% of Upstream Fishway Flow Volume Relative to Water Withdrawal Volume
3 cfs	89 MG	337 MG	26%
4 cfs	119 MG	337 MG	35%

* based on 18 years of water withdrawal data.

Maintaining 3-4 cfs through the fishway represents approximately 26% to 35% of the withdrawal volume. In short, maintaining the fishway flow by reducing water withdrawals for water supply does not appear to be possible.

How can these fishway flows be provided when no water is currently passed below Great Pond Dam? The following alternatives should be considered.

- Pump water from Richardi Reservoir to Great Pond during April and May. During the April through May period, Richardi Reservoir is essentially full. It appears that water could be pumped from Richardi Reservoir to Great Pond for the purpose of maintaining a 3-4 cfs fishway flow. In short, it would be a circular loop of pumping 3-4 cfs to Great Pond, releasing flow through the fishway, diverting 3-4 cfs back into Richardi Reservoir at the Farm River Diversion Dam and then pumping it again to Great Pond. The other benefit of this option is that 3-4 cfs is maintained in the short tributary between the dam and Farm River serving as an attraction flow[3] to the fishway. Note that according to the BWSC there are three pumps at Richardi Reservoir, although only one is typically used. The primary pump has a capacity of 7.5 MGD (11.6 cfs), however, it can only operate in a fully opened or closed position; it can not be throttled. Thus to maintain the 3-4 cfs continuous flow through the fishway would require cycling the pump. A disadvantage of this alternative is the potential of inadvertently moving river herring into Richardi Reservoir during their upstream migration when water is diverted at the Farm River Diversion Dam into Richardi Reservoir for the purpose of providing water for the fish ladder. To preclude fish from being diverted into Richardi Reservoir a screen could be added to the gravity intake structure. Further analysis would be needed to determine the screen sizing to prevent impingement of fish.

- Another alternative is resurrecting the existing diversion from the Cochato River to Richardi Reservoir. The Cochato River was previously diverted into Richardi Reservoir; however, diversions ceased due to contamination at the Baird & McGuire Superfund Site, which is located further upstream near the Cochato Brook headwaters. Resurrecting the diversion would require providing evidence that the water quality is acceptable for drinking purposes. The benefit of this alternative is two fold. First, having the ability to divert the Cochato River to Richardi Reservoir would likely reduce the number of water shortage problems experienced in the recent past. It is assumed that during non-passage season—particularly during the summer when shortages typically occur-- both the Farm River and Cochato River could be used to supplement demand. Re-opening the Cochato River diversion would provide Tri-Town with greater flexibility to meet demands. Second, during the upstream and downstream fish passage seasons, it is proposed that diversions only occur from the Cochato River; the Farm River diversion would be "closed".

- A third alternative is to install a pump that would withdraw water from the tailwater pool immediately below the dam, and discharge the flow into the fishway exit. This too would essentially be a confined loop of pumping 3-4 cfs from the tailwater pool and into the fishway. The disadvantage of this option is 3-4 cfs would not be maintained in the short tributary between the dam and Farm River thus there would be no attraction flow to guide fish to the fishway entrance. In addition, there would be greater operation and maintenance costs.

In addition to maintaining flows for upstream passage, downstream passage in the fall is necessary. The peak of the downstream passage season is from September 1 to November 30 depending on flows and water temperatures. Note that although the duration of downstream migration may be from September 1 to November 30, monitoring of river herring movement in Great Pond could result in reducing the duration of time in which flows are maintained in a proposed notch in the dam for downstream passage. However, for purposes of the analysis below, we assumed that downstream passage flows would be provided from September 1 to November 30. To facilitate downstream passage we suggest installing a 1-foot wide by approximately 3 foot deep notch. The notch would be filled with stoplogs until such time when downstream migration was to occur. During the downstream passage period, the stoplogs would be maintained to provide approximately 1 foot of spill through the notch. There is a plunge pool below the dam to receive downstream migrants, although some deepening of the pool may be required. How much flow and how long should the notch remain open to permit downstream passage?

