Hathaway Pond Dam – Sippican River

Feasibility Study Report

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Prepared for:

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BACKGROUND

The Hathaway Pond dam (Figure 1) is owned by Susan Hampson and is currently not used by the dam owner for any economic purpose. An adjacent cranberry operation, Beaton's Inc., northeast of the dam is using water pumped up from the impoundment as a secondary water source (Figure 2). The dam is classified as a Significant Hazard Potential Dam or a Class II hazard dam (Class III is the highest rating) due to the potential for downstream loss of life and property associated with catastrophic failure of the dam. The owner of the dam is under an order to remove or repair the structure from the MA Office of Dam Safety (ODS), following an inspection in 2006 by GAF Engineering (Appendix A – Dam Inspection Reports) that documented significant structural failures compromising the safety of the structure in its current state. Additional inspections occurred in 2008 and 2009. Following a significant rain event in March 2010, a sinkhole developed in the embankment to the right of the primary spillway, breaching the dam. The sinkhole was temporarily filled with sandbags. After this event, the condition of the dam was downgraded from "Poor" to "Unsafe" and is under a permanent drawdown order from the MA Office of Dam Safety, awaiting either repair or removal by the owner (Appendix B).

The owner offered the dam for sale to other area property owners including those using the water source of Hathaway Pond, without receiving offers or agreements for purchase. In 2008, the Coalition for Buzzards Bay (CBB) entered into an agreement to purchase the eight acre property that includes the dam, contingent on being able to develop a cost effective strategy for addressing the dam safety issue while concurrently improving the ecological conditions of the river, including elimination of the barrier to migratory fish migration associated with the dam. CBB is seeking an alternative to the public safety and environmental problems associated with the dam that does not disrupt the existing adjacent agricultural operations. In 2010 CBB and Beaton's, Inc., the operator of the only agricultural entity currently authorized to draw water from the Hathaway Pond impoundment, formally agreed to cooperate in identifying and implementing a solution to the environmental and safety problems at the dam that will not disrupt the cranberry bog production (Appendix C).

MA Department of Fish and Game conducted a preliminary assessment of the environmental impacts of the dam (Appendix D). The findings from that study indicated the dam was a barrier to natural riverine function and the existing fish ladder was inefficient at passing migrating herring. Inter-Fluve was hired to perform an alternatives analysis of potential solutions that address the safety and environmental issues at the Hathaway Pond site without disrupting adjacent agricultural operations. This report is the result of that effort.

