

BRIEFING PAPER

ON PAST AND PROPOSED MANAGEMENT
OF THE HERRING RIVER ESTUARY

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Environmental History of the Herring River Estuary

The Herring River and associated salt marshes in Wellfleet (MA) represent the largest riverine estuarine system within the Cape Cod National Seashore. Core analysis has shown that salt marshes first became established about 2000 years before European settlement (Roman 1987). Several meters of salt marsh peat have accumulated since that time throughout the estimated 1000-acre wetland.

With seventeenth century settlement, two millennia of natural marsh development, subject only to a long-term sea-level rise, episodic storms and normal coastal processes (such as natural inlet closures during the last two centuries at Bound Brook and Duck Harbor), were interrupted with the sequential emplacement of dikes blocking tidal flow to salt-water marshes. By 1909, the entire system to the river mouth at Chequesset Neck had been diked, usually for the stated purpose of reducing breeding habitat for salt marsh mosquitoes (probably *Aedes sollicitans* and *A. cantator*) (Whitman & Howard 1906). The final 1909 diking was undertaken amid controversy and concern for the effects of the structure on salt hay production and the lucrative herring fishery. Salt hay farms disappeared (Snow 1975) and the herring run, whose annual auction at the turn of the century produced enough income to pay all elected officials in the Town of Wellfleet, shortly declined. The mosquito nuisance persisted, however, causing the town to dig drainage ditches in the originally salt, now freshened, marshes behind the dikes (Town of Wellfleet Annual Reports, Portnoy & Reynolds 1997).

During the 1920s and 1930s, the freshened mainstream was channelized and straightened from High Toss Road to the present Route 6 to enhance drainage. Still, nuisance mosquito problems persisted. The Chequesset golf course was constructed around 1934 within the Mill Creek sub-basin; several fairways were established, with apparently little filling, on the originally intertidal marsh. Around 1959, as a large portion (ca. 80%) of the Herring River flood plain was incorporated into the newly authorized Cape Cod National Seashore, developers built some houses within the 10-ft MSL elevational contour (i.e. the 100-year flood elevation) landward of the dike.

By the time of Seashore establishment in the early 1960s, and after 5 decades of diking and drainage, most of the original emergent marshlands had given way to freshwater wetland plants (Snow 1975). Upland shrubs and trees invaded hundreds of acres of flood plain between High Toss and Old County Roads where saltwater wetland values were lost, and, because of the drainage, not

replaced by those associated with freshwater wetlands.

By the early 1970s, the original tide gates had deteriorated to the point where considerable seawater was again entering the system (Moody 1974, Snow 1975). Oysters and soft-shell clams began to re-colonize above the dike; low areas of the golf course were occasionally flooded with seawater; and the two homeowners in the flood plain apparently felt threatened by a flood hazard. Debate about the rebuild was apparently intense, and local residents proposed an alternate plan to provide tidal restoration to Old County Road. Salt marsh ecologists recommended tidal restoration (Snow 1975); however, the restoration plan failed at Town Meeting. Thus the state allowed, and partially financed, the reconstruction of the dike in 1974 but with conditions set by the local conservation commission that: 1) the tide water levels observed during dike failure be maintained to sustain re-colonizing shellfish and finfish; 2) the repair allow the free passage of alewives through the dike (Massachusetts Department of Natural Resources. Order of Conditions, DNR 77-2 for Reconstruction of the Herring River Dike issued 13 December 1973 and supplemented by Order of Extension issued on 4 February 1975).

Throughout the late 1970s, the Association for the Preservation of Cape Cod supported studies to document tide heights and vegetative cover above the dike (Moody 1974, Snow 1975), and lobbied for salt marsh restoration. Tide height monitoring showed that the new dike's gate opening was too small to achieve the tide heights prescribed in the Order of Conditions, and local fishermen complained that siltation had increased and shellfish had declined since the new dike was built (letter dated 20 March 1979 from State Attorney General's office to Massachusetts Coastal Zone Management). However, town officials, to whom the state had given control of the tide gates after reconstruction, did not implement any increases in sluice-gate opening.