Using the standard weir equation, the discharge through a 1-foot wide notch flowing with 1 foot of depth would be approximately 3 cfs. The outmigration of juvenile herring typically occurs between September 1 to November 30- a total of 91 days, although DMF has indicated that it could potentially be narrowed further from October 1 to October 31, a total of 31 days. Assuming 3 cfs is maintained in the notch

[3] The purpose of attraction flow is to create a flow/velocity field below the fishway to attract fish to move upstream and into the fishway entrance.

during the outmigration period (91 days and 31 days), the total volume of water needed (in MG) is summarized in Table E-4.

Table E-4: Flow Range Needed to Maintain Downstream Flow Relative to Water Withdrawals

Fishway Flow	Fishway Flow converted to MG for the period September 1 to November 30 (MG)	Average Total Water Withdrawal for the period September 1 to November 30 (MG)	% of Downstream Fishway Flow Volume Relative to Water Withdrawal Volume
3 cfs	176 MG	632 MG	28%
Fishway Flow	**Fishway Flow converted to MG for the period October 1 to October 31 (MG)**	**Average Total Water Withdrawal for the period October 1 to October 31 (MG)**	**% of Downstream Fishway Flow Volume Relative to Water Withdrawal Volume**
3 cfs	60 MG	213 MG	28%

Again, maintaining 3 through the notch throughout the downstream passage season would impact water supply withdrawals. How can these downstream passage flows be provided when no water is currently passed below Great Pond Dam? The following options should be considered.

- Again, consider the option of diverting flow at the Farm River Diversion Dam into Richardi Reservoir and then pumping to Great Pond Dam. However, note that during the September 1 to November 30 period, Richardi Reservoir water levels are drawn down to supplement Great Pond. Again, the disadvantage of this alternative is the potential of diverting juvenile river herring into Richardi Reservoir when the Farm River Diversion is operating, unless the intake is screened.

- Again, consider resurrecting the existing diversion from the Cochato River to Richardi Reservoir, recognizing the water quality and political issues.

- Again, consider a pump in the tailwater pool below Great Pond Dam.

- For all alternatives, and as noted above, the duration of providing downstream passage flows could potentially be narrowed by observing river herring movements in Great Pond. This option would entail "holding" fish in Great Pond until such time when basin flows and water temperatures are ideal. When these conditions are present the notch would be opened to move fish downstream. Water would be pumped from Richardi to Great Pond primarily to support downstream flow needs through the notch. However, note that to move river herring near the notch, a small volume of outflow is necessary in the notch to attract fish to the exit.

Order of Magnitude Cost Estimates for Restoration Effort

Order of magnitude cost estimates were prepared for the following alternatives:

- Modification of the bypass channel and lowering of the Ames Pond Dam spillway;
- Additional feasibility related work associated with the Hollingsworth Dam removal alternative;
- Removal of the Hollingsworth Dam;
- Installation of an Alaska Steeppass Fishway at Hollingsworth Dam;
- Installation of an Alaska Steeppass Fishway at Great Pond Dam.

Note that the estimates are truly order of magnitude and include several assumptions which are outlined in more detail in the main report. However, the major assumptions relative to the Hollingsworth Dam removal alternative include: a) no cost to structurally support the building atop Hollingsworth Dam, b) sediments are clean and would be allowed to be naturally transported downstream, c) no scour protection is needed at the upstream bridges and d) no Phase IB[4] archeological investigations are required. Given these assumptions and others noted in the report, shown in Table E-6 are the order of magnitude costs.