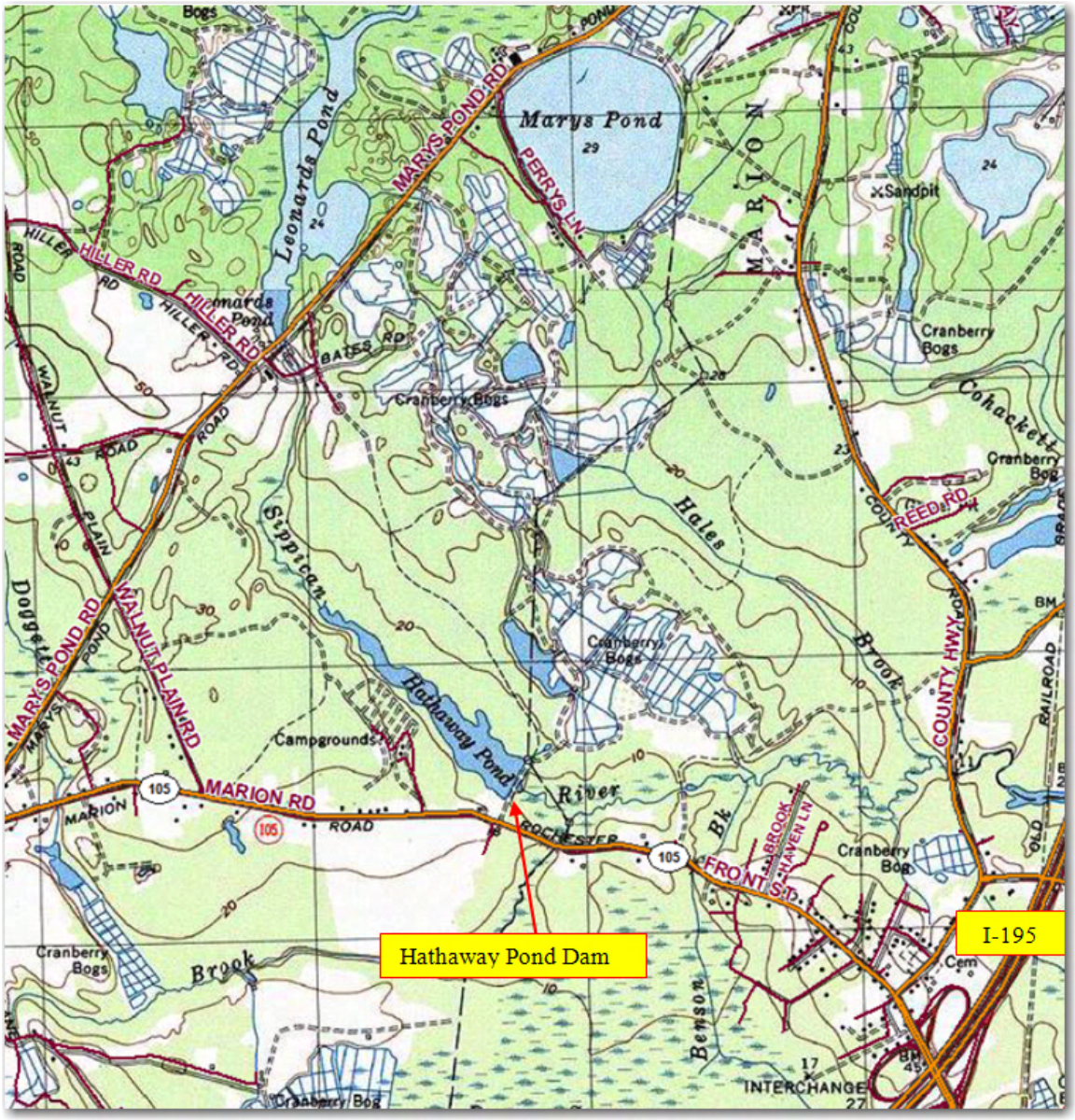

Figure 1: Overview map

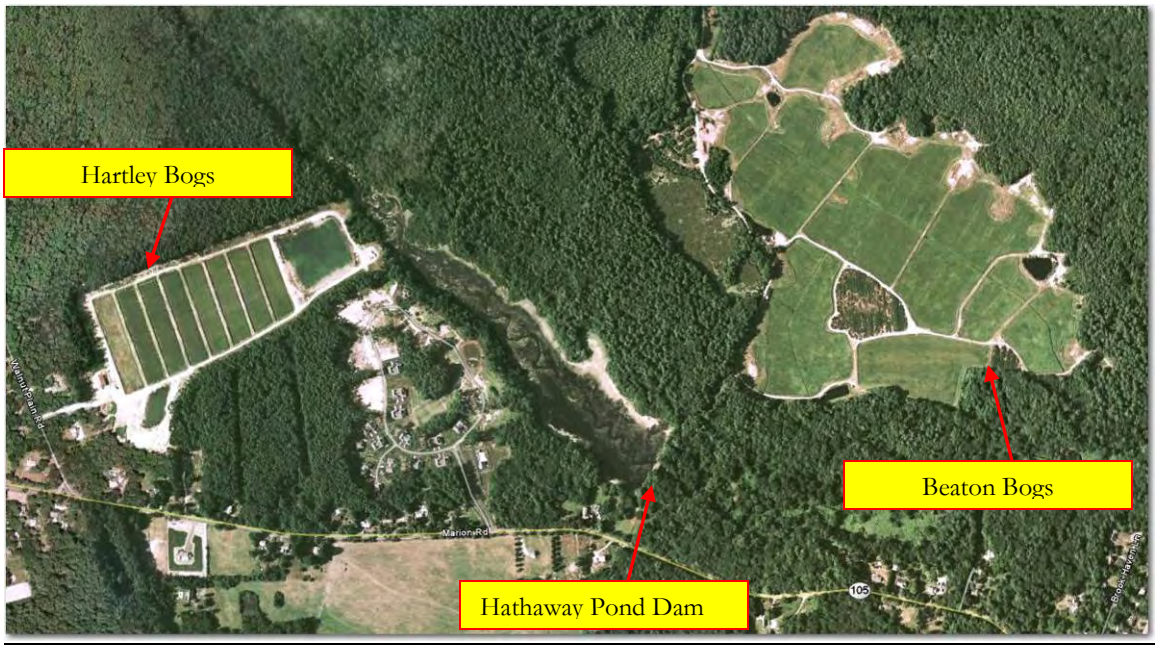

Figure 2: Hathaway pond dam and adjacent cranberry operations

SITE CONDITIONS

Hydrology

Hathaway Pond is a 22 +/- acre impoundment on the Sippican River in Rochester, MA. Upstream of the impoundment, the river channel enters a confined valley on its way up to the Leonard's Pond Dam, approximately 1.5 miles upstream. The channel in this reach is distinct, meandering within tight valley walls. Groundwater appears to enter the valley bottom freely in this reach, evidenced by a number of floodplain wetlands emanating from assumed groundwater seeps along the valley toe. Below the dam the river channel is wide near the spillway, then narrows and meanders through floodplain wetlands to its confluence with the Weweantic River, about 3-4 miles downstream. The bed through this reach was not surveyed specifically but photo evidence indicates coarse gravels and cobbles exist for much of the reach.

Details, analysis, and photos of Hathaway Pond, the dam, and appurtenant structures are included in the 2006 report by GAF Engineering (Appendix A). Based on this report, the impoundment holds approximately 132 acre-feet at normal pool and 200 acre-feet at maximum pool. These results may be overstated, as survey of *only* the centerline of the impoundment by Inter-Fluve revealed average depths in the range of 3-4' at normal pool (Appendix E - Long Profile); less than the 6' assumed for a volume of 132 acre-feet in the GAF Engineering report, and likely less than the bathymetric average within the entire wetted impoundment. Surface and groundwater resources within the 9.5 mi^2 catchment above the dam are highly manipulated for the benefit of agricultural

production of cranberries. The dam at Leonard's Pond upstream of Hathaway Pond, provides water for cranberry operations as well and influences hydrology at Hathaway Pond. Estimates of stream flow statistics in the area are complicated by the glacial geology of Southeastern Massachusetts, however, work performed by the USGS (Bent, 1995 – Appendix I) in the area provides flow duration statistics for a gage (01105905) located about 1.5 miles downstream of the dam (drainage area = 28.1 miles) on the Sippican River at County Road. If an adjustment based simply on the ratio of drainage areas is applied, the resulting line provides an approximate estimate for seasonal flow values at Hathaway Pond (Figure 3).

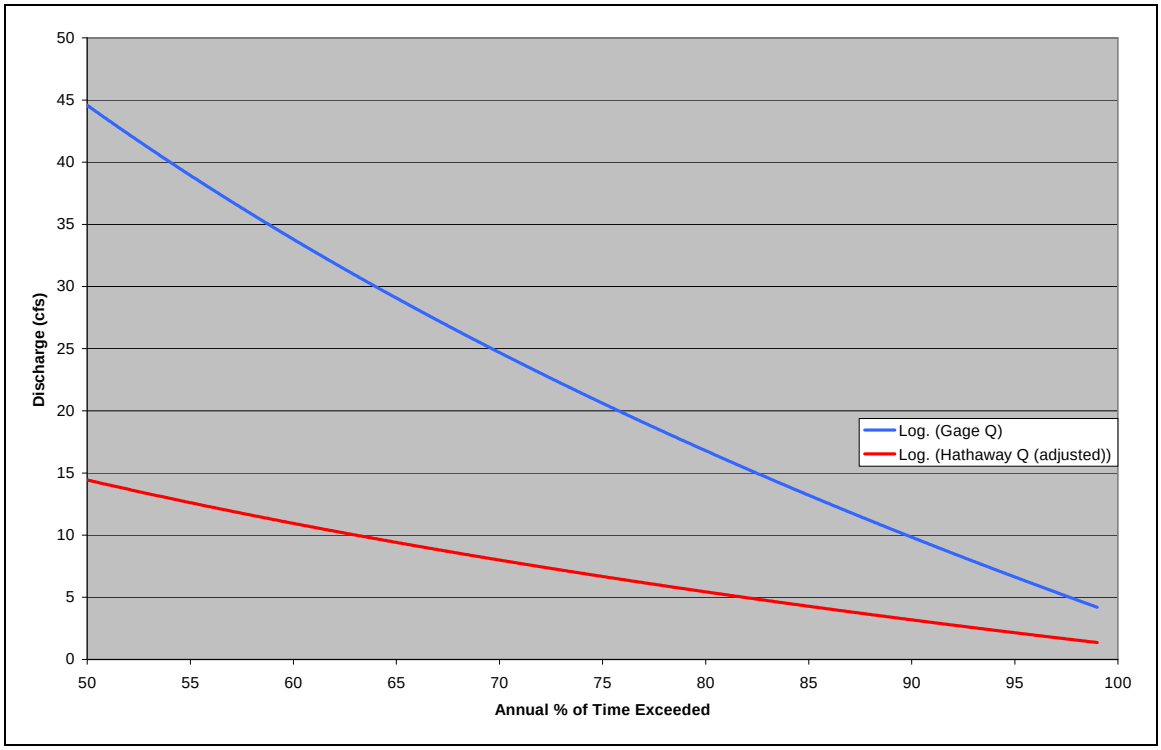

Figure 3: USGS analysis of stream (base) flow duration, Sippican River. BLUE is the curve generated for the gage location, RED is the curve approximated at Hathaway pond.

Impoundment Sediment

The impoundment includes a relic river channel (Figure 4) with substantial sinuosity, indicating sediment accumulation behind the dam is minor. Sediment input to Hathaway Pond would be expected to be minor considering the proximity of Leonard's Pond upstream, a significant sediment trap itself. A survey and depth of refusal sampling completed by Inter-Fluve in 2009 confirmed that the quantity of accumulated sediment is small. To assess the *quality* of sediment within the impoundment, four sediment samples were collected in May 2009 in the impoundment and one sample downstream of the dam. Analysis revealed contaminants in 1 of the 5 samples.

