DRAFT

General Investigation Feasibility Report and Environmental Assessment

SOMERSET & SEARSBURG DAMS

(Deerfield River Watershed Study)

Greenfield, Massachusetts

US ARMY CORPS
OF ENGINEERS
New England District

February 2007

GREEN RIVER FISH PASSAGE
GREENFIELD, MASSACHUSETTS
CORPS OF ENGINEERS, NEW ENGLAND DISTRICT

EXECUTIVE SUMMARY

This restoration study focuses on four dams on the Green River in Greenfield, Massachusetts: the Wiley & Russell Dam, the Mill Street Dam, the Swimming Pool Dam, and the Pumping Station Dam. The dams block the migration of anadromous fish upstream to spawning areas and smolt movement to the ocean and prevent catadromous fish, which live in fresh water and spawn in the ocean, from accessing their primary habitat. The sectioning of the river has also impacted potamodromous fish, which are freshwater species that move to faster moving streams in the watershed to spawn. The Deerfield River watershed has its headwaters in south central Vermont and joins the Connecticut River in Greenfield, Massachusetts. The total drainage area is about 665 square miles with 350 square miles in Massachusetts and 315 in Vermont. The Somerset and Searsburg dams are located in Vermont, and by virtue of being mentioned in the authorizing legislation, loaned their names to the study. The total river length of the Deerfield River is 70.2 miles. Major tributaries to the Deerfield are the North River, Green River, Chickley River, and the Cold River. Up to 30 miles (15 in both Massachusetts and Vermont) of fish habitat can be restored by providing fish passage at the four locations along the Green River. Other than holding an impoundment, two of the dams, the Wiley & Russell Dam and the Mill Street Dam, no longer serve any practical purpose. Two of the dams, the Swimming Pool Dam and the Pumping Station Dam, maintain recreational and public water supply impoundments. The study area is shown on Plates 1 and 2.

The study considers the fish passage options of fish ladders, rock ramp fishways or bypass channels for the Swimming Pool and Pumping Station dams. The alternative list was expanded to include dam removal and partial breaching at Wiley & Russell and Mill Street dams. The study also considers instream aquatic habitat improvements along several channel reaches near Leyden Woods Apartments and a reach between Mill and Meridian Streets. A restored migratory corridor along the Green River will provide an increased quantity and quality of habitat for fish, leading to more abundant fish populations. Also, restoration of riparian buffer zones at the impoundments of the two lower dams will increase the productivity and ecological value of the area.

This report was prepared by the New England District, U.S. Army Corps of Engineers (USACE) in partnership with the Massachusetts Executive Office of Environmental Affairs and the Town of Greenfield, Massachusetts. The report includes an Environmental Assessment for the proposed project. Its preparation complies with the Council on Environmental Quality and USACE regulations for implementing the National Environmental Policy Act of 1969, which requires the Federal government to consider the environmental effects of a proposed action and to consult interested agencies, groups, and the public during the planning process.

An Incremental Analysis was prepared to quantify the habitat benefits that would accrue for each of the proposed restoration plans. The Incremental Analysis quantified the benefits of various options to identify the most effective restoration plan. It's purpose is to identify the alternative(s) which would cost effectively optimize the habitat for the target anadromous fish species to be restored, while minimizing any negative effects to existing habitat and species such as lacustrine and riverine fish, and wetland species. The recommended plan consists of the removal of both Wiley & Russell and Mill Street Dams and installation of fish passage structures at Swimming Pool Dam and Pumping Station Dam. This plan maximizes the environmental benefits and offers the greatest degree of habitat restoration for each dollar invested in the project. The restoration project would extend migratory habitat and spawning habitat for anadromous fish over a distance of 30 river miles. It is a cost-effective plan that reasonably optimizes environmental benefits that are in the national interest and consistent with Corps regulations. The estimated implementation cost for the recommended plan is $2,053,000, and the project would be cost shared 65 percent Federal and 35 percent non-Federal. Operations and maintenance of the project would be a non-Federal responsibility and are estimated to cost $12,000 per year for a 50-year life of the project.