Table E-6: Order of Magnitude Cost Estimate for Restoration

Item	Description	Estimated Cost ($)
1	Budgetary Estimate for Bypass Channel and Lowering Ames Pond Dam	$65,000
2a	Budgetary Estimate for Remaining Feasibility and Engineering Associated with Removal of Hollingsworth Dam	$285,000
2b	Budgetary Estimate for Removal of Hollingsworth Dam	$343,000
3	Budgetary Estimate for Upstream Fish Passage at Hollingsworth Dam	$154,000
4	Budgetary Estimate for Upstream and Downstream Fish Passage at Great Pond Dam	$107,000
	TOTAL (including Hollingsworth Dam Removal, Items 1, 2a, 2b, and 4)	$800,000
	TOTAL (including ladders only, Items 1, 3, and 4)	$326,000

<u>Notes:</u>

Table E-6 does not account for:

- Operation and maintenance costs.
- Costs to install, operate and maintain a pump below Great Pond Dam (should this alternative be considered) to provide water to maintain flows needed for upstream and downstream passage.
- Costs to operate and maintain the Richardi Reservoir pumps to provide water to maintain flows needed for upstream and downstream passage.

Next Steps

There are several questions that need to be addressed before considering river herring restoration to the Monatiquot River Basin. Based on our site inspection and hydraulic modeling analysis, it appears that the bypass channel could be resurrected. In addition, minor modifications at Ames Pond Dam may be necessary to permit upstream passage. In short, it is possible to move river herring to the base of the Hollingsworth Dam. The greater challenges are moving river herring above the Hollingsworth Dam and into Great Pond. Based on our review, the key questions that must be addressed before restoration is pursued further are as follows:

- *Does the Hollingsworth Dam have sufficient spillway capacity?* It is unknown if the Hollingsworth Dam can safely pass the ½ Probable Maximum Flood (PMF) without overtopping. Contact with Hollingsworth Pond, LLC, the dam owner, indicated that MA Dam Safety has not required any hydrologic study to estimate the ½ PMF. A fish passage facility affixed to the spillway will only serve to further reduce the discharge capacity of the dam. The spillway

[4] Any time there is ground-disturbing activities, it requires consultation with the State Historic Preservation Office. An evaluation would be needed to determine if ground-disturbing activities could impact archeological artifacts.

capacity issue should be resolved before a fishway is considered. Obviously, dam removal would resolve the spillway capacity issue.

- *Is the Hollingsworth Dam owner supportive of both fish passage options at the dam*? Most specifically, is Hollingsworth Pond, LLC willing to remove the dam given the building structural support issues that would need to be addressed?

- *Are the water suppliers- Braintree Water and Sewer Commission and Randolph/Holbrook Joint Water Board (the Tri-Town Board) -willing to modify operations to maintain flows below Great Pond Dam to facilitate upstream and downstream fish passage? More specifically, are the water suppliers willing to use Richardi Reservoir to essentially pump flow to Great Pond for the purpose of maintaining a fishway flow? In addition, is the Tri-Town Board willing to consider resurrecting the diversion from the Cochato River to Richardi Reservoir?* The answers to these questions are critical to the overall restoration effort. If the water suppliers are not amenable to restoring river herring to Great Pond, and because Sunset Lake does not appear to be viable for restoration, it does not make sense to provide fish passage at Rock Falls, at Ames Pond Dam and at Hollingsworth Dam. Other than the small Hollingsworth Pond, there are no sizeable waterbodies above Hollingsworth Dam to support river herring spawning.

- *Are there any requirements to modify the Great Pond spillway to pass the ½ PMF?* The Great Pond spillway can not safely pass the ½ PMF without overtopping the earthen dam. It is unclear if MA Dam Safety will require modifications at the dam in order to meet the spillway capacity design requirements. If modifications to the dam are required, and if the water suppliers are amenable to river herring restoration, opportunities could exist relative to constructing fish passage simultaneous to dam modifications.

Our recommendation is that before any further analysis is conducted, answers to these questions are necessary. We also suggest that any fish passage alternative at Hollingsworth Dam (as well as creating passage from Rock Falls to Hollingsworth Dam) should be contingent on obtaining buy-in from the water suppliers to restore river herring to Great Pond. It does not appear reasonable to restore the lower portion of the basin if Great Pond is unavailable for river herring restoration.

