Feasibility Study of Removal of the Hatfield Dam (Mill River, Hatfield, MA): Feasibility, Environmental Cost-Benefit Analysis and Evaluation of Alternatives for Fish Passage

Proposal for

Project Contact

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Project Information

Project title: Feasibility Study of Removal of the Hatfield Dam (Mill River, Hatfield, MA): Feasibility, Environmental Cost-Benefit Analysis and Evaluation of Alternatives for Fish Passage

Project location: Hatfield, Massachusetts

Land ownership: private

Type of project: Dam removal, alternative fish passage

Anticipated species to benefit: Atlantic Salmon, Blueback Herring, American Shad, Lamprey, Dwarf Wedge Mussel.

Project start date: January 15, 2003

Project end date: December 31, 2004

Partners Involved

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Introduction

The Mill River is a tributary of the Connecticut River and drains approximately 30,000-acres in the towns of Conway, Deerfield, Hatfield, Northampton, Whately, and Williamsburg. In spite of its small size, the Mill River watershed is widely recognized as one of the state's most significant because of its exceptional wildlife habitat. At present the river and its tributaries are known to support the greatest diversity of freshwater mussels in Massachusetts, including the state's only viable population of Federally Endangered dwarf wedgemussels. It also contains one of the Commonwealth's largest blocks of unfragmented forest, an exemplary floodplain forest community and habitat for over 20 state-listed plants and animals.

For the past five years, UMass Extension has coordinated a multi-agency watershed project in the Mill River watershed, raising awareness, assessing resources, issues and opportunities, and coordinating local efforts to protect the resources of the river and its watershed. We are now focusing our work on four critical issues for the river: 1) water withdrawals, 2) the Hatfield Dam (risks and benefits of either removing or repairing the dam), 3) beaver impacts on dwarf wedgemussel habitat, and 4) uncertainty about dwarf wedgemussel reproductive and dispersal biology. In response to these issues, we intend to coordinate a multifaceted study of the Mill River that will provide the information necessary to develop a conservation plan for the river, its endangered mussels and other rare species.

We have begun the process of lining up funding and conducting the various studies that will be necessary for developing a conservation plan for the Mill River. We have conducted a detailed hydrological and instream habitat study of the main stem Mill River, from the Connecticut River up to its confluence with Roaring Brook, with the exception of the impoundment behind the Hatfield Dam. This work was done using the MesoHABSIM approach developed at Cornell University and focuses on dwarf wedgemussels and a target fish community developed specifically for the Mill River. Using this approach we are evaluating the impact of current and potential future water withdrawals on river habitat for fish and mussels. This proposal requests funding to address another of the key issues identified for this watershed: the fate of the Hatfield Dam.

The approximately 150-foot long, 15 ft high, three hundred-year-old Hatfield Dam is located in Hatfield, Massachusetts near the mouth of the Mill River, a tributary to the Connecticut River. The dam is located on a rock outcrop approximately six feet in height. The dam itself is approximately ten feet high for a total approximate height of sixteen feet. This dam, the only one on the Mill River, blocks the movement of fish (Atlantic Salmon, American Shad, Blueback Herring and Lamprey) and other aquatic organisms between the Connecticut River and the Mill River watershed. The tributaries to the Mill River, however, appear to contain ideal spawning and nursery habitat for Atlantic salmon. The discovery of a nesting salmon downstream of the dam further suggests that the fish might be available to establish a run at this system. The review of existing, historical (albeit, anecdotal) information will help clarify that the proposed dam removal or other type of fish passage will facilitate the restoration of an Atlantic salmon run. A recent inspection of the dam by the Massachusetts Office of Dam Safety has rated this dam as at risk of failure, raising the possibility of dam removal for the sake of public safety as well as river restoration.

Dam removal at the site is complicated by a number of factors. The Mill River watershed is considered important due to the large diversity of freshwater mussels, including the federally endangered dwarf wedgemussel, that reside in the river and its tributaries. Removal of the dam could negatively impact that mussel population through the introduction of predatory species. It could also potentially impact the extensive upstream wetland system through a decrease in water levels. Therefore, a project team has been assembled to examine the feasibility and potential impact, of river restoration through removal of the Hatfield Dam or other design alternatives that help restore one or more ecological functions of the river.