Wiley & Russell Dam

Mill Street Dam

Swimming Pool Dam

Pumping Station Dam

SOMERSET & SEARSBURG DAMS
DEERFIELD RIVER WATERSHED STUDY
GENERAL INVESTIGATION

GREEN RIVER FISH PASSAGE
GREENFIELD, MASSACHUSETTS

US ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT

February 2007

SOMERSET & SEARSBURG DAMS
DEERFIELD RIVER WATERSHED STUDY
GENERAL INVESTIGATION

GREEN RIVER FISH PASSAGE

GREENFIELD, MASSACHUSETTS
CORPS OF ENGINEERS, NEW ENGLAND DISTRICT

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SECTION 1: INTRODUCTION

This restoration study focuses on four dams along the Green River in Greenfield, Massachusetts that block the migration of anadromous fish upstream to spawning areas. These dams also prevent smolt movement to the ocean and prevent catadromous fish, which live in fresh water and spawn in the ocean, from accessing their primary habitat. Dam removal or fish passage facilities can restore up to 18 miles of fish habitat along the Green River.

1.1 STUDY AUTHORITY

Authority to conduct the Deerfield River Reconnaissance Study originated with the Senate's recommendation, in the 1998 Appropriations Bill, to "…initiate and complete a reconnaissance study of possible operational or other changes, including the conveyance of Somerset and Searsburg Dams to the Corps, to enhance ecosystem restoration." The authority of this Senate recommendation is based on an original Senate resolution of the Committee on Public Works, adopted on 11 May 1962.

1.2 STUDY PURPOSE AND SCOPE

As the Deerfield River Reconnaissance Study was initiated, it quickly became apparent that the two dams of interest in the authorization, and their associated lands located in Vermont, had been sold to other private interests as part of a deregulation plan. Both dams continue to generate hydroelectric power and the impoundments are used for recreation. Therefore, no further investigation of these two sites was necessary. However, both the State of Vermont and the Commonwealth of Massachusetts requested that the Corps expand the scope of study to include the remainder of the Deerfield River, a tributary of the Connecticut River.

The scope was then reduced when the Vermont interests opted out leaving only the Massachusetts segment. Through the involvement of the Commonwealth of Massachusetts Executive Office of Environmental Affairs and its watershed initiative, the reconnaissance study was completed with the focus becoming the four Green River dams located in Greenfield, Massachusetts. The study documented in this report describes alterative plans to restore fish passage and riverine habitat upstream of these four dams on the Greenfield River. A total of 30 river miles of fish habitat would be restored if fish passage at the four dams could be achieved.

1.3 STUDY AREA CHARACTERISTICS AND SETTING

The Green River originates on the south slopes of Mt. Olga in Marlboro, Vermont and flows approximately 30 miles to its confluence with the Deerfield River in Greenfield Massachusetts (Plate 1). That confluence is approximately 4 miles upstream from the confluence of the Deerfield River with the Connecticut River. The Green River watershed includes the Vermont towns of Marlboro, Brattelboro, and Halifax, and the Massachusetts towns of Leyden, Colrain, Shelburne, and Greenfield. The total length measured in river miles is approximately fifteen in Massachusetts and fifteen in Vermont.

As a tributary to the Connecticut River, the Green River historically provided migratory, spawning and nursery habitat for native anadromous fish, including Atlantic salmon, American

shad, blueback herring and sea lamprey, as well as the catadromous American eel. During the last 200 years, the construction of dams for various industrial uses along many New England Rivers, including the Connecticut, Deerfield, and Green Rivers, has blocked the migration of pre-spawning adults of these

Plate 1 Project Location Map

species to their historic upstream spawning habitat. Consequently, their populations were either eliminated or significantly reduced.

During the last two decades, various state and federal government agencies have been working cooperatively to restore anadromous fish to their historic habitat in the Connecticut River and its tributaries, the Deerfield and Green Rivers included. Restoration efforts have included identification of specific restoration locations, stocking anadromous fish to historical upstream spawning and nursery
habitats, and provision of fish passage beyond dams, by either dam removal, or creating by-pass structures such as fish ladders, lifts and/or partial dam breaching. In addition, studies of potential restoration areas have been conducted to identify anadromous fish habitat and the best methods to restore and/or access this habitat. Currently, many tributaries to the Deerfield River, including the Green River, are stocked with Atlantic salmon fry in order to reestablish anadromous populations in these rivers.