Figure E-1: Monatiquot River Watershed and Proposed Migration Route

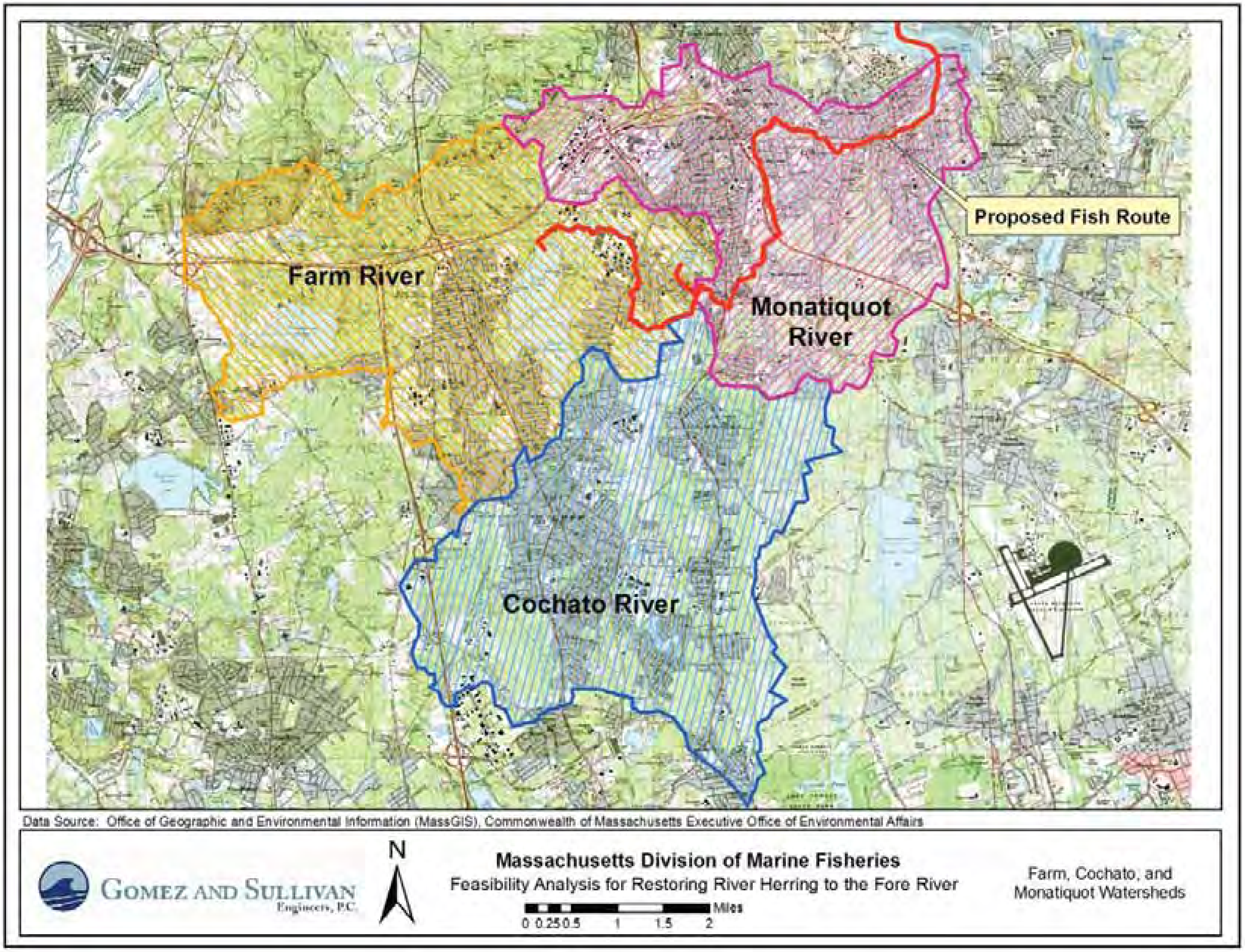


Figure E-2: Drainage Areas of the Farm, Cochato and Monatiquot Rivers