In 1980 and 1981, the National Park Service, at the request of the state Attorney General's office, measured tide heights and found them to be well below the levels prescribed in the order of conditions (Portnoy 1981, 1982). Around the same time, the Department of Environmental Quality Engineering, now Department of Environmental Protection (DEP), was monitoring the effects of the new dike and advised the Attorney General that salt marsh vegetation and water quality were declining, and sediment was accumulating, in the river due to the new restriction on tidal flow (memo from DEQE to Attorney General's office dated 22 August 1983). The Attorney General then required and received control of the gates from the Town, and DEQE staff began to open the dike's sluice gate in small increments both to comply with the legally mandated conditions on the rebuild and to allow a scientific evaluation of possible restoration alternatives (Roman 1987, see below).

The Rationale for Tidal Restoration

The rebuilding of the Herring River Dike was very controversial because, by the early 1970s, scientists, resource managers and the public were beginning to understand that salt marsh estuaries had important social, economic, cultural and aesthetic values. As early as 1973 eminent estuarine ecologists John Teal and Ivan Valiela, of Woods Hole Oceanographic Institution and Boston University, respectively, recommended that the Town restore the salt marsh by replacing the dike with a bridge. Since that time a huge body of literature has accumulated that demonstrates the role of productive salt marshes in pollution control, storm surge protection, fish and shellfish nursery habitat, waterbird use and overall near-shore marine productivity. It has also been shown that the

productivity of New England salt marshes increases along with increasing tidal range (Steever et al. 1976).

Local people also expressed concern that the rebuilt dike may impede herring passage, a concern voiced at the time of the original dike proposal (Whitman & Howard 1906) and repeated recently by the Division of Marine Fisheries (Phillips Brady, personal communication 2003) who has management responsibility for anadromous fish in Massachusetts. Wellfleet town records (1885-1945) show a precipitous decline in proceeds received from the annual herring auction around the time of dike construction, and a dramatic increase in funds spent on “mosquito control”, mostly ditch digging, after dike construction in 1909 (Portnoy & Reynolds 1997).

Some have argued that the diking of the Herring river has created thriving brackish and freshwater wetlands that should be preserved by protecting them from tidal flow and salinity; however, ecological and water quality research by NPS and others over the past two decades shows that the wetlands above the dike are degraded and depauperate. The exclusion of seawater and lowering of the water table has allowed invasive and exotic *Phragmites* to replace native salt marsh grasses in portions of the diked marsh that are low and have therefore remained wet (e.g. below High Toss Road). Drier portions of the old salt marsh, i.e. areas effectively drained between High Toss and Old County Roads, are hardly wetlands at all having been rapidly invaded by trees and shrubs, again including exotic species, especially since 1960.

In addition, in the early 1980s NPS scientists documented major water quality problems associated with the long history of diking and drainage, including surface water acidification, the release of toxic metals (Soukup & Portnoy 1986) and oxygen depletion (Portnoy 1991), each causing repeated and massive fish kills (Portnoy et al. 1987) and probably contributing to the mosquito nuisance. For example, acidity was so high in the fall of 1980 that even large American eels (*Anguilla rostrata*) were killed by the thousands from just above the dike to Route 6. Fish abundance and diversity drops radically above the Herring River Dike (Roman et al. 1995). Despite the long history of marsh alterations aimed at mosquito control, Wellfleet’s dominant nuisance mosquito (*Ochlerotatus cantator*) breeds in abundance throughout the acidified waters of the diked flood plain (Portnoy 1984). Poor water quality, and low water levels, apparently block important mosquito predators, particularly fish.

NPS and collaborators at the Marine Biological Laboratory at Woods Hole found that diking and drainage had radically altered the original salt marsh peat, reducing its capacity to both protect adjacent uplands from storm surges and control pollution (Portnoy & Giblin 1997a). Drainage of the originally sponge-like and waterlogged peat has caused its pore spaces to collapse, and aeration has accelerated the decomposition and loss of organic matter. As a result of both of these processes, plus the dike’s blockage of new sediment from the marine environment, large portions of the wetland have subsided by as much as 80 centimeters (31.5 inches) since 1908. [In addition, sea level has risen at least 20 cm over the past century.] Recent monitoring of sediment elevations shows that this subsidence continues to the present, in some places as much as a centimeter per year.

The history of intense peat drainage and aeration also explains the high acidity and metals concentrations in surface water, contributing to fish kills (Soukup & Portnoy 1986). Soil and surface-water acidification following salt marsh diking and drainage has long been recognized as a severe environmental problem at sites throughout the world (Breemen 1982, Lynn & Wittig 1966, Calvert & Ford 1973, Edelman & Van Staveren 1958, Gosling & Baker 1980, Sammut et al.