The issues of dam removal and how it will impact river ecosystems are not confined to the Mill River. As part of a proactive effort to protect this valuable ecosystem and its many rare and endangered species, we are developing new approaches for evaluating the environmental costs and benefits of dam removal and for identifying ecologically-based stream flow requirements that can be used elsewhere in the Connecticut River watershed and throughout the state.

Project Description

The Hatfield dam – the only dam on the main stem Mill River – is leaking. The Mill building at the dam is vacant and for sale. There may now be an excellent opportunity to remove the Hatfield dam and restore the river's free-flowing hydrology and habitat continuity out to the Connecticut River. In addition to restoring river continuity and anadromous fish to the river, removal of the dam will create more habitat for native, flow-dependent fish and mussels, and conditions whereby the Mill River could serve as a source for repopulating rare species to the Connecticut and other tributaries of the Connecticut River. There are however serious environmental risks. Extensive wetlands above the dam could be significantly affected by the dam's removal. Further, removing the dam could allow predatory fish access to the upper Mill River and potentially threaten rare mussels, including the dwarf wedgemussel. Moreover, the dam has historic and scenic values and the impounded pool above the dam provides the only canoe-friendly area on the Mill River. For these reasons, many towns' people, including the Conservation Commission in Hatfield, would—at this stage-- rather see the dam repaired.

In order to open a dialogue with community leaders and residents about the potential removal of the Hatfield dam, we need solid information about the costs and environmental risks and benefits of dam removal, as well as consideration of intermediate options that would facilitate fish passage even if the dam were retained. To address these issues we are proposing two complementary studies. Combined, the two studies will analyze:

- Potential for opening full or partial passage for anadromous fish and other species
- Risks and benefits of increasing free flowing habitat in the Mill River
- Reduction of wetlands and associated impacts on habitats
- Removal costs and technology
- Alternatives to removal (fish passage structures, by-pass channel, roughened ramp, or combination thereof)

- Involvement of the community in evaluating alternatives and generating support for a course of action that would improve conditions for anadromous fish, rare and endangered species, and ecosystem health

We seek funding from NOAA Fisheries-CRWC partnership and Massachusetts Environmental Trust (MET) to fund a feasibility study for the potential removal or modification of the Hatfield Dam as one element of this larger project that will support the development, with MA Division of Fisheries and Wildlife (MDFW) and the U.S. Fish and Wildlife Service (USFWS), of a conservation plan for the Mill River. We have nearly completed work on the hydrology and instream habitats of the main stem river. MET has agreed to provide $30,000 for two critical habitat components of the of the dam feasibility study: impact of dam removal on instream habitat and wetland habitat. The NMFS proposal focuses on hydraulic and engineering issues related to the dam itself and alternative means of providing anadromous fish passage that will complement MET funded components. This proposal describes the entire feasibility project with understanding that funding for Tasks 3 and 4 is being funded by MET. Task 6 is an in-kind contribution of UMass Extension's Natural Resources and Environmental Conservation program.

There are four teams of scientists working on this project addressing four complementary aspects of removal: engineering, hydrological modification, aquatic habitat and outreach. Below are objectives and tasks performed by each group.

Task 1: Evaluate engineering aspects of dam removal and alternative fish passage strategies.

Objective: In order to assess the feasibility of dam removal, we will address three important issues. The first critical issue will be the quality and quantity of the impounded sediments. A second question to consider is whether removal of the dam will create hydraulic conditions enabling desired anadromous fish passage. The final question will be the stability of the channel resulting after removal of the dam.

Task 1.1 - Existing Data Review and Site Investigation

a) Review the available data and resource information regarding the dam and dam site such as aerial photographs, dam inspection reports and other information available from the Massachusetts Office of Dam Safety, past studies of the dam, watershed history and potential contamination information, information regarding abutting property owners, 1979 FEMA study as well as any information on historical anadromous fish runs and/or fisheries.

b) Perform a visual site inspection in the project area to broadly characterize the river channel's geomorphic characteristics, site accessibility and construction related issues. Manual sediment probes will be undertaken to estimate the volume of sediment impounded behind the dam and evaluate the general sediment characteristics of the existing channel bed.

c) Perform a visual inspection of the dam, noting any visible leaks, cracks or deterioration. This work task does not include topographic survey.

d) Collect information sufficient to estimate the costs of dam removal, dam repair and other project implementation alternatives.