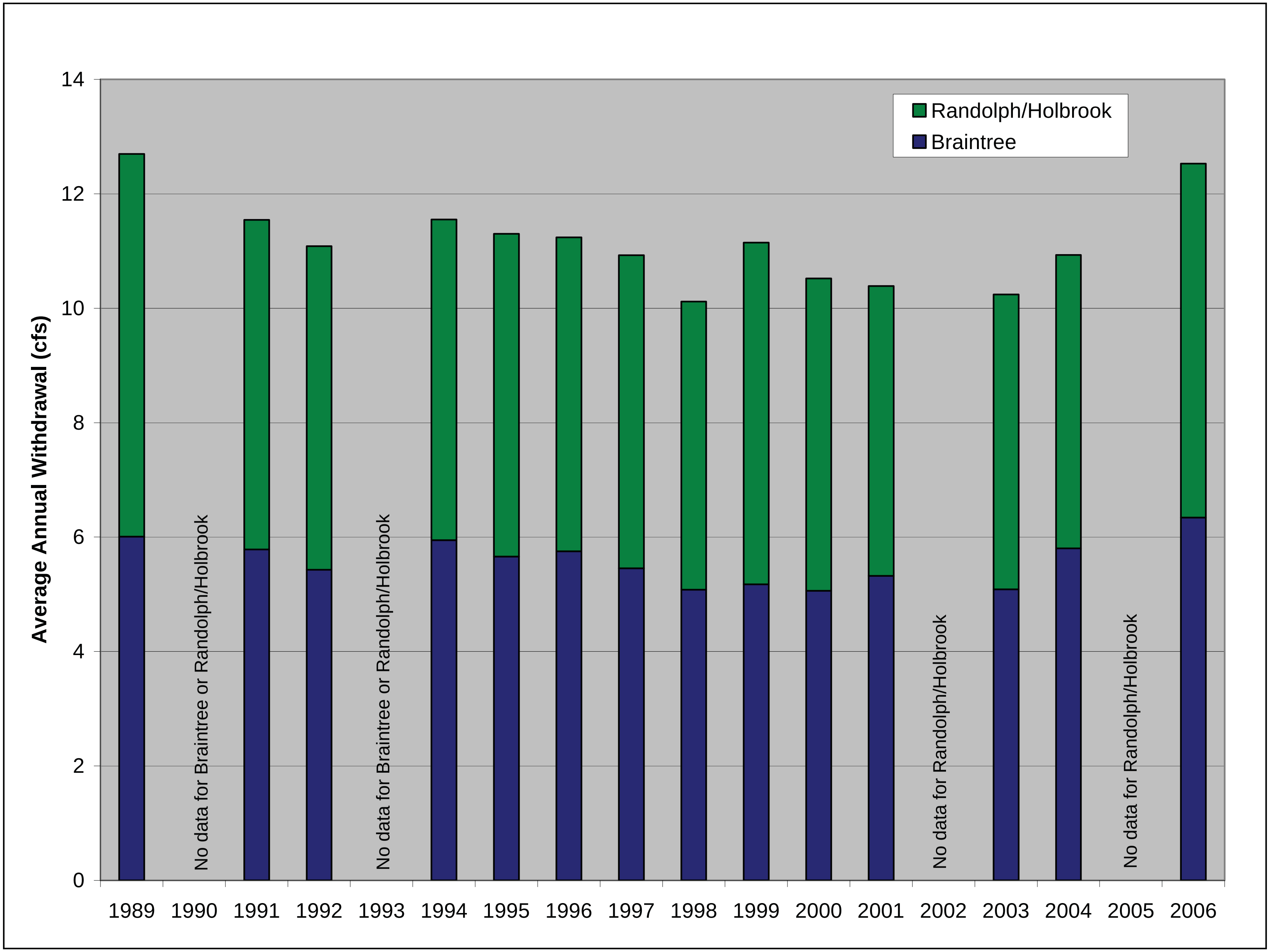


Figure E-3: Average *Annual* Flow Withdrawn from Great Pond by Braintree and Randolph/Holbrook