1995). In brief, sulfur is abundant in salt marsh sediments, and innocuous so long as regular tidal flooding maintains a fairly oxygen-free environment. Diking and drainage allow oxygen-rich air into the sediment, converting the sulfur to sulfuric acid, which leaches, along with acid-mobilized metals including toxic aluminum, into surface waters.

Evaluating and Planning Habitat Restoration

With recognition of major ecological and water quality impacts of the tidal restriction, the NPS, Massachusetts Coastal Zone Management (Wetland Restoration Program), National Oceanic and Atmospheric Administration (NOAA) Restoration Center, and most recently the Wellfleet Conservation Commission have begun to develop a program of restoration management. Complete and abrupt removal of the dike structure has not been a responsible option because of concerns for flooding of two houses and portions of the golf course. Also, the marsh surface had subsided in response to tidal restriction (see above): therefore, deep flooding with restored tidal flow could actually impede the reestablishment of salt marsh plants. Shellfishermen were also concerned that restored tidal flow could carry sediments onto shellfish beds downstream of the dike. Finally, the potential for salt-water intrusion into domestic wells, installed since diking in 1909, needed to be studied. Thus, as a first step, an hydrodynamic model was necessary to predict tide heights and salinities throughout the flood plain given various openings or removal of man-made restrictions. Once the range of physical outcomes was predictable, all agencies and the public could choose the alternative that best promoted ecological recovery and protected social interests (e.g. homes, wells, golf course, shellfish beds).

The first hydrodynamic model of the Herring River system was developed in the mid-1980s (Roman 1987); a new model, employing much more detailed bathymetric and tide-height data, was completed and presented to the Town in October 2001 (Spaulding & Grilli 2001). The Herring River tide gate structure is fitted with three openings: one sluice gate allowing limited tidal flow in both flood and ebb directions and two flapper gates allowing only ebb-directed flow. Investigators have developed tide height (and salinity) model(s) that predict tide heights throughout the flood plain for different configurations, or removal, of the tide gates. Alternatives employing the existing structure range from the present small opening of the sluice gate only, to removal of all three tide gates; the 2001 study also modeled the effects of complete dike removal. For all these alternatives, the model predicts water levels and salinities in the Herring River basin for a mean tidal range, as well as for a 100-yr storm event. When these water levels are coupled with elevations of the wetland surface and critical flood prone areas, it becomes possible to make responsible decisions concerning restoration. Further, the salinity mixing model predicts flushing times and the extent of seawater excursion within the marsh-estuary given various dike configurations. Based on the mixing model, scientists predict that the system's water quality problems and degraded aquatic habitat for fish and benthic animals could be improved with tidal restoration (Roman 1987, Roman et al. 1995). In addition, typical marsh-estuarine vegetation would increase in extent; water quality problems, including stream anoxia and acidity, would diminish; estuarine nursery habitat for fish would be improved; and benthic invertebrate populations (including hard clams, soft-shelled clams, oysters and non-commercial species) would increase. Mosquito populations would decrease due to better tidal circulation and better access and water quality for predatory fish.

The modeling, while showing the potential natural-resource benefits of tidal restoration, also

clarified the remaining ecological and social questions that needed answers before a comprehensive restoration program could proceed:

Question 1. *What is the potential of tidal restoration causing **saltwater intrusion into adjacent domestic wells?***

In 1990, the USGS used geophysical soundings and well installation and sampling to determine that, with 20 meters of fresh water between domestic well screens and the salt/fresh ground water interface, there was no chance that tidal restoration in Herring River could affect those private wells installed in the adjacent upland (Fitterman & Dennehy 1991). The wells of the two dwellings situated within the flood plain, however, could be affected by either surface seawater flow or a landward repositioning of the salt/fresh ground water boundary, which may be expected with tidal restoration.; options for well protection or relocation still (2003) need to be studied.