As a result of the restoration efforts, several fish passage facilities have been constructed on the Connecticut River, and many of the anadromous species noted above have been partially reestablished, and have access to its upstream regions as far north as Vermont. There is also unobstructed passage through the first several miles of the Deerfield River to its confluence with the Green River, and continuing through the Green River approximately 1.2 miles to the Wiley & Russell Dam in Greenfield. However, there is no fish passage beyond this dam in Massachusetts, preventing any further potential upstream migration of returning pre-spawning Atlantic salmon adults (as well as other migratory fish species). The Mill Street Dam, the Town Swimming Pool Dam, and the Pumping Station Dam, all located along an approximate 8.7-mile reach of the Green River in Greenfield,

continue to obstruct fish passage to upstream regions of the river as well. The proposed project would provide anadromous fish passage at each of these four dams on the Green River enabling fish migration to spawning and nursery habitat in upstream portions of the Green River and its tributaries. One other dam exists upstream in the village of Guilford, Vermont, which already has a fish ladder installed and will allow fish to pass further upstream of that point.

1.3.1 Physical Characteristics of the Watershed

Relatively steep rocky slopes and narrow valleys in the upper reaches and a narrow flat plain in the lower reaches characterize the Green River basin. Elevations in the basin vary from 140 +/- ft. National Geodetic Vertical Datum (NGVD) at the most downstream dam to 2,400 +/- ft. NGVD at the headwaters (an average drop of 75 feet per mile). The Green River floodplain in Greenfield mainly is narrow, flat, deforested, and development is mostly commercial and residential. In the upper reaches, the floodplain is mostly wooded or agricultural with sparse residential development.

1.3.2 Water Quality

The Green River has been designated as Class B, Cold Water Fishery according the Massachusetts Surface Water Quality Standards (314 CMR 4.00) set by the Massachusetts Department of Environmental Protection (DEP). This is defined as waters in which the maximum mean monthly temperature generally does not exceed 68°F (20°C) and, when other ecological factors are favorable, is capable of supporting a year-round population of cold-water stenothermal aquatic life such as trout. Proposed draft Water Quality Standards revisions have designated the Green River above the water supply dam as “Class A, Cold Water, Public Water Supply, High Quality Water”.

The 2000 water quality assessment performed by the DEP (2004) reported that the water quality in the segment of the river between the Pumping Station Dam and the Town Swimming Pool Dam was supporting its designated uses for aquatic life, primary and secondary contact recreation, and aesthetics. The water quality in the segment of the Green River from the Swimming Pool dam down to the confluence with the Deerfield River was also assessed as supporting these same uses, however an alert status was assigned to the assessments for all of these uses based on concerns about degraded habitat quality conditions, occasional elevated bacteria counts in the main stem and several tributaries, and in stream turbidity, trash and debris. The Department of Public Health has

also reported that the Green River Swimming pool on the Green River has experienced occasional elevated bacteria counts that exceeded the swimming standards and resulted in beach closures. (DPH Marine and Freshwater Beach Testing Annual Reports for.2002, 2003, and 2004)