Contaminants, in that sample, that exceeded probable effect concentration levels were mercury, chromium, and copper. Based on the results of the initial sampling, the location of the contaminated sample was bracketed by additional samples located upstream and downstream in May 2010. Analysis of these additional samples did ***not*** find detectable levels of contaminants, indicating the contamination found in the May 2009 sample may be spatially limited. Based on these results, if dam removal is pursued, two options are available to deal with the contaminated sediment. The first is to remove all material between the bracketed "clean" samples taken in May 2010, with the assumption that all of this material is contaminated. The second option is to initiate further testing to better isolate the area of contamination, and potentially reduce the area and volume of contaminated material to be managed during the project. The DRAFT Sediment Management Plan (Appendix F) will be updated to reflect the best approach based on the option pursued.

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Figure 4: Aerial view (7/2007) of the Hathaway Pond in a dewatered condition showing the intact relic stream channel

Cranberry Operations

As mentioned, Hathaway Pond provides a secondary water source to approximately 55 acres of bogs located just north and east of the dam. The water is pumped from a short canal (at the northeast corner of the dam) up and into the bog complex. An agreement was tendered between CBB and Beaton's Inc. (Appendix C) to investigate alternative solutions to providing the necessary water to these bogs that would allow restoration of the Sippican River as well the continuation of cranberry operations on the Beaton property. A report investigating these alternatives was performed by Benjamin Gilmore P.E., guided by the three options of repair, partial breach, and full removal that are outlined in more detail below. The conclusion of the report indicates that the best *long term* solution to maintain cranberry production for the Beaton bogs that rely on Hathaway Pond as a water source is to construct a groundwater fed reservoir on the Beaton property. In addition, maintaining the hydraulic connection of the existing canal and pump apparatus (see Sheet 1 of drawings in Appendix E) would allow some water to be drawn from the Sippican, at the location of the current dam/pump station, if necessary. This conclusion helped guide the alternative analysis for the dam as discussed below, since one of the initial constraints for all alternatives was to avoid disruption of the cranberry operation. All of the alternatives evaluated can meet this constraint with modifications to the existing canal and pump drawing water from Hathaway and modifications to canals and water control structures allowing transfer of water from Leonard's Pond through Hiller Front bogs and into Hiller "Back" bogs, shown in Figure 2. These manipulations will meet the temporary water use requirements of the Beaton bogs to bridge the gap in time between any modification to Hathaway Dam and completion of the recommended groundwater fed reservoir. The full report is included as Appendix G.

Another cranberry bog operation, the Hartley Bogs, is located on the right side (west) of the river near the head of the Hathaway Pond impoundment. Comprised of approximately 15 acres, this operation drains water to, but does not draw water from either the Sippican River or Hathaway Pond. These bogs are not constructed on historic wetlands, but instead the existing ground was excavated down to an elevation where interaction with groundwater would be assured. Concerns have been noted by the bog owners that changes to the water level of Hathaway Pond, associated with dam modification or removal, could affect the elevation of groundwater within their bog system. Data were provided by the Hartley's collected in the mid 1990's from monitoring wells on the property, prior to construction of the bogs. This data (Figure 5 and 6) indicates a variability of approximately 6' in the natural seasonal cycle of groundwater in the area and a spatial variation of approximately 2' at any given moment on the property. The USGS has a long term monitoring well in nearby Wareham. Data from the well are plotted along with the Hartley data to illustrate

agreement. The long term data set from the USGS well is plotted in Figure 7, to illustrate the consistent seasonal trend in groundwater levels in Southeastern MA. The range between maximum and minimum recorded elevation at the USGS gage over 50 years of recording is about 8'.

To ascertain the impact of water surface changes in Hathaway pond on the Hartley bogs, two test wells were dug and monitored on the property beginning in May 2010 by CBB. Concurrent to the placement of the wells, Hathaway Pond Dam was to be drawn down to comply with the safety order from ODS. The anticipated full drawdown of the reservoir did not occur, but a partial drawdown did occur. The data gathered appear to show no causal relationship in any of the three test wells with water elevations in Hathaway Pond (Figure 8 and 9). In addition, the two wells furthest from Hathaway pond exhibit steady seasonal trends consistent with the long term USGS well and the well data from the mid 1990's collected prior to bog construction. Changes in groundwater levels in the well closest to the river did not appear to respond to changes in the water level of Hathaway Pond. This well (CBB #2 in Figure 8) is in the vicinity of the ground/surface water reservoir associated with the cranberry operation, which may be influencing groundwater levels. These data, although limited, seem to indicate that groundwater elevations on the Hartley property are insensitive to the level of Hathaway Pond within the range observed. If Hathaway Dam were removed, the water elevation of the Sippican River might reside around 76' +/- based on review of preliminary survey elevations, approximately 3.5' below the lowest elevation of the pond within the monitoring period.

Figure 5: Locations of Hartley monitoring wells ca. 1994

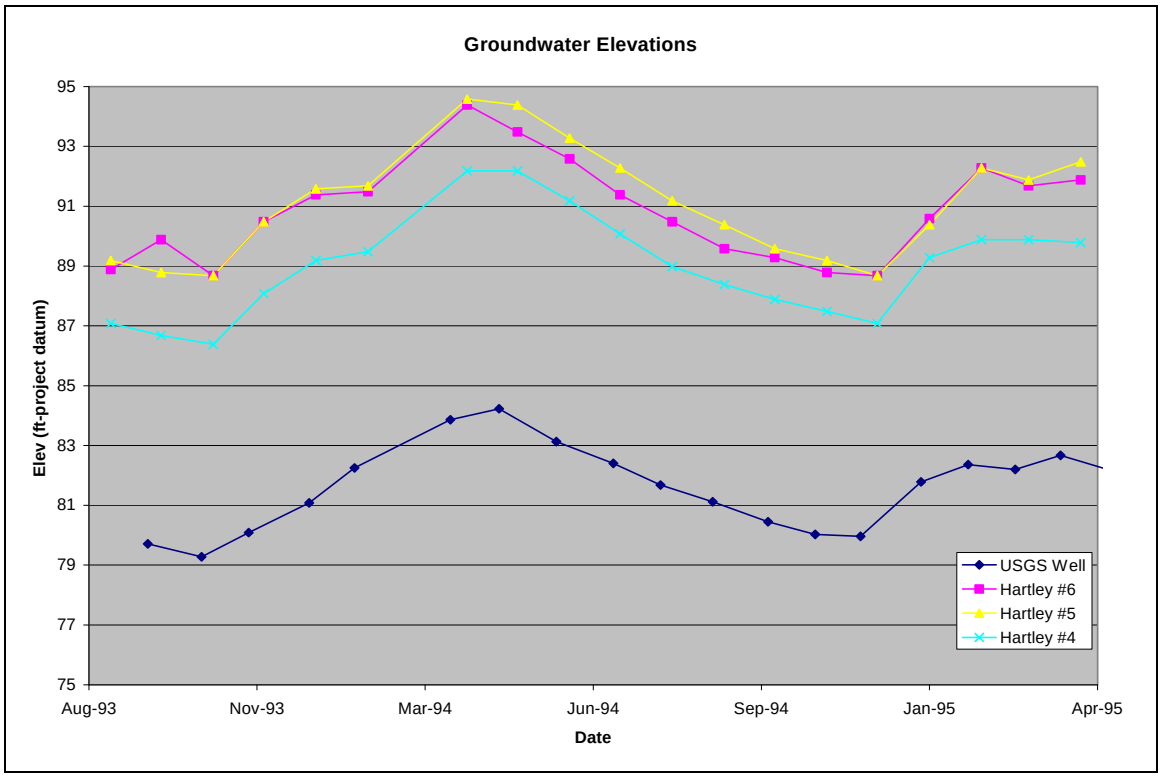

Figure 6: Groundwater elevations from the Hartley property and adjacent USGS monitoring well in Wareham. Well #4 is closest to Hathaway Pond then # 5 and #6