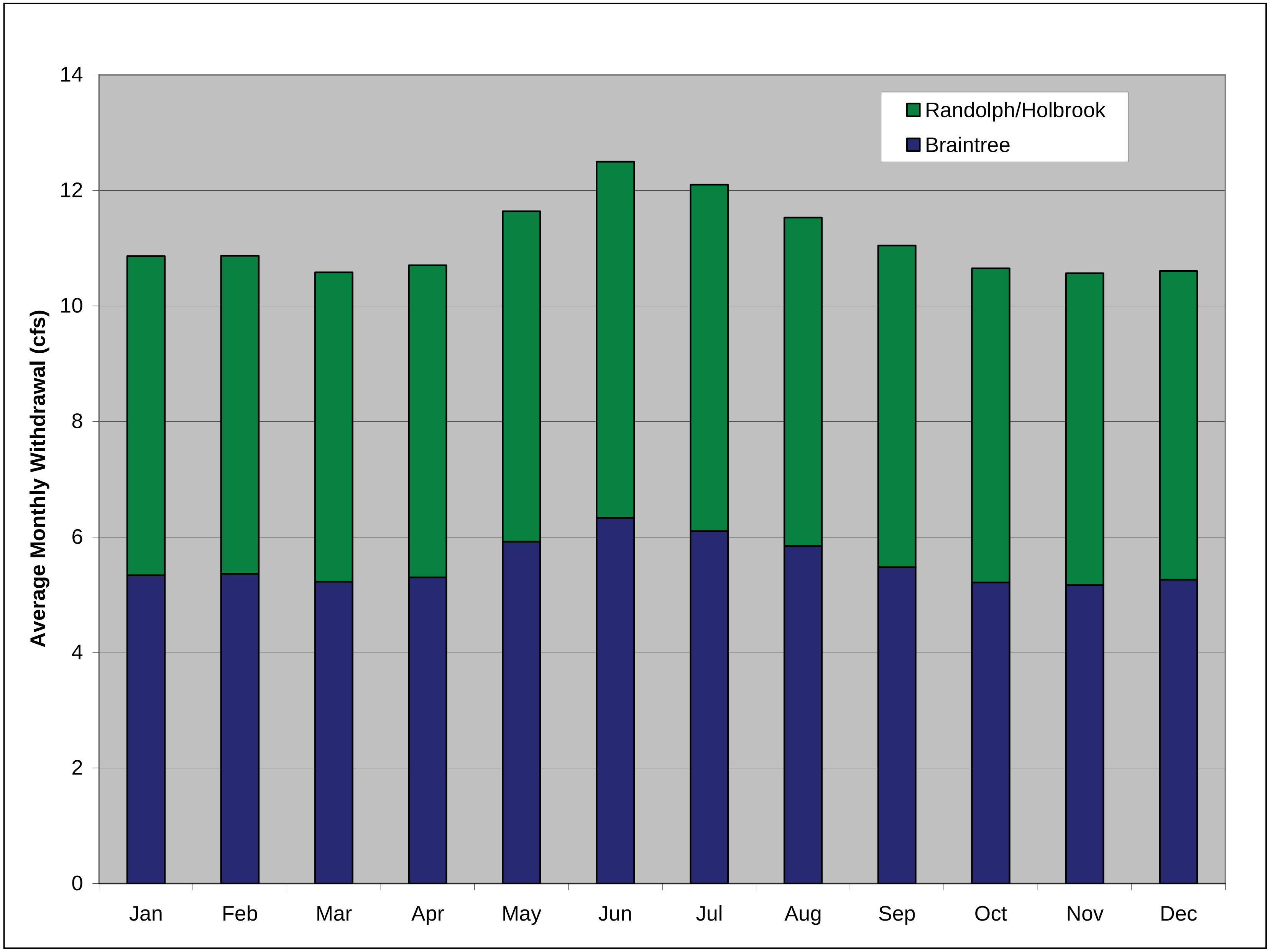


Figure E-4: Average *Monthly* Flow Withdrawn from Great Pond by Braintree and Randolph/Holbrook (1989-2006)