1.3.3 Environmental Resources

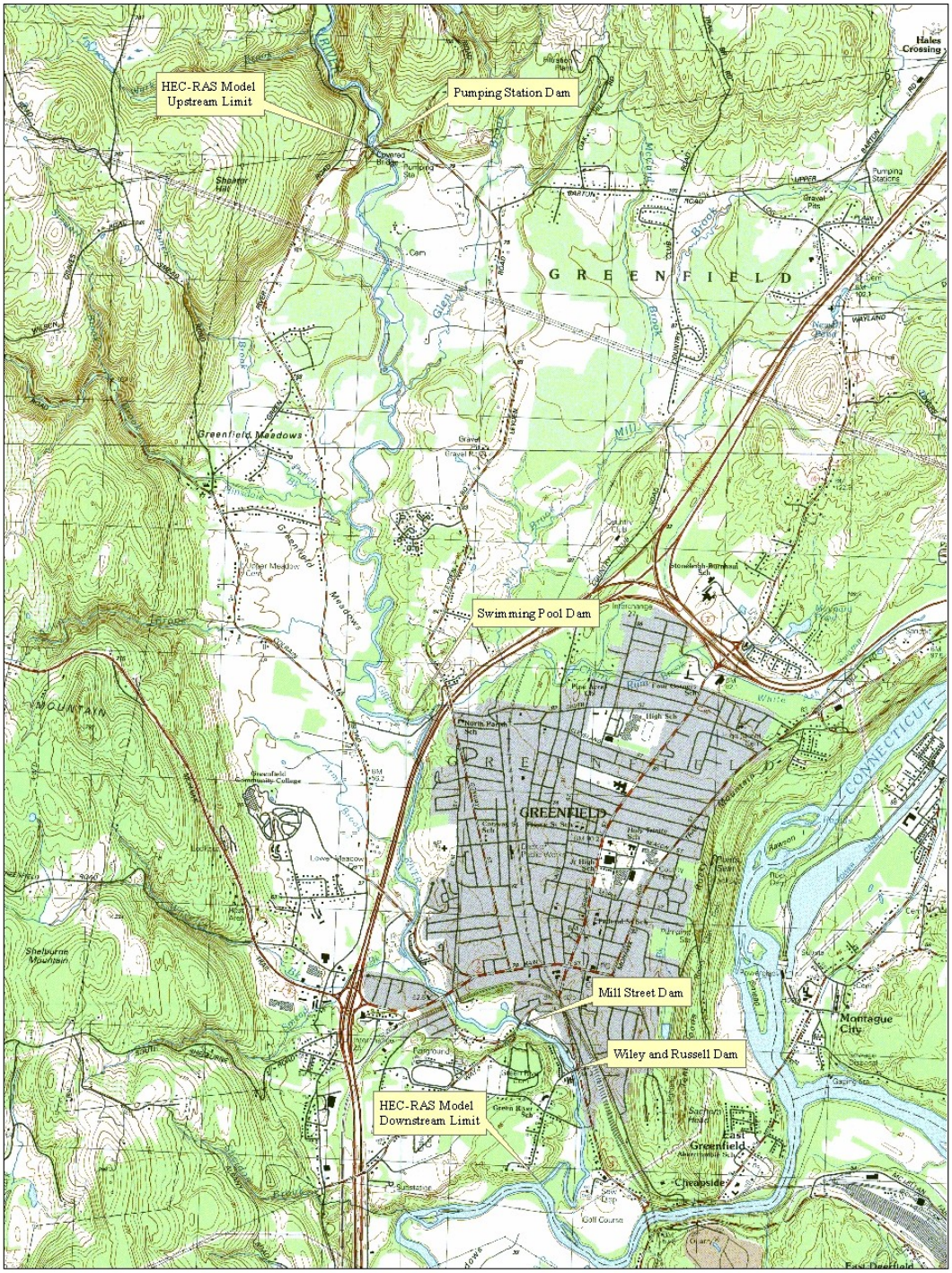
The proposed restoration of fish passage and riverine habitat on the Green River represents an opportunity to enhance locally, regional, and nationally important environmental resources. Anadromous fish and other aquatic life and the wildlife that depend on the river's resources would benefit from implementation of a restoration project. If no measures are taken to restore fish passage and riverine habitat on the Green River, fish passage will continue to be impeded and the benefits to regionally and nationally recognized resources would not accrue. The improvements in fish and wildlife resource value that would be generated with the project would not be achieved.

The improvements listed above would contribute to the regional efforts to restore anadromous fisheries in the Connecticut River where they have important ecological, economic and cultural importance. Anadromous and catadromous fisheries are by definition (Corps of Engineers Engineering Regulation

ER 1105-2-100) federally significant. Removing the impoundments would re-expose the riparian banks allowing vegetation to be reestablished providing overhang shade and additional fish habitat along the river. The latter would improve the habitat niches, moderate temperatures, and reduce direct solar radiation onto demersal eggs (attached to the substrate). The removal of dams and adjacent structures would restore a natural river ecosystem with important fishery and recreational values and would enhance water quality in the Green River.