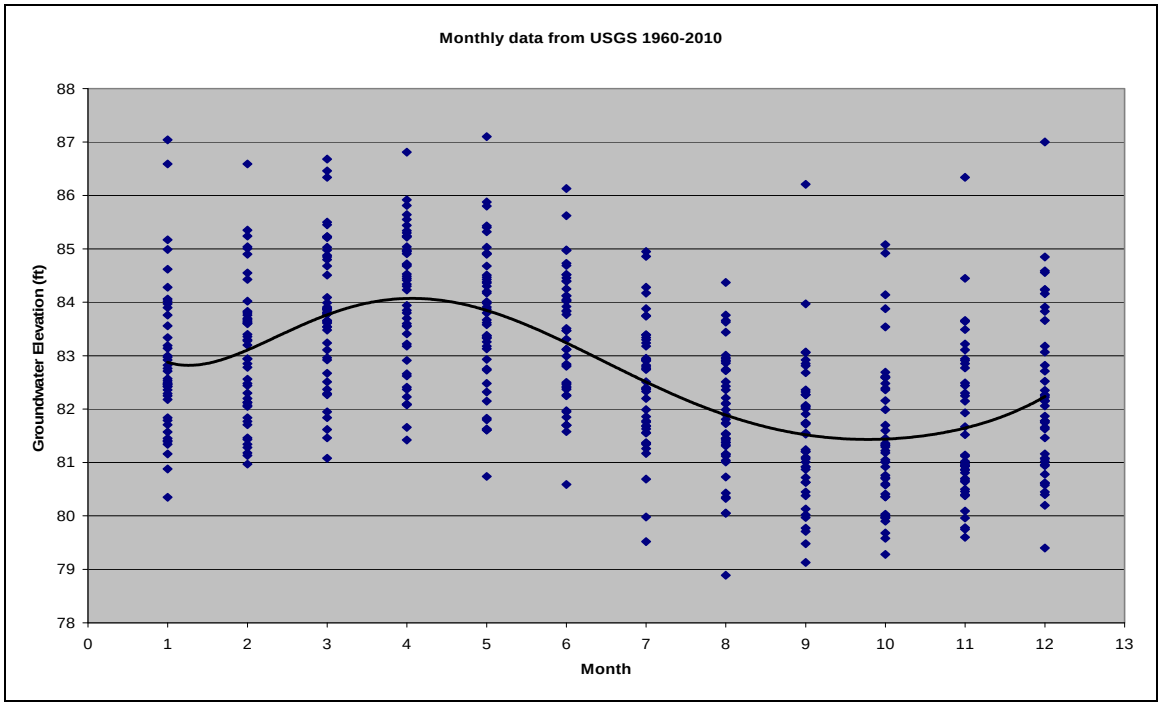

Figure 7: Monthly data from the long term USGS groundwater monitoring well in Wareham. Data range 1960 to present.

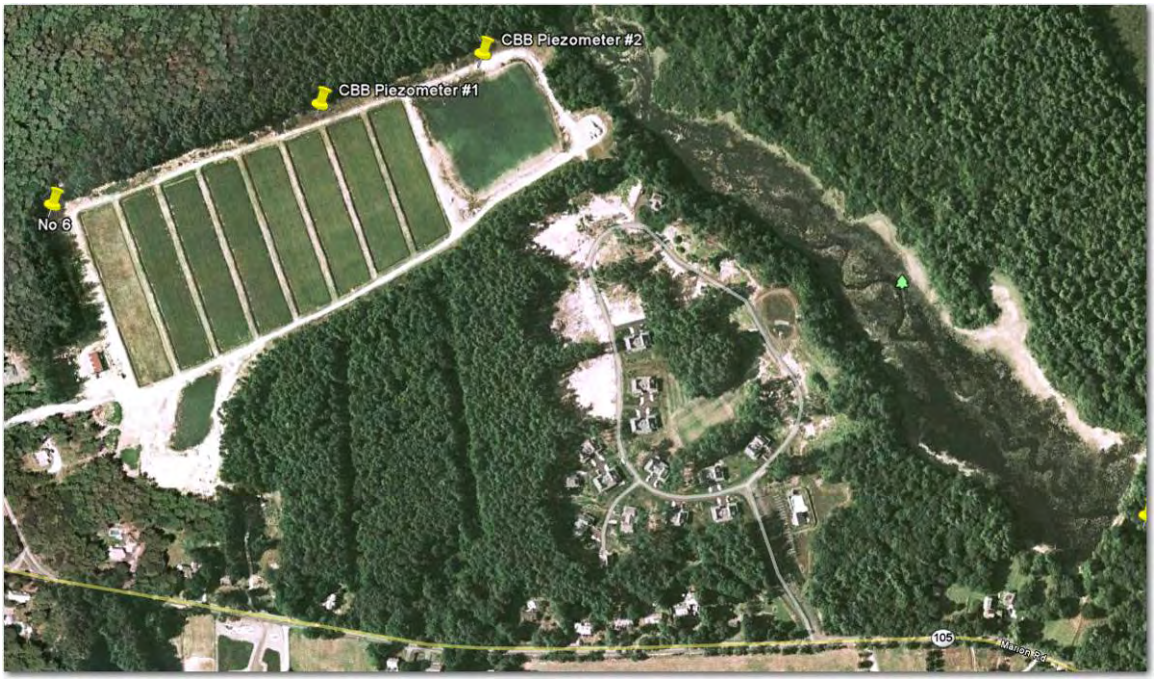

Figure 8: Locations of CBB monitoring wells installed 2010. Note well #6 is the same well used by the Hartleys in their 1994 study