This hydrologic work was expanded in 2003 to include the potential for salt water intrusion into supply wells around the Mill Creek tributary of Herring River, also including Chequesset Neck (Martin, in review). The USGS Water Resources Division installed three additional observation wells through the fresh-salt groundwater interface, logged their water quality, and modeled the effects of tidal restoration (Masterson 2003). The investigators applied the tide heights and salinities predicted by a 2001 hydrodynamic model (see below) of the surface water system to a model of the local groundwater aquifer; they then ran the model for a virtual 300 years to assess the long-term effects on the interface. Results corroborated the above-mentioned 1991 Fitterman and Dennehy study, indicating that opening the Herring River Dike should not affect well-water quality. Importantly, this analysis, and its conclusion of no impact, also included wells adjacent to Mill Creek, in the event that the golf course is able to relocate fairways and Mill Creek is kept open for salt marsh restoration (see question 2 below). Besides establishing water quality in now six, deep observation wells around the flood plain, this study also summarizes domestic water quality from health records as a base line for future monitoring.

Question 2. *How can the **CYCC golf course** be protected from tidal flooding?*

Four fairways are within the Mill Creek flood plain and therefore subject to flooding if the Herring River Dike were to be substantially opened. In the late 1980s, the NPS and the CYCC cooperated on a study (Nuttle 1990) that addressed this issue by measuring soil saturation, precipitation and fresh water outflow from Mill Creek throughout the annual hydrologic cycle and coupling observed discharge with model-predicted Herring River tide heights. From this it was determined that, given the low elevations of the fairways, a dike was required at Mill Creek to prevent salt water damage should the Herring River Dike be substantially opened. A pumping system would likely be needed during high precipitation and runoff events to remove impounded fresh water from behind the dike. This new structure could be built at the site of an old dike across Mill Creek, utilizing the existing earthen berm and thereby reducing construction costs.

Additional surveys and engineering studies are being initiated at Mill Creek in 2003. This project originally focused on reconstruction of a dike at the mouth of Mill Creek to protect the course from flooding after the Herring River Dike was opened (per Nuttle 1990, see above); however, the Golf Club is now very interested in relocating flood-prone fairways outside the flood plain. Therefore, it is uncertain whether a dike across Mill Creek is even needed, and engineering studies have been temporarily redirected to produce a detailed survey of any sensitive structures within the Mill Creek flood plain that might be affected by tidal restoration. Earthtech, Inc. is undertaking these surveying

and assessment tasks through cooperative agreements among the NPS, Massachusetts Coastal Zone Management Wetland Restoration Program (MCZM-WRP) and the Coastal America Foundation. For potential dike construction, stakeholders are exploring funding sources with MCZM-WRP, the Natural Resource Conservation Service, US Fish & Wildlife Service, Environmental Protection Agency, US Army Corp of Engineers, and the NOAA Restoration Center.

Meetings were held in 2003 with the CYCC, the MCZM-WRP, the NOAA Restoration Center, the Town and the National Seashore to share environmental information, to identify management alternatives that accommodate both habitat restoration and a nine-hole golf course, and to outline compliance steps.

Question 3. *Are there **contaminants** stored in the sediments upstream of the dike, and, might increased flow lead to their activation?*

Because of the long history of diking and peat drainage, marsh sediments above High Toss Road are extremely acidic with porewater rich in dissolved aluminum and ferrous iron, explaining the depauperate aquatic fauna and past fish kills. Note however that these contaminants have not been introduced to the marsh (from the watershed or elsewhere) but have been generated within the marsh peat by diking, peat drainage and aeration. The production of these “acid sulfate soils”, of which there are hundreds of acres north of High Toss Road, is a widely observed and studied problem associated with salt marsh drainage worldwide (see above).

NPS and cooperating scientists at the Marine Biological Laboratory Ecosystems Center and Boston University conducted field and greenhouse experiments in the early 1990s to assess the effects of restored tidal flow and salinity on sediment and water quality and salt-marsh plant growth above the Herring River Dike (Portnoy & Giblin 1997b, Portnoy 1999). This work showed that restored high water levels and salinity reversed the chemical processes responsible for the release of acidity and toxic metals; pH rebounded within a few months. Salt marsh grasses thrived once pH had recovered. Importantly, the sulfide produced by sulfate reduction, a process that will occur with re-flooding of the marsh, strongly precipitates aluminum, ferrous iron and whatever other metals may be present (and whatever their origin), eliminating their potential toxicity to aquatic fauna. Thus, the return of regular seawater flooding both eliminates an existing problem and helps to protect the estuary and receiving shellfish waters from any future contamination by metals.