1.3.3 (a) Historic and Archeological Resources

The Green River is considered archaeologically sensitive for the presence of prehistoric archaeological sites dating from the Middle Archaic (5500 – 3000 B.C.) to the Contact Periods (1500 – 1620 A.D.). The Green River was used for hydropower for a number of industries during Greenfield's history. The Wiley and Russell Dam was determined to be a contributing element to the Greenfield Tap & Die Plant No. 1, a district eligible for the National Register of Historic Places. The former Greenfield Tap & Die Company, an important tool making concern, operated from 1912 to 1992 at the site of an older, similar industry. It is anticipated that removal of the Wiley and Russell Dam will require prior documentation through the Historic American Engineering Record (HAER). The proposed removal of the Mill Street Dam, and the construction of fish ladders at the Swimming Pool and Pump Station dams, should have no effect on historic properties provided that all staging and project features are situated in previously disturbed areas. Consultation has been initiated with the Massachusetts State Historic Preservation Officer and the Stockbridge-Munsee Tribal Historic Preservation Officer.



STUDY AREA MAP

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1 inch equals 2,500 feet

U.S. Army Corps of Engineers
Section 206: Environmental Restoration
Green River
Greenfield, MA

PLATE 2

1.4 EVALUATION METHOD

The primary goals of the project are restoration of anadromous fisheries, aquatic habitat, and improvement of water quality. Every habitat is made up of physical, chemical, and biological components each of which can be defined through various criteria. For purposes of this evaluation, habitat criteria (water quality, aquatic habitat, and anadromous fish habitat) were broken down into basic requisites for aquatic life. Three requisites related to water quality were identified: dissolved oxygen, temperature, and flow. Aquatic habitat was broken down into four component requisites: spawning substrate, in-stream cover, forage, and benthic invertebrates. Habitat requisites for anadromous fisheries were identified as upstream passage, downstream passage and spawning habitat.

The Corps prepared an Incremental Analysis to quantify the habitat benefits that would accrue for each of the proposed restoration alternatives. A quantification of benefits is necessary to determine the cost effectiveness of various restoration plans. The recommended alternative is selected using information showing the changes in costs among alternatives. The method used for evaluating the Green River involves the examination of three primary habitat types that define the existing ecosystem of the study area. These include:

- Riverine habitat, which exists in the reaches of the river between each of the dams, upstream and downstream of their impoundments.

- Lacustrine habitat; which consists of the impoundments upstream of each dam; and

- Wetland habitat, which is located at various locations along the edges of the river or adjacent to the river, and may be hydraulically dependent upon the water levels of the river and/or the impoundments. (The primary wetland examined in this study is located in the oxbow area adjacent to the impoundment upstream of the Mill Street Dam.)

In conducting the Incremental Analysis, these habitat types are evaluated in terms of positive or negative changes that might be expected with each of the possible restoration alternatives. In evaluating the changes that would occur, it is possible that implementation of some of the restoration alternatives will decrease one habitat type while increasing another (e.g., by the removal of dams, the amount of lacustrine habitat formed by the impoundment will be reduced, however the riverine habitat will improve). The method used evaluates changes in the area and quality of each habitat type for each alternative and considers how costs change when increments of habitat improvement are added.

1.5 STUDY COORDINATION

The Commonwealth of Massachusetts Executive Office of Environmental Affairs (EOEA) and the Town of Greenfield, Massachusetts partnered with the Corps to fund and support the study. EOEA provided local coordination by organizing public information meetings, hosted meetings for involved agencies, and, with assistance from the Natural Resources Conservation Service, conducted a public education and outreach session. The Corps also sent letters to various Federal and state resource agencies as well as various public interest groups.

SECTION 2 – PROBLEM IDENTIFICATION

2.1 EXISTING CONDITIONS

This section of the report will provide details on each of the four dams being evaluated on the Green River as well as highlight the plan formulation constraints affecting the analysis.

2.1.1 WILEY & RUSSELL DAM

This is the first dam in the series of four dams along the Green River, located 1.2 miles above the confluence with the Deerfield River. It is a run of the river timber crib dam and concrete spillway 10 to 14 feet in height and about 185 feet in length. The dam is founded on bedrock and consists of an open timber crib with a vertical downstream face. The crib is covered on the top with a thin concrete cap and has a thin inclined concrete upstream face extending into the sediments impounded behind the dam. The structure has concrete and stone masonry abutments with abandoned outlet structures on both abutments. The two low-level outlet structures have deteriorated significantly and are inoperable, and the entire dam has fallen into considerable disrepair. The dam was constructed in 1936 for water supply for the Greenfield Tap & Die Company adjacent to the site. The Town of Greenfield currently owns the dam and was issued orders by the Massachusetts Department of Environmental Management (DEM, now known as the Department of Conservation and Recreation, DCR) that required the dam to be repaired by October 1999. The required repairs have not been performed to date. The Town has plans to revitalize the neighboring community and may have reservations about removal of the dam as it provides an aesthetically pleasing reflecting pool and has historical significance to some people. Removal or passage would provide access to 0.3 miles of habitat within the Green River.