Task 1.2 - Hydraulic Analysis

a) Coordinate with the Natural Resource Conservation Service (NRCS), who will provide survey of selected cross sections of the Mill River for this phase of the project. It is understood that this survey will be referenced to national or state horizontal and vertical datum's. Although the level of survey provided is expected to be sufficient for this feasibility study, more detailed survey may be necessary for future design phases. MMI will coordinate with NRCS and will provide a schematic to them indicating where survey will be required. MMI will additionally review the survey provided by NRCS for completeness and request additional data if necessary. It is understood that the survey will be provided to MMI in electronic format suitable for use in AutoCAD.

b) Develop a hydraulic model using the U.S. Army Corps of Engineers (ACOE) Hydraulic Engineering Circular-2 (HEC-2) or Hydraulic Engineering Center - River Analysis System (HEC-RAS) computer modeling procedures. The model will be based on the HEC-2 model created for the 1979 FEMA Mill River Flood Insurance Study (FIS).

   Using the FIS model in conjunction with the cross-sections surveyed by NRCS, MMI will conduct a preliminary hydraulic analysis to assess the feasibility of fish passage for Atlantic Salmon, American Shad and Blueback Herring if the Hatfield Dam is removed. The assessment will be based on predicted water surface depths and velocity profiles and will consider the Connecticut River water surface elevations as published in the FIS. MMI will provide recommendations regarding channel cross-sections and channel modifications associated with dam removal. It is assumed for this scope that only one alternative of a full breach of the dam (without modification of the natural ledge) will be modeled. It is likely that future design will require additional survey and refinement of the modeling effort conducted in this study such as survey of the toe of the dam.

c) Perform a steady-state sediment scour analysis utilizing the hydraulic model output and allowable shear stresses for bed materials present in the project reach and sediment data provided by Hydrology Group. Determine the potential for sediment transport and scour upstream and downstream of the dam for complete dam removal. Provide recommendations regarding channel gradients and any required sediment removal and bed or bank armoring.

Task 2. Hydrology.

Objective: The hydrological component will discuss how dam removal will alter the hydrological equilibrium imposed by the dam 300 years ago. Specifically, we anticipate the riparian wetlands to be altered to a different hydrologic type and/or plant community due to the lowered river water level and the promotion of groundwater drainage to the channel. This analysis will predict lateral (away from the channel) and longitudinal (along the channel) changes in the water table and associated changes in the extending wetland. This study will also investigate the seasonal flow hydraulics associated with the "natural" ledge at the current dam site to determine the probability and frequency of likely migration periods.

Task 2.1 – Database Assemblage for the Mill River Watershed

We will develop a database for characterizing and modeling the Mill River hydrology and include it in GIS coverage. The following are specific parts of this task:

a) Review and organize relevant information made available, especially electronic geospatial data describing topography, hydrography, geology/soils, wetland areas, and land use. Anticipated changes in streambank and streambed geometry determined by the engineering portion will be valuable.

b) Perform an on-site inspection of the watershed and use a GPS to locate specific features of hydrological significance, e.g., observation well locations (if any are available).

c) Obtain information regarding the management of the reservoirs located high in the watershed.

d) Organize available USGS hydrological records, especially river discharge, for systems in and around the Mill River Watershed.

e) Develop a meteorological database that encompasses the Mill River Watershed. The Hydrology Team will work with the Northeast Regional Climate Center to identify and obtain the necessary data.

Task 2.2 – Groundwater and Riparian Wetland Evaluation

a) Develop groundwater model for the Mill River floodplain with special attention to the area adjacent to the current impoundment. MODFLOW will be the model's analytical basis. This activity will involve confidently initializing the model to current conditions. MODFLOW is flexible and can be implemented relatively rapidly. The data requirements, available from Task 1, include: a basemap of the study area, topography, and general aquifer properties: hydraulic conductivity, porosity, depth.

b) Compare current wetland areas to modeled and measured groundwater distribution and quantify a correlation between the two. This analysis may involve investigations of near-by watersheds to refine our understanding of geophysical controls on wetland propensity.

c) Run the groundwater model under various hypothesized dam removal scenarios and weather patterns to determine the range of possible groundwater dynamics resulting from dam removal.

d) Using (b) and (c), predict changes in riparian wetland extents. This subtask may be able to utilize the streambank and sediment predictions from the hydraulic analysis made by the engineering component of the project.