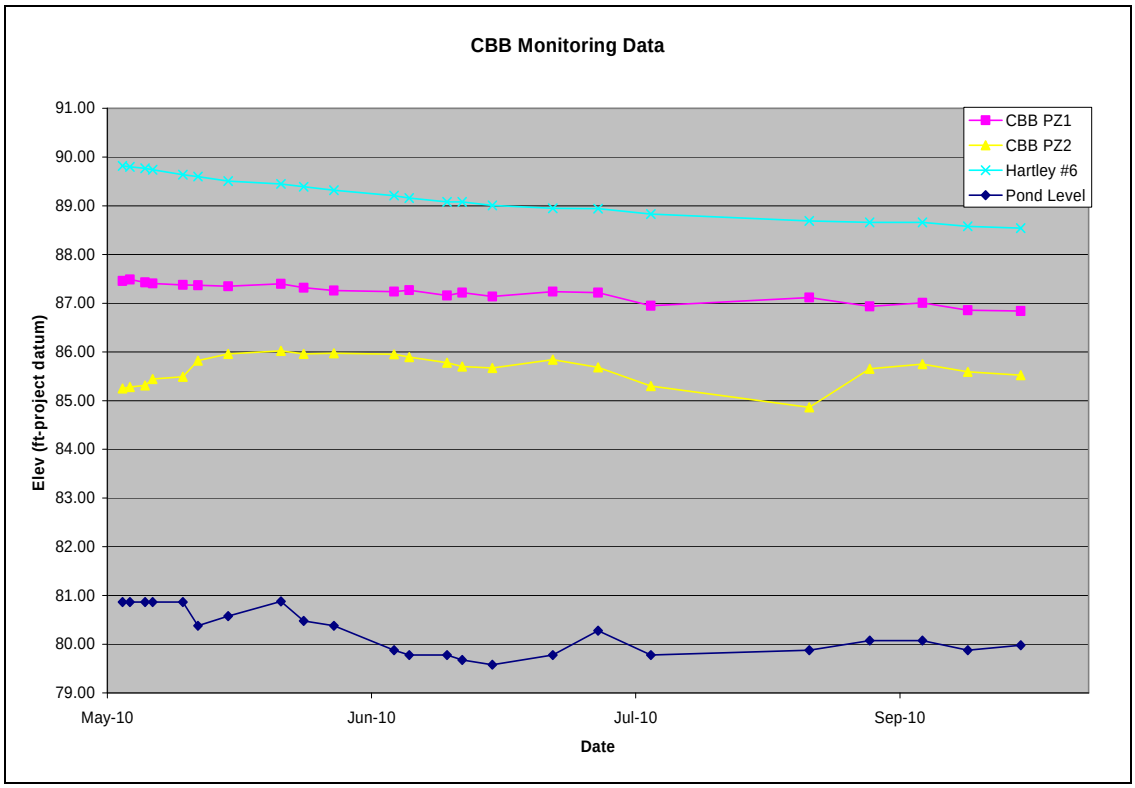

Figure 9: Results of CBB well monitoring and concurrent Hathaway Pond levels

Ecology

The impact of dams on the ecologic function of a river system is well established. The dam structure itself represents a barrier to the natural transport (both upstream and downstream) of water, sediment, and aquatic species. This is of particular concern for anadromous species that historically ascend freshwater streams to complete their life cycle, and are prevented from doing so by dams. The extirpation of Atlantic salmon from much of the northeast is due in part to the impact of dams. Dams create impoundments that displace riverine habitat with lake habitat. This conversion often extirpates riverine species within the impoundment, and also affects reaches below the dam by sending warm water downstream, often extirpating temperature sensitive species (such as brook trout). Because the sediment supply from upstream is effectively shut off, channel erosion often increases in the river below the dam as "hungry water" mobilizes sediment to correct the imbalance. These are a few of the more noticeable impacts, a host of additional impacts related to water quality (dissolved oxygen, nutrient cycling), hyporheic exchange, and non-fish aquatic species exists as well.

The Sippican River is classified as a Riverine Priority Vegetation Community in areas directly north and south of Hathaway Pond. These Riverine Priority Vegetation Communities are one of 8 systems identified by Natural Heritage Endangered Species Program as being "most critical to the conservation of the Commonwealth's biodiversity." Immediately surrounding Hathaway Pond is classified as BioMap Core Habitat, a designation given to large, relatively intact tracts of land that are able to support threatened or endangered species and native communities. Below the dam along the Sippican River are a number of state threatened and endangered floral and faunal species, however none of these have been documented upstream of the dam. The river itself maintains a run of alewife with varying returns ranging from up to 900 fish to as low as a few dozen based on counts completed during various years by Alewives Anonymous. A run of blueback herring has not been specifically identified, but local fish biologists indicate they likely use the Sippican, though in lower numbers than the alewife due to habitat preferences (Steve Hurley, MA DFG, personal communication). It is acknowledged that some alewife spawning may occur in the Hathaway Pond impoundment, but habitat here is limited in quality and in quantity relative to Leonard's Pond (upstream). A habitat evaluation of Hathaway Pond and Leonard's Pond is underway by the Massachusetts Division of Marine Fisheries, but results are not currently available. A concrete sluice with approximately 8 baffles serves as a fish ladder around the Hathaway Pond Dam; however it lacks the attraction flow necessary for fish to effectively find and enter the ladder. It is unlikely that this structure effectively and consistently, passes fish, particularly river herring.

The Sippican River itself is a depressed fishery. Recent fish surveys by MA DFW indicate a total of 9 species of resident (non-anadromous) fish below the Hathaway Pond dam and a total of 7 species of fish below the Leonard's Pond Dam upstream, indicating that natural migration patterns are being affected. Most fish present are habitat generalists, able to occupy both riverine and pond like conditions, typical of disturbed systems fragmented by dams. Local biologists have indicated the Sippican could harbor brook trout habitat, particularly in the area upstream of the dam where groundwater inflow to the stream is substantial from the adjacent valley walls. This species is present in nearby basins, but assumed to be extirpated from the Sippican River.

ALTERNATIVES ANALYSIS

Three alternatives to inform the decision of how to address safety liability and environmental problems associated with the dam have been developed to date. A fourth alternative, a "do-nothing" approach is included as well, simply to underline the existing situation at the site and perhaps future consequences. Associated concept drawings of these alternatives have also been developed (Appendix E). All alternatives were evaluated under the constraint of not disrupting cranberry agriculture, and the Gilmore Report indicates that alternate routing of water from Leonard's Pond and creation of a new ground/surface water reservoir is feasible and preferable to continuing to rely on water from Hathaway Pond for cranberry operations in the Beaton bogs. Gilmore indicates that the construction of the proposed ground/surface water reservoir would be "cost neutral" due to revenue generated from selling excavated soil. The Gilmore Report (Appendix G) does indicate that $15,000-$20,000 of upgrades to water control structures and canals would be necessary to temporarily improve the routing of water from Leonard's Pond, while the reservoir is under construction. All alternatives presented here are thus considered to have no impact to cranberry operations as long as a connection between the river and the existing pump station can be maintained and these temporary upgrades can be made. The costs of maintaining the pump connection and the temporary upgrades to the bog water system are included in alternatives 3 and 4. The narratives for each alternative are organized into a summary, cost opinion, and a discussion of the *important* advantages and disadvantages. A summary table of the advantages, disadvantages, and cost is provided at the end of each discussion.

1. *Do-nothing Option*
    - The existing dam, spillway, and fish ladder are left in situ and their condition is not improved

Summary – Under this alternative, the current ODS order would remain in effect requiring the impoundment to be maintained in a drawn down state. This condition makes the dam less

effective at providing water for cranberry operations, less effective at passing fish and does not permanently address the issue of safety. The cost of ongoing required dam safety monitoring would remain.

Safety concerns would be paramount. A catastrophic failure of the dam has already been identified by the Office of Dam Safety as a scenario to be avoided. Typically such failures, as has already been the case, occur during significant flood events. Even with the spillway completely open, floods in excess of this capacity can build a sizeable volume of water behind the dam.

Liability for such a catastrophic failure would be substantial for the dam owner. In addition, the cost of fines levied from the Office of Dam Safety for continued non-compliance of their order to remove or repair would grow.

Ecological impacts associated with compromised fish passage would remain or worsen as the existing fish ladder would continue to perform poorly. Habitat within the impoundment would be suspended between riverine and impoundment characteristics, reducing the viability of all species that utilize either of the two habitats.