The DEM Office of Dam Safety Inspection and Evaluation Report, dated June 18, 1998, lists the dam (ID no. 2-6-114-3) as “Small Size”, having a “Significant Hazard” classification, and being in generally poor condition. The report documents significant deficiencies in the condition of the dam and recommends detailed engineering investigations into the stability and adequacy of the dam as well as extensive remedial work. Specific deficiencies included: no corrective actions taken on previously identified deficiencies from a 1993 inspection; major cracking in the abutments; extensive tree and brush growth; spalling and severely decayed concrete; stones missing from masonry abutment walls; sinkholes along right abutment wall; trash racks and sluice gates no longer intact; and controls inoperable. Recommended investigations included: detailed hydraulic/hydrologic assessment to determine adequacy of the spillway; structural stability analysis of the masonry abutments and the timber crib and concrete spillway structures; investigation into the outlet structures integrity and seepage potential; and development of a written operations and maintenance plan.

The Corps performed an initial visual inspection on September 5, 2001 with regard to the possible installation of a fish passage. This confirmed the reported deficiencies and recommendations of the 1998 DEM report. The dam’s spillway, abutment walls, and outlet structures have not undergone any visible maintenance activities and have continued to deteriorate. The dam is considered to be in a very poor to unsafe condition. Extensive remedial, replacement, or removal actions are required to bring the dam and associated structures into a safe operating condition. Considerable deterioration and decay has occurred to the concrete

weir, timber crib members, masonry abutment walls, and adjacent outlet structures. There is currently no means to regulate the pool level behind the dam. The right abutment diversion conduits that ran to the old mill building are full of silt and sand deposits and the old timber gates have rotted away. The left abutment low-level outlet discharge is also blocked with debris and the old cast iron gate is inoperable. Most of the historical storage behind the dam is silted in with sediments, which block the intake to the old low-level outlet gate. Potential contamination of these

upstream sediments is under investigation by others at this time and is not addressed herein. Significant damages have occurred to the downstream right abutment masonry wall (looking downstream) since the last inspection, several large portions of the wall have collapsed due to seepage and repeated freeze/thaw action. The remaining portions of the masonry wall are unstable and ready to collapse. The dam is currently susceptible to a potential piping failure due to ongoing seepage through and around the right masonry abutment, as well as possible collapse of the deteriorated spillway structure.

The Corps performed a second site inspection on August 7, 2002 of the left abutment area to obtain more detailed information and to select subsurface boring locations for the proposed fish ladder. An old masonry and concrete foundation is located adjacent to this end of the timber crib spillway where the proposed fish ladder would be built. This old foundation appears to be the remnant of a flow diversion structure used for industrial purposes when the dam was functioning. The dam's inoperable low-level outlet used to discharge through the foundation of this structure. There is also an abandoned underground masonry channel running upstream under the north foundation wall. The foundation is currently filled with concrete and masonry rubble materials.

The Town would have to satisfactorily address all of the identified dam safety deficiencies prior to the construction of any viable fish passage structure under the Corps program. Due to the severity of the deterioration, conventional remedial repairs are probably no longer economically viable. The Town should consider the construction of a new dam immediately downstream of the existing dam or construction of the alternative rock ramp fishway if an impoundment structure is still part of the local neighborhood revitalization plans, otherwise the dam should be removed.

2.1.2 MILL STREET DAM

This is the second dam on the Green River, located about 1.5 miles above the confluence with the Deerfield River. It is a run of the river concrete gravity dam about 12 feet in height and about 170 feet in length. The dam was originally owned and used by Greenfield Electric Light and Power, but is currently owned by the town of Greenfield. The adjacent Mill Street Bridge was reconstructed in 1981 and spans directly over the dam. The bridge's new left abutment was

Photo 1: The Wiley & Russell Dam is located just upstream of the Meridian Street Bridge.

constructed directly over the original dam abutment, and the new right bridge abutment is located just upstream of the old dam. The Corps performed an initial site inspection on September 5, 2001 with regard to the possible installation of a fish passage. The dam appears to be founded on bedrock, as several outcrops are located at the dam's right abutment and also partially visible in the river bottom below the dam. It is not known whether the reconstructed bridge abutments are founded on bedrock. The dam has a single low-level outlet, of which the operating condition is unknown. Considerable deterioration of the concrete pier supporting the gate controls has occurred. Overall the concrete spillway section appears to be in fair condition, with the outlet works area being in poor condition. The Town would have to undertake repairs to the outlet gate structure if the dam is to remain and a fish ladder installed there. Removal or passage would provide access to 2.2 miles of additional habitat along the Green River.