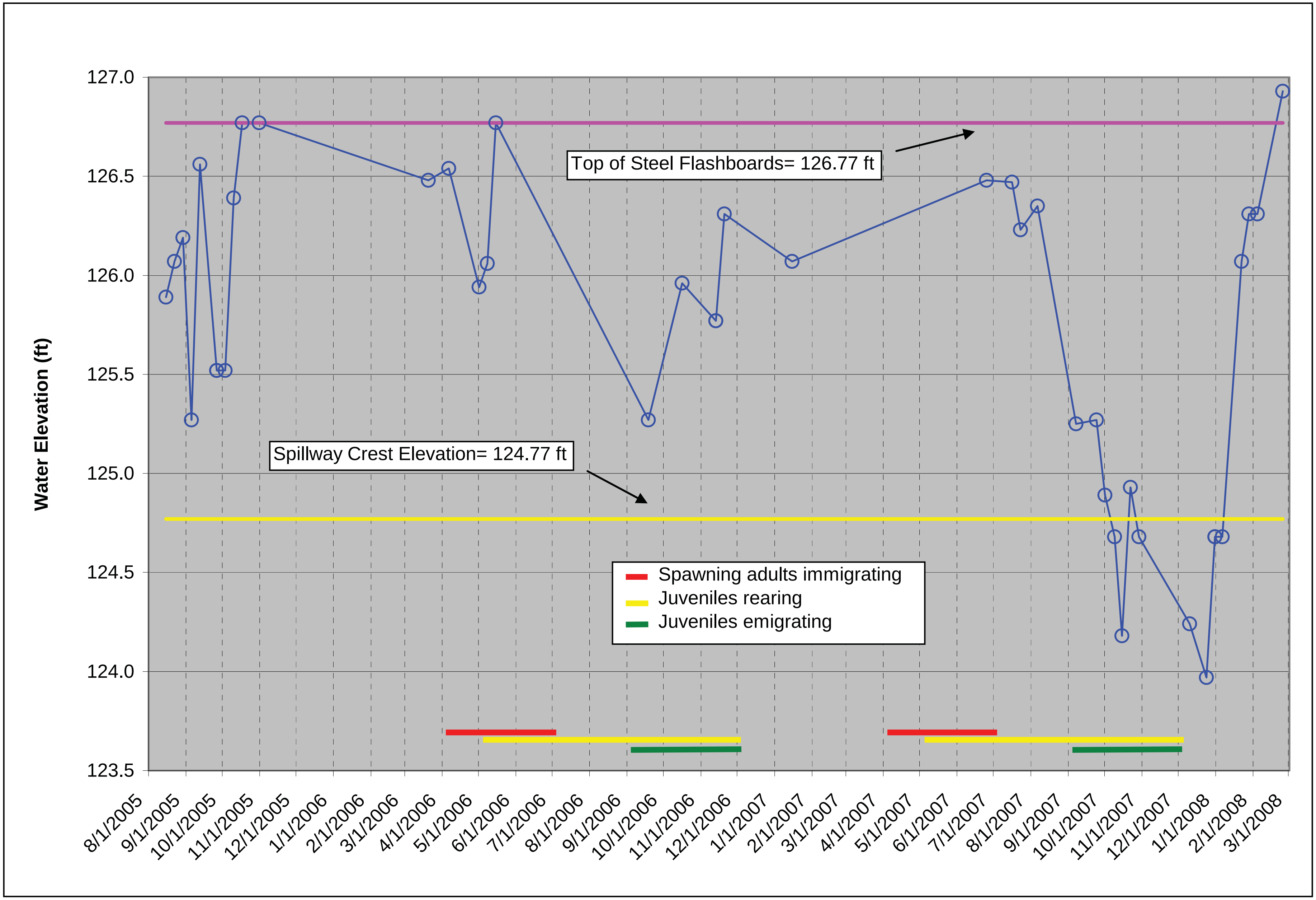


Figure E-5: Great Pond Water Levels (August 2005-February 2008)

Figure E-6: Plan Map of Transect Locations Used in Hydraulic Model (1of 2)

Figure E-6: Plan Map of Transect Locations Used in Hydraulic Model (2 of 2)