2. *Dam Repair Option*

- Make necessary improvements to fix the existing function and structure of the dam to MA Office of Dam Safety standards
- Add a more effective fish ladder to improve fish passage characteristics

Summary – The requirements to bring the dam into compliance are detailed in the GAF report. Additional review for this study by a structural engineer has added that the concrete spillway should be replaced instead of repaired. Note that no structural review of the dam has occurred since the March 2010 breach and additional measures may be required. The addition of a steep pass fish ladder is intended to improve the attraction flow and fish passage characteristics for river herring over the currently installed ladder.

Cost - Given the hazard classification of the dam coupled with the perpetual maintenance associated with the structure, the indirect costs following the initial capital investment to bring the structure into compliance with contemporary dam standards would be substantial. In addition to the GAF report (2006) where a detailed analysis of total costs (construction and engineering) for repairing the existing structure were estimated at $160K - $200K, a recent review of the structure by a structural engineer (Appendix H) increased that estimate to $330K - $400K based largely on their opinion that the retaining wall on the downstream side of the main spillway had in fact already failed and should be rebuilt to remain viable. Previous reviews by GAF Engineering had not included costs for this continued deterioration. The failure of the earthen embankment in March 2010 indicates

additional work may be required to improve stability of the earthen berm as well. Additional costs associated with this recent failure were not incorporated into this estimate.

All engineered structures have a finite design life and require annual maintenance and eventually replacement. If we assume a 100 year design life for the purposes of understanding this cost, annual maintenance and inspection is likely on the order of $3,000/year and a major rehabilitation of the concrete spillway is required once during the 100 year period at a cost of $300-$400K. These maintenance costs were not factored into the analysis of cost shown below in Table 1, but are important to understand when considering the long term capital required to maintain the structure.

Table 1: Summary of costs for dam repair with a fish ladder

Hathaway Pond - Repair and Fish Ladder Option

Item	Total Cost	Notes
Mobilization	$ 19,800.00	5% of construction total, includes site controls
Dewatering	$ 5,000.00	Pump Around during low water conditions
Concrete Spillway Demolition	$ 8,000.00	Demo, Haul and Dispose
Construct New Spillway Wall	$ 160,000.00	Construct New Concrete Spillway
Construct Repairs Earthen Berm	$ 135,000.00	Make repairs noted in GAF report
Construct Steep Pass Fish Ladder	$ 88,000.00	Steep Pass Ladder
Subtotal	$ 415,800.00	
Contingency (20%)	$ 83,160.00	
Total	**$ 498,960.00**	

Engineering and Oversight

Item	Total Cost	Notes
Final Design	$ 110,000.00	New Spillway Design and Fish Ladder
Construction Oversight	$ 15,000.00	Assume 8 Days Oversight, Includes Structural Oversight
Subtotal	$ 125,000.00	
Contingency (20%)	$ 25,000.00	
Total	**$ 150,000.00**	

A fish ladder added to the main spillway will likely improve attraction characteristics for migrating alosids such as river herring, thereby incurring a net improvement in fish passage at the dam over the existing structure for these species. However, passage by resident species of fish, which still need connectivity of habitat for refuge, diversity and for different life history needs, likely will not be passed by this structure. Costs for fish ladders vary by the type of ladder, size, and materials

utilized in construction. Recent cost data (Figure 10) from installations across the New England area have been compiled by NOAA (Turek et al. 2007)

Fishway Costs (2007$)[1]

Fishway Type	Cost Range	Cost/ Foot Rise
Steep Pass (17)	$30,133 - $624,653	$21,899
Pool-and Weir (4)	$83,507 - $341,242	$37,947
Denil (5)	$374,049 - $470,469	$40,644
Nature-like (10)	$25,580 - $620,685	$36,653

[1]Costs include design, permitting and construction; excludes fishway repair projects and dam repair costs

Figure 10: NOAA cost data for fishways in the northeastern USA (Turek et al 2007)

Draft criteria for choosing an optimum configuration to pass shad or river herring, indicates that ladders should be <3 m (9.1 ft) and feature a minimum slope of 6H:1V (personal communication, A. Haro, USGS Conte Anadromous Fish Laboratory, Turners Falls, MA). The head at Hathaway Pond is within this range and a steep pass or denil fishway could be constructed near the location of the primary spillway. Based on an initial survey completed by Inter-Fluve, the difference between upstream and downstream water elevations at the dam can vary from 4-6'. If we assume an average of 5' for estimating purposes, a denil structure may cost $200K and a steep pass structure on the order of $110K. These costs are based only on the design and construction of a fish ladder and are independent of other repairs necessary at the dam. Based on recent discussions with USGS researchers, a clear advantage does not exist between denil or steep pass structures, thus the lower cost option is preferred.

Important Advantages – The addition of a fish ladder does provide an improvement for passage of river herring, though passage for resident species is likely not addressed, thus continuing to limit range, connectedness and access to habitat for most fish species in the Sippican River. Development of alternate water sources for the Beaton bogs may not be necessary with this alternative.

Important Disadvantages – Cost and liability are the two most important factors against pursuing this option. The short term capital expenditure and long term maintenance costs far outweigh any marginal advantages. The liability associated with owning a dam, particularly a high hazard structure, is difficult to quantify, but tends to be avoided when considering risk and asset management decisions.

Repairing the dam provides no restorative effect on the river system, although the fish ladder as stated above, may improve passage for river herring over the existing structure.

Table 2. Dam Repair Option with Fish Ladder

Estimated cost	*Advantages*	*Disadvantages*
$648,960 *(Plus: $3000/year estimated annual maintenance cost, and one major overhaul per 100 years)*	• Maintain full volume of Hathaway Pond for irrigation • Improvements to dam stability • Slightly improved fish passage for river herring from current conditions	• Significant capital expense (and not eligible for ecological restoration funding grants) • Significant maintenance expense • Significant liability risks • Maintains significant dam hazard rating • No restoration of natural river habitat or river processes (including temperature and dissolved oxygen) • Fish passage for resident species is likely not improved • Least effective option for passage of diadromous fish

3. *Partial Removal Option*
    - Add a fishway / roughened channel that would improve fish passage characteristics beyond that of a fish ladder option
    - Remove the state designation of the term "dam" from the property, and the associated annual maintenance, inspection, and liability associated with dam ownership
    - Maintain a connection with the draw point of the exiting pump system
    - Provide an alternative with costs between repair and removal

Summary – The partial removal option features the removal of 2.0' of the crest elevation of the dam, installation of a natural step pool fishway. Figure 11 illustrates a similar approach on the nearby Acushent River.

Figure 11: Fishway at a dam on the Acushnet River

Ideally this alternative would remove the significant liability and maintenance cost associated with dam ownership, but because a hydraulic structure remains in place, both liability and maintenance remains, although at a lower level. Both of the following criteria must be met to remove the dam from the Office of Dam Safety (ODS) roster; <6' of head at the design 100 year flow and <15 acre-feet of impounded water at this flow. Even if these two requirements are met, the Director of ODS may, at their discretion, continue to require annual inspections and maintenance due to an assumed hazard to the public. Preliminary discussions with ODS indicate that this dam likely would qualify for such an extension of the statute. Without a clear solution that removes the liability of dam ownership, the focus of this alternative moves toward maintaining a smaller impoundment, with a lower dam, while improving fish passage.