2.1.3 SWIMMING POOL DAM

This is the third dam on the Green River, located about 3.7 miles above the confluence with the Deerfield River. It is a run of the river concrete dam about 2 feet in height and about 75 feet in length, located adjacent to a public beach. The dam is currently owned and used currently by Greenfield for recreation purposes. An initial site inspection was performed on September 5, 2001 with regard to the possible installation of a fish passage. The dam is founded directly on bedrock and appears to be in very good condition. The dam consists of a low concrete sill extending across the river with concrete piers extending above the river bottom. During summer months, slide gates are placed between the piers to impound a small pool for recreation and swimming. Modifications for fish passage would provide access to 4.6 miles of additional habitat along the Green River.

Photo 2: The Mill Street Dam is partly beneath the Mill Street Bridge.

Photo 3: The Swimming Pool Dam is located at the town park off Nash's Mill Road.

2.1.4 PUMPING STATION DAM

This is the fourth dam on the Green River, located about 8.3 miles above the confluence with the Deerfield River. It is a run of the river concrete gravity dam about 17 feet in height and about 95 feet in length. The dam is owned and currently used by Greenfield for water supply. The Corps performed an initial site inspection on September 5, 2001 with regard to the possible installation of a fish passage. The dam is founded directly on bedrock and appears to be in very good condition. It consists of a concrete overflow spillway across the main river channel, a concrete outlet works structure at the left edge of the river, and a low embankment and concrete wall extending to the left abutment. A modification to provide fish passage would open 12 miles of additional habitat along the Green River.

Photo 4: The Pumping Station Dam is located just upstream of the covered bridge on Eunice Williams Drive.

2.2 FUTURE CONDITIONS WITHOUT PROJECT

If no project is implemented to provide fish passage on the Green River, the status quo will prevail. The river will continue to be used for stocking juvenile anadromous species but the four dams in Greenfield will continue to block upstream passage of anadromous fish and segment the river and its native fish population. A possible exception to that forecast is the potential failure of the Wiley & Russell Dam if remedial work is not performed in a timely manner.

2.3 PLANNING CONSTRAINTS

As a tributary to the Connecticut River, the Green River historically provided migratory, spawning and nursery habitat for native anadromous fish, including Atlantic salmon, American shad, blueback herring and sea lamprey, as well as the catadromous American eel and the potadromous smallmouth bass, white sucker, and brook trout.

This investigation identified and examined practical methods to achieve fish passage at each dam accounting for physical or operational constraints that exist to limit the range of alternatives. Two of the four dams are beneficially serving the community. The Pumping Station Dam provides storage for public water supply. Its removal is not an option. The town of Greenfield operates the Swimming Pool Dam off Nash's Mill Road to create a pool behind it for seasonal public recreation. The Town does not support its removal to provide fish passage. Therefore, the study considers dam removal only at Wiley & Russell Dam and Mill Street Dam. The study team initially considered an alternative fish passage measure of a by-pass channel around the Wiley & Russell and Mill Street dams. However, there is no good path for such a channel to follow with the upstream and downstream areas separated by the roadway embankment and both industrial and residential development. The cost of acquiring land itself was found to be more expensive than other fish passage alternatives. Also, the trap and truck method of fish passage was eliminated from further study because of the logistical constraints and seasonal variability associated with restoring passage for such a wide variety of aquatic species.

SECTION 3 – CONSIDERATION OF ALTERNATIVES

3.1 SITE SPECIFIC ALTERNATIVES

The following site-specific fish passage measures were identified for further study after considering planning constraints, including prevailing site conditions. It should be noted that different alternatives can be applied to each site but something has to be done at every site in order to achieve all the project benefits.