Task 2.3 – Deposited Sediment Evaluation

The physical or chemical composition of the sediments that have been trapped behind the dam over the past 300 years has not been characterized. It is important to understand this composition because, if the dam was removed, these sediments would constitute the riparian land

surface and we need to know how these are likely to consolidate. As part of this task, the Hydrology Group will:

a) Collect at least four sediment samples from behind the dam. If possible, the sample core will be extended to either bedrock or the pre-dam streambed armoring. The samples will be transported to Cornell and analyzed for particle density, bulk density, porosity, and moisture content. Samples will also be re-characterized after drainage and drying. Umass and certified laboratory will investigate the contents of contaminants like metals, organochlorine pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons according to EPA standards and methods. Samples will be collected via a hand boring sediment sampler. Sample locations will be located with GPS.

b) We will use a probe to measure sediment depth at several additional locations throughout the impoundment, again using GPS to locate measurement sites.

Task 2.4 – Hydrological Evaluation

Because stream hydrology in the Northeastern U.S. is typically tightly linked to overland flow, it is possible that dam removal will substantially change the patterns of stream flow. This task will determine the sensitivity of the watershed hydrology to the dam. We will provide the following as part of this task:

a) Develop a streamflow model using the Soil Moisture Routing model (SMR) (Frankenberger et al. 1999). This model was developed specifically for the Northeastern US's unique surface hydrology; specifically, surface runoff in this region is typically generated from a small portion of the landscape where shallow groundwater has saturated the soil to the surface. Few models exist that can simulate this process, especially when surface saturation is controlled by shallow subsurface flow over bedrock, fragipans, or other shallow restrictive layers. SMR has been successfully applied to several basins in the New York State (e.g., Frankenberger et al. 1999, Kuo et al. 1999, Mehta et al. 2003, Johnson et al., 2003) and is currently being implemented in Pennsylvania, Connecticut, New Jersey, and Vermont. SMR requires geospatial information regarding soil hydraulic properties, land use, and topography and basic meteorological data, all obtained in task 1. One of the important inputs into SMR is the depth of unsaturated soil between the ground surface and the either a restricting layer (e.g. bedrock) or water table. For hillside areas, the depth to a restricting layer is generally available in soil surveys data. When water table depths are required, either direct measurements or additional modeling are needed. MODFLOW will first be run to simulate water table depths in the Mill River floodplain for pre- -dam removal conditions and this information will be used as input data to SMR while confidently initializing SMR.

b) SMR will be run again, using MODFLOW results for the post-dam removal and various meteorological scenarios, to investigate the range of possible changes to stream discharge as a result of dam removal.

Task 3. Aquatic Habitat.

Objective . Evaluate changes in instream habitat conditions for fish and mussels related to dam removal, and likely impacts on target fish communities (including host fish for mussels and predatory fish).

a) Define distribution of hydromorphologic units (mesohabitats) in the stream reach that will be created by dam removal. Building upon the prediction of river corridor (previous instream habitat study of main stem Mill River) and its hydraulic configuration provided by hydrodynamic model (Dam feasibility study) we will use GIS to predict the distribution of pool, riffle, and run areas in the newly created river section.

b) Using response functions obtained in the former study we will evaluate habitat suitability for key fish and mussel species in the simulated river corridor for the area above the Hatfield dam. The model will be developed for a range of low flow conditions (0.3 – 1.7 cfsm). The results will be incorporated into habitat flow rating curves obtained in our 2002 study and compared with the original curve. The total change in fish and mussel community habitat during summer low flows will be analyzed.

c) Building upon the results of hydrological simulation we will develop habitat time series for river with and without dam. This would help us to determine seasonal variation of habitat for target fish and mussel species, and estimate the gain in persistent habitat for flow-dependent species.

Task 4. Wetland habitat

Objective;Assess wetland habitat above the Hatfield dam and use habitat and hydrological models to predict the effects of dam removal on wetlands and wildlife habitat.

a) Use aerial photographs and field surveys to identify and delineate wetland vegetative communities. Enter data into GIS and estimate aerial extent of each vegetative community.

b) Establish cross valley transects sufficient to sample all important vegetative communities. Survey transects to create cross valley profiles.

c) For each vegetative community intersected by the transects, use Habitat Evaluation Procedures (HEP) to evaluate Habitat Suitability for a suite of wildlife species likely to use wetlands above the Hatfield Dam. Habitat Suitability Indices (HSIs) for like vegetative communities will be averaged and used along with total area of the community within the study area to calculate Habitat Units (HUs) for each species.

d) Using hydrology data from the dam feasibility study, model changes in vegetative communities in response to dam removal. Calculate the percent change in area for each vegetative community.

e) Using hydrology data from the dam feasibility study and predicted changes in wetland vegetation, evaluate likely changes in Habitat Suitability for each species in response to dam removal. Using average HSIs for each vegetative community and predicted area of each vegetative community, calculate Habitat Units after dam removal for each species.

f) For each species, compare Habitat Units as they change from current conditions to those expected after dam removal. Summarize results for use in community outreach.