The incorporation of the natural fishway will provide fish passage to a greater range of species at various life stages. The fishway will be placed on a gradual slope, less steep than a fish ladder. The construction of this fishway includes some key challenges. The valley bottom below the dam is wide and flat, and will require the fishway channel to be elevated above the floodplain down to meet the existing channel. One bank boundary for the fishway channel can likely be the dam embankment itself, but the other will need to be constructed of fill, which will likely create wetland impacts. These impacts may be offset by restoration in the upstream impoundment, but this cannot be verified without more detailed design. The inlet of the fishway at the dam is an extremely critical area, as the inlet must be structurally substantial and controlled to convey an average flow with

suitable hydraulics for fish passage. Larger flows must quickly spread out and occupy the primary spillway to dissipate energy.

The dam itself will undergo a significant change. The current spillway will be removed and replaced with a long (approximately 130') primary spillway with a fixed elevation crest. The crest will be reinforced with either articulated block or rip rap, providing a hard, flexible lining to accommodate the 100 yr event design flow. The fishway will occupy a portion of this spillway and will act as a secondary spillway structure, handling flows consistent with annual average volumes. The remaining portion of the dam (approximately 370') will be repaired following the recommendations in the GAF report.

The Gilmore Report indicates the long term solution to providing water to the Beaton bogs is the construction of a groundwater fed reservoir. However, the current canal and pump configuration may be able to provide supplemental water to the Beaton property if the canal were deepened to ensure interaction with the new water level in the Sippican. Further, existing water from other bogs on the property (labeled "Hiller Front" in the Gilmore Report) can be routed through the Beaton bogs (labeled "Hiller Back" in the Gilmore report) to provide the necessary volume of water for cranberry operations while the groundwater reservoir is being constructed.

Cost – The cost associated with option 2 is shown below in Table 3. The structure will still be maintained as a dam and thus will continue to have the long term maintenance and monitoring costs associated with it. The major cost of replacing the concrete spillway will be removed, leaving an annual maintenance cost of $3,000/year, though these may be reduced depending on the final configuration of the structure (see discussion under full removal option above). The spillway is made of a flexible rock lining as opposed to a rigid concrete structure and therefore will have a longer design life associated with it. Other repairs required for the dam under the GAF report were included, based on the linear feet of dam remaining outside the footprint of the new spillway/fishway construction. Contaminated sediment appears to be a minor component if it plays a role at all in this option and is not explicitly noted in the costs. Costs associated with providing water to the Beaton bogs will focus largely on the construction of the groundwater reservoir noted in the Gilmore Report. Costs for improvements to the canal and pump system are highly dependant on the final configuration of the dam, but a median value for planning purposes is listed as $10,000. Median costs for improvements to the existing drainage paths to pull water from "Hiller Front" into "Hiller Back" are listed as $20,000.

Table 3: Summary of costs for partial removal

Hathaway Pond - Partial Removal Option

Item	Total Cost	Notes
Mobilization	$ 11,000.00	5% of construction total
Dewatering	$ 5,000.00	Pump Around during low water conditions
Concrete Spillway Demolition	$ 8,000.00	Excavator with a Thumb, Haul and Dispose
Partial Earthen Berm Removal	$ 1,750.00	Remove 2' depth of 130' of Earthen embankment
Construct Primary Spillway	$ 15,000.00	Rip Rap Primary Spillway
Construct Earthen Berm Repairs	$ 100,000.00	Make repairs noted in GAF report, NOT covered by other tasks
Construct Fishway	$ 50,000.00	Includes 120' Fishway and Inlet Construction
Revegetation	$ 2,000.00	BRS trees/shrubs NO seed; Assumes volunteer Install, Materials only
Pump Canal Improvements	$ 10,000.00	Deepen and widen existing canal to pump to maintain water connection, add headgate and fish screen to inlet
Beaton Drainage Improvements	$ 20,000.00	Improve drainage on Beaton property to allow water flow from "Hiller Front" to "Hiller Back" bogs.
Subtotal	$ 222,750.00	
Contingency (20%)	$ 44,550.00	
Total	**$ 267,300.00**	

Engineering and Oversight

Item	Total Cost	Notes
Final Design	$ 65,000.00	Includes Spillway Design and Fishway design
Construction Oversight	$ 15,000.00	Assume 8 Days Oversight, Includes Structural Oversight
Subtotal	$ 80,000.00	
Contingency (20%)	$ 16,000.00	
Total	**$ 96,000.00**	

Important Advantages – The primary advantage of this option is improvements to fish passage relative to the dam repair option. A secondary advantage is cost, in that this alternative is less expensive than the full repair option.

Important Disadvantages – Several disadvantages present themselves under this option. First the long term maintenance and liability costs associated with the ownership of a dam would continue. Maintenance may be less, given the new spillway configuration, but will not be eliminated. The added fishway will provide passage for a greater range of species and life stages of fish over both the existing structure and the fish ladder option; however it remains a contrived approach to passage and is not ideal for movement of fish. Funding for this option may be limited as many restoration funding sources view partial removals as less desirable to complete removals when allocating limited restoration funds.

The last, and perhaps the most, important disadvantage is that this scenario does not restore natural river processes. Sediment transport, natural disturbance regimes, the fluid transfer of flora and fauna along the river corridor and water quality characteristics, including temperature and

dissolved oxygen, are still altered by the presence of this dam. The only improvement over existing conditions is some improvement in fish passage, and perhaps the transition to more emergent wetlands near the upper end of the impoundment.

Table 4. Partial Removal Option with Natural Fishway

Estimated costs	*Advantages*	*Disadvantages*
Partial Removal and Fishway *$363,300* *(Plus: $3000/year annual maintenance costs)*	• Larger water volumes available in impoundment for cranberry irrigation (but does not prevent need for utilization of alternate water supplies*) • Improved fish passage from current condition • Improvements to the stability of the dam • Decreased risk of dam failure *See Gilmore Report	• Dam maintenance costs remain • Liability associated with dam ownership remain • No restoration of river process • Fish passage is not maximized • Fewer funding options • Long term maintenance of fish passage structure necessary to maintain effectiveness • Still no passage for some resident fish native to natural low gradient of Sippican River • Some temperature and dissolved oxygen impacts remain • No guarantee that dam will be removed from dam safety requirements • Alteration/fill of wetland resource and buffer zone alterations required for fishway construction could create permitting difficulties

4. *Full Removal Option*

- Completely remove the dam and earthen embankment
- Minimize downstream sediment transport from impoundment
- Provide optimal fish passage for ALL species
- Restore river processes and function
- Maintain a connection via the existing canal to the Sippican River for pumping water

Summary – A preliminary investigation into the removal of the Hathaway Pond dam revealed a relatively uncomplicated project for full removal. Sediment sampling results indicate minor contamination in the impoundment in only 1 of 4 samples (Appendix F). Follow-up sampling failed to replicate this contamination, indicating contaminants may be limited in their spatial extent. An

investigation into the volume of sediment accumulated in the impoundment indicated very little sediment is present, and a full removal could be expected to discharge little material downstream. The presence of a relic channel (Figure 4) in the impoundment provides a historic and effective planform channel for the restored river to occupy following removal. Construction would occur during low flow conditions beginning with the removal of the primary concrete spillway. The earthen embankment would then be removed and graded into existing floodplain elevations on either side of the former dam footprint. For this study, removal of the *entire* berm was assumed, though if designed, a portion of the berm may be left intact as dictated by the hydraulic conveyance under large flood events. As with the Partial Removal option above, additional excavation and perhaps the installation of a head gate structure and a fish screen would be required to maintain the hydraulic connection between the existing canal and the new river channel. Habitat restoration within the impoundment channel may be performed using logs placed by an excavator to accentuate pools and restore areas of local scour that build microhabitat within the channel bed. A pedestrian bridge may be installed to allow access across the river at the current location of the dam to maintain connections between Rt. 105, hiking trails and adjacent conservation lands.