Regarding other contaminants recent (1999) sampling just above and below the Herring River Dike by Dr. James Quinn of URI revealed little to no contamination by synthetic organic compounds; this is expected because of the lack of commercial and industrial development. Even if isolated pockets of synthetic organic contaminants already occur within the flood plain (e.g. landfill leachate), it's important to realize that the diking does nothing to stop their discharge into the river and, thence, into the harbor, today.

See Question 8 for coliform discussion.

Question 4. *What changes would occur in erosion and **deposition of sediment downstream** of the dike, under a variety of expected scenarios (e.g. storm surges, large rainfall events)?*

Some shellfishermen are concerned that increased flows through the dike could cause sediment to accumulate on shellfish beds downstream; however, Spaulding and Grilli's (2001) model predicts channel velocities that are insufficient to resuspend sediment. In addition, highest velocities would occur during flood tides causing net transport to be upstream, rather than downstream.

Nevertheless, because concerns persist, the NPS has secured the services of a geological research fellow, Amy Dougherty, an independent researcher from the Association of Women Geologists to study past, present and projected sedimentation, including the effects of restored tidal flow, with a report expected in January 2004 (Dougherty in prep.)

Preliminary results from this study show that sedimentation patterns below the dike were relatively unaffected by its construction. With the exception of a small deposit of sediment directly down stream of the sluice gate, the configuration of the Herring River below the dike looks the same today as it did in 1848, 60 years before dike construction. Therefore if building a dike the width of the river did not affect sedimentation below it, then opening a small portion of the dike is unlikely to. To prove that any change in sedimentation would be proximal to the dike, we can look at historical accounts from the late 1960s when the dike's gates rusted open: there were no complaints of sedimentation associated with shellfish grants. On the contrary, interviews conducted by Coastal Zone Management reported that the shellfish, which colonized just below the dike after the breach, were subsequently covered with mud when the structure was repaired. With respect to the re-suspension of upstream sediments during large rainfalls, the Spaulding and Grilli (2001) modeling study states that during these events it is possible that velocities could be great enough to move sediment downstream. However, the movement of this sediment would happen regardless of whether the dike is opened or closed because the forcing is in a seaward direction and the flapper gates allow for the passing of ebb flows.

Dr. Spaulding has also pointed out that spring and storm tides under present culvert conditions already exert stress to the system similar to what we anticipate from modest experimental sluice-gate openings, with no evident sediment disturbance. In planning the suggested phased program of experimental openings, it would be very important to identify, with the help of Town resource managers and fishermen, specific areas of concern for monitoring both before and during the incremental openings. At these critical locations, we would measure current velocities and sediment load during peak ebb and peak flood conditions during spring, neap and mean tides.

It is generally agreed that phased, incremental dike openings accompanied by intensive monitoring is both a powerful and prudent approach to examine effects on water quality and sedimentation, and to validate further the hydrodynamic and salinity models.

*Question 5. Would opening the dike in any way threaten **the Gut**, the sand spit that channels the Herring River outflow into Wellfleet Harbor rather than directly into Cape Cod Bay?*

According to Dr. Graham Giese, who has studied the coastal geology of the outer Cape for the past 40 years, the stability of The Gut is primarily dependent on littoral sediment transport along the Cape Cod Bay shore and aeolian (wind-borne) transport within the barrier dune system. The broad salt marshes behind The Gut barrier beach, which incidentally impose a formidable resistance to erosion in the case of storm overwash from the Bay, have been very stable for decades, as observable on aerial photographs. In addition, the occurrence of a broad mudflat of

fine-grained sediments on the river side of this peat bank attest to low flow velocities under present conditions with no scouring. Increased flow from Herring River during the ebb will be accompanied by increased water velocities through the channel along this creek bank; however, flows are unlikely to be sufficient to resuspend sediment (see above # 2).

Geologic Research Fellow Amy Dougherty, mentioned in Question 4, is also evaluating this concern with a report due in February 2004.

As a base line for future monitoring, AmeriCorps volunteers collected elevation profiles along four east-west transects across the Gut and also mapped the peat bank adjacent to Herring River in the winter of 2001-2002. As far as we know, this is the first such data set available and establishes a quantitative means of addressing changes to The Gut barrier beach and salt marsh system.