Task 5: Fish passage

Task 5.1 Project the passability and suitable habitat for migratory and exotic fish species.

a) Based on published swimming performance data of Atlantic Salmon, Blueback Herring, American Shad, Smallmouth and Largemouth Bass evaluate potential passage at various flow patterns projected by the hydraulic model on the dam site. Incorporating the hydrological time series from SMR model we will quantify the periods with high probability of passage.

b) Using fish data obtained in 2001 and 2002 develop fish response curves for Smallmouth Bass. We will follow the steps described in Task 3.1 and project habitat suitable for this species upstream of the dam. Because this analysis is to determine the threat that SMB could pose to Tessellated Darter we will focus here on quantification of habitat persistent during foraging period. It will be superimposed over the spatial distribution of Tessellated Darter habitat to identify potential overlaps. Again the results of hydraulic and hydrological models will be key input to this model.

Task 5.2 Evaluate fish passage alternatives

a) Organize a workshop including site visit with fish passage engineers from FWS and discuss available options. During this expert panel meeting we will analyze available data and local circumstances. We will create consensus of expert of viable options and set basic criteria for design development.

b) Write a short report describing and sketching available alternatives, their costs and performance. US FWS engineers will provide conceptual guidelines and sketches for technical fish ways as an agency service. Our team will summarize their findings, investigate a concept of nature-like bypass channel, provide sketches of possible options and write separate report. The report will be reviewed by US FWS prior to delivery.

Task 6: Outreach

Objective: As part of an outgoing outreach program in the watershed, communicate results of this study and the complementary feasibility study, to Hatfield community officials, interested citizens, agencies, and organizations, and facilitate decision-making about the future of the dam.

a) Create readable summaries of the study results for distribution. Post the summary on the Mill River Watershed web site (as html and downloadable PDF). Report results in the Mill River Watershed newsletter.

b) Convene a public forum in the Town of Hatfield where study results will be presented and discussed and the various options considered.

c) Convene a working group including the dam owner, town officials, and representatives of cooperating agencies and organizations to discuss study results and public input, and decide on a course of action.

Task 7. Prepare and submit final report.

Each member of study team will create draft report related to the investigated topic. The reports will be incorporated as a chapters of final report and accompanied by integrative analysis and concluding recommendations.

Study team

The interdisciplinary study team consists of three specialized teams that provide complementary expertise in engineering (Milone and MacBroom), habitat and hydrology (Instream Habitat Program at Cornell University) and outreach (UMass Extension). Each team will carry the responsibility for the tasks directly connected to the represented expertise. The project staff and technicians will be working across the disciplines to assure integrative thinking. The project coordination center will be located at University of Massachusetts with field data collection and preliminary analysis for tasks 2, 3, 4, 5, 6 & 7 conducted by UMass staff and technicians. The final analysis and reporting will be performed by the entire team and coordinated by UMass.

Tasks, Funding, and Responsibilities

Task	Funding	Primary Responsibility	Supporting
1.1 Evaluate engineering aspects	**NMFS**	**MMI**	**UMass**
1.2 Hydraulic Analysis	**NMFS**	**MMI**	**Cornell**
2.1 Database Compilation	**NMFS**	**Cornell**	**UMass MMI**
2.2 Groundwater & riparian wetland eval	**NMFS**	**Cornell**	**UMass**
2.3 Deposited sediment eval	**NMFS**	**Cornell**	**UMass**
2.4 Hydrological eval	**NMFS**	**Cornell**	**UMass**
3 Aquatic habitat	**MET UMass**	**UMass**	**Cornell**
4 Wetland habitat	**MET UMass**	**UMass**	**Cornell**
5 Fish passage	**NMFS**	**Cornell**	**UMass**
6 Outreach	**UMass**	**UMass**	**Cornell**
7 Report preparation	**NMFS MET UMass**	**UMass**	**Cornell MMI**