Cost - The management of sediment and restoration of a river channel following dam removal account for a majority of both design and construction expenses associated with these projects. Preliminary results seem to indicate that both of these issues are at the extreme minimum in terms of cost and complexity if full removal were pursued. Little if any maintenance costs are associated with this option.

Costs associated with maintaining water for the Beaton bogs are the same as described above under the partial removal option. Some additional expense is anticipated to deepen the canal that provides water to the existing pump, as full removal decrease the water elevation of the Sippican further than a partial removal scenario. For this, $5,000 was added to account for additional excavation, bringing the estimated median cost for this effort to $15,000. The cost to retrofit existing drainage structures to move water from Hiller Front to Hiller Back remains approximately $20,000.

Optional expenses include pedestrian bridge and channel restoration features within the former impoundment, but the advantage is only in creating habitat more quickly following removal, as the habitat will develop on its own in the years following dam removal. A pedestrian bridge can take many forms and thus entail a range of costs depending on the intended use and design. A median cost of $20,000 is assumed here for planning purposes.

Table 5: Summary of costs for full removal

Hathaway Pond - Full Removal Option

Item	Total Cost	Notes
Mobilization	$ 5,000.00	5% of construction total
Concrete Spillway Demolition	$ 8,000.00	Excavator with a Thumb, Haul and Dispose
Earthen Berm Removal	$ 22,500.00	Remove 500' of Earthen embankment
Sediment Management	$ 20,000.00	Includes special handling of a limited volume of material and sediment trap maintenance
Revegetation	$ 6,000.00	BRS trees/shrubs NO seed; Assumes volunteer Install, Materials only
Pump Canal Improvements	$ 15,000.00	Deepen and widen existing canal to pump to maintain water connection, add headgate and fish screen to inlet
Beaton Drainage Improvements	$ 20,000.00	Improve drainage on Beaton property to allow water flow from "Hiller Front" to "Hiller Back" bogs.
Subtotal	$ 96,500.00	
Contingency (20%)	$ 19,300.00	
Total	**$ 115,800.00**	

Engineering and Oversight

Item	Total Cost	Notes
Final Design	$ 45,000.00	Assumes minor sediment management and permitting
Construction Oversight	$ 8,000.00	Assume 5 Days Oversight, Double if Habitat Features Included
Subtotal	$ 53,000.00	
Contingency (20%)	$ 10,600.00	
Total	**$ 63,600.00**	

Optional Items

Pedestrian Bridge	$ 20,000.00	Ped Bridge across existing dam site
Construct Channel Habitat Features	$ 20,000.00	Includes LWD, Some pool excavation
Subtotal	$ 40,000.00	
Contingency (20%)	$ 8,000.00	
Total	**$ 48,000.00**	

Important Advantages - The full removal option effectively and completely removes the unsafe structure currently under an enforcement order by ODS. In addition it ensures the most effective restoration of fish passage for both resident and migratory species of fish, regardless of species, age or size. Further, full removal restores the physical processes associated with annual flooding and sediment transport that characterize natural river systems. These two processes are the foundation for the formation of complex habitats, both in the channel and the restored floodplain, required for sustaining a diverse and healthy community of riverine flora and fauna. The removal of the pool behind the dam decreases the effects of solar heating, returning the downstream reach to a more normal thermal regime. The full removal option is the least expensive of the three options and carries with it little additional costs associated with maintenance. Long term exposure to risk and liability would not be a factor since the dam would cease to exist.

Important Disadvantages – No obvious disadvantages to dam removal present themselves within the limits of this study.

Table 6. Full Removal Option

Estimated costs	*Advantages*	*Disadvantages*
Full Dam Removal *$203,400 – assuming no habitat restoration* *$227,400 – with habitat restoration* *(Annual maintenance cost: none)*	• 100% fish passage for all native species migratory and resident • Restored natural river processes • Restored floodplain wetlands • Improved water quality • Eliminated public safety risk • Funding available for removal and sediment management through habitat restoration programs • Low cost	• none

RECOMMENDATION

As mentioned above the dam has been permanently drawn down under order from MA Office of Dam Safety following the collapse incident in March 2010. Thus, the dam's current status quo is in a state where safety liability issues remain, safety monitoring/reporting is required, and fish cannot adequately pass. While the Hathaway Pond Dam impoundment has been previously utilized as a secondary source of water for the Beaton's/Hiller bog system, the current regulatory order over the Dam by the MA Office of Dam Safety makes the previously used volumes unavailable. These things will not change until some action is taken.

The cost to make these volumes available again through repair of the dam structure is estimated at approximately $650,000 plus annual maintenance and liability insurance costs, but this offers limited benefit to environmental issues caused by the dam (barrier to most fish passage, habitat impacts and altered riverine processes remain intact). In light of these significant costs and disadvantages as well as the Gilmore Report conclusion that an adequate alternative water source could feasibly be developed to supply the adjacent cranberry bog operation, the most cost effective and beneficial alternative would be to remove the dam and concurrently develop the alternate water supply for the Beaton bogs as outlined in the Gilmore Report. This alternative is the lowest cost at approximately $180,000, has the highest likelihood of being funded through existing habitat restoration grant programs, does not disrupt the adjacent agricultural operations, and provides the most significant environmental benefits.

Table 7: Cost summary table

	Repair	*Partial Removal*	*Full Removal*
Construction	$ 498,960	$ 267,300	$ 115,800
Optional Construction Items	-	-	$ 48,000
Final Design & Oversight	$ 150,000	$ 96,000	$ 63,600
Total	$ 648,960	$ 363,300	$ 227,400

All estimates assume the following:
- 20% Contingency
- Specifics such as disposal locations, private property access, and impoundment access can be expected to impact costs
- These costs are based on a coarse level analysis of each option and are expected to change during final design
- Permitting is included in Final Design and Oversight

REFERENCES

Turek, J.; Cavallero, L.; Linder, C. 2007. Economic Costs of Diadromous Fish Passage in the Northeast. Presentation at the 2007 American Fisheries Society Conference, San Francisco, CA.

Bent, G. 1995. Streamflow, Ground-Water Recharge and Discharge, and Characteristics of Surficial Deposits in Buzzards Bay Basin, Southeastern Massachusetts. U.S. Geological Survey Water Resources Investigations Report 95-4234

APPENDICES

A	–	Dam Inspection Reports 2006, 2008, and 2009
B	–	Office of Dam Safety Order
C	–	CBB – Beaton Inc. Agreement
D	–	MacBroom Report on Hathaway Pond for MA DER (former Riverways)
E	–	Concept Drawings for Hathaway Pond
F	–	DRAFT Sediment Management Plan
G	–	Benjamin Gilmore Report on Beaton Water Supply Needs
H	–	Structural Review of Hathaway (2010)
I	–	USGS Report on SE Massachusetts Hydrology