Question 6. *How would opening the dike alter the salinity patterns of Wellfleet Harbor?*

Freshwater discharge from Herring River was measured during the Spaulding and Grilli (2001) study and previously to be about 0.1 m³/sec; Wellfleet Harbor's tidal flow is at least 100 times greater; expectedly, low salinity (<32 ppt) due to Herring River discharge is only realized within a few hundred meters below the dike at low tide. With all three culverts open (Case 5 in the model) salinities above the dike increase dramatically over hundreds of acres, potentially extending estuarine habitat for shellfish and finfish, but there is little change seaward of the dike because of the overwhelming influence of seawater from Wellfleet Harbor.

Dr. Spaulding emphasizes that, because harbor tidal volume is so much greater than river freshwater discharge, adjustments to the Herring River Dike will cause profound changes in the river, but negligible changes in the harbor.

Question 7. *What changes would occur in both nutrient inputs and phytoplankton (food for shellfish) in the harbor should the dike be opened?*

As mentioned in Question 7, the influence of Herring River discharge on harbor water quality is very small given the huge difference between their volumes. Thus there would be little change on nutrient flux, and dependent phytoplankton, on the seaward side after opening the dike. In greenhouse microcosm experiments NPS did observe that re-salination of acid sulfate soils, typical of the drained wetlands above High Toss Road, mobilized ammonium-nitrogen; however, this should be a short-term phenomenon. The ammonium is presently adsorbed to clay particles. To the extent that seawater reaches these sediments, ammonium will desorb and will be available as a nitrogen source to primary producers, both phytoplankton and wetland vascular plants. However, with the incremental opening of the dike any increases in ammonium will be gradual, i.e. not a large pulse. Also, with the high flushing rate in Wellfleet Harbor proper, this nitrogen is not expected to cause excess algae blooms.

Question 8. *How would the opening of the dike affect fecal coliform counts, as these are used by the State to determine if areas are safe for shellfishing?*

According to George Heufelder of the County health department, Bob Duncanson of the Chatham Water Quality Laboratory and others with experience in managing bacterial contamination in coastal systems, increasing seawater flow through the dike should reduce

coliform counts at and seaward of the dike. Operative factors include increased water clarity and UV penetration, improved aeration and survival of microbial predators, lower temperature and increased salinity; however, the overwhelming factor is increased dilution by the much increased tidal volume. Bob did suggest that to the extent that high marsh pools develop and are not flushed daily by the tides, we could see episodic “coliform” release into surface waters after spring tides or storm events. Although this release is a potential in all of our salt marsh estuaries, we should plan to monitor it.

For a discussion of the effects of tidal restoration on mosquitoes, wildlife and vegetation see Argow (2000).

Current management status

Since December of 1984, the opening for seawater inflow into Herring River through the Chequesset Neck dike has remained unchanged: the sluice gate opening has remained about 51 cm (20 inches). Tidal flow through this opening, about three times the cross-sectional area of the pre-1981 setting, still fails to flood the marsh surface above High Toss Road; a salt-water wedge travels upriver and just reaches this road’s culvert during extreme high tides.

The state DEP awaits the resolution of local issues before opening the dike further. Scientists have recommended small incremental openings to allow for careful ecological and hydrologic monitoring and adaptive management of any unanticipated developments.

Water quality problems continue to stress resident and migratory fauna. In consultation with the State DMF, National Seashore resource management staff has regularly blocked the annual summer emigration of juvenile herring from Herring Pond to avoid complete mortality when these fish enter the often-anoxic lower estuary (Route 6 to High Toss Road). Nuisance mosquitoes continue to breed abundantly in drainage ditches where poor water quality, especially high acidity and toxic aluminum mobilized by diking and peat drainage, blocks access by predatory fish. In recognition of the river’s poor water quality caused by decades of diking and drainage, the DEP included the Herring River on its 2003 “303(d)” List of Impaired Waters in compliance with the federal Clean Water Act.

Ownership, maintenance and management of the dike structure are the responsibility of the Town; however, Mass. Highways inspects and reports on the condition of the structure every two years. Both 1996 and 1998 reports indicate that the structure is sound. Further, an inspection by James McBroom, P.E. arranged by the NOAA Restoration Program in December 2003 found the structure to be in good condition and able to accommodate flows anticipated with the gates fully open (McBroom 2003).

In 2003 the Wellfleet Conservation Commission has voted to support estuarine restoration within the Herring River flood plain, and is planning a series of informational meetings with Town officials and the public. The Commission formally requested technical assistance and funding to promote restoration from the MCZM-WRP in fall 2003.

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