3.1.1 Site 1 – Wiley and Russell Dam

Alternatives:

a) no action (maintain existing condition)
b) remove dam or partial breach of dam
c) construct fish ladder
d) construct rock ramp fishway

3.1.1 (a) Maintain Existing Condition

If no project is implemented, the Wiley & Russell Dam will remain as an impediment to upstream fish passage. The dam is in poor condition, especially its right abutment. It is anticipated that the State Office of Dam Safety will require the town of Greenfield to perform repairs. Major structural repairs as well as repairs to its gate structure and controls should be performed. It is also possible that the dam could fail as a consequence of the cumulative effects of high water events and deferred maintenance. In 2005, the sluiceway on the right bank of the river blew out downstream of the dam, creating a condition of greater uncertainty (see Photo 6).

3.1.1 (b) Dam Removal or Partial Breach of Dam

Removing Wiley & Russell Dam would create unimpeded access for fish to travel upstream. If means for fish passage were also provided at the Mill Street, Swimming Pool and Pumping Station Dams, a fish ladder at Wiley & Russell Dam would provide access to excellent spawning habitat upstream.

Photo 5: Water pours through a failed sluiceway fed by the Wiley & Russell Dam impoundment. This location is immediately upstream of the Meridian Street Bridge.

Criteria for partial or complete dam removal to allow migrating fish upstream was provided by the U.S. Fish & Wildlife Service (USFWS). These included removal parameters, allowable flow conditions, and the maximum allowable change in water surface elevations at the dams for natural fish passage. A partial breach of the Wiley & Russell Dam called for removal of one-third of the spillway length in the middle channel section of the dam (60'long x 3'high). The removal height was determined knowing the maximum allowable difference between the upstream and downstream water surfaces at the dams cannot be greater than a 3-foot difference for a flow of 360 cfs. A 3-foot difference or less would allow migrating fish to access areas upstream naturally without need for a fish passage facility. The same elevation and flow criteria were applied to the complete dam removal alternative, which would return this section of the river to a nearly natural (pre-dam) state.

The hydraulic analysis of the Green River used the Corps of Engineers HEC-RAS computer model to compute water surface profiles. It is a standard step method for calculating water surface elevations for steady gradually varied flows, based on river geometry and structures crossing the channel. Input for the model consists of channel geometry, hydraulic roughness coefficients, bridge and dam elevation data and structural geometry, and flow data.

Dimensions of the dam, bridges, and river channel cross sections through the study reach were obtained from the HEC-2 files for the Greenfield, MA Flood Insurance Study. Supplemental survey was conducted in November 2001 to better define existing conditions of the structure, channel, and surrounding topography. This new survey data was incorporated into the model to better define the existing conditions. The new survey provided accurate elevation data for possible sediment loads just upstream of the dam.

Results of the HEC-RAS analysis computed elevations and velocities at each cross section for flows ranging from four times the annual average daily flow ("fish flow"), 360 cfs, to the 500-year flood event of 16,350 cfs. The results from this range of flows defined the local flow characteristics needed to identify whether the alternatives would meet the natural fish passage criteria, and define possible areas that are susceptible to scour and erosion due to velocity increases. The fish flow was used to model the maximum allowable flow that a migratory fish could overcome with an upstream/downstream water surface elevation difference of less than 3 feet at the site of the removed or partially breached dam. The HEC-RAS model results for this flow determined that for the dam removal alternative the water surface elevation difference was 6 feet at Wiley & Russell dam. This is due to the model's inability to predict the new river bottom elevation after dam removal. This study did not identify the thickness of accumulated sediment behind the dam. However, topographic surveys determined that ledge outcrops exists along the river bottom just below Wiley & Russell Dam at a low enough elevation to permit natural fish passage. It is highly probable that this ledge outcrop exists under the dam structure at the same elevation and when the dam is removed, sediments will erode (or possibly removed) sufficiently to create a new river bottom at this ledge surface. A notch could be cut to ensure the target species can overcome the ledge if it is found to be a barrier to fish passage. In any event, if the HEC-RAS model were run with this adjusted river profile in place, the water surface elevation difference from upstream to downstream would be less than 3 feet for the dam removal option. Model results of the partial breaching of the dam (8 foot difference from upstream to downstream) indicate that this method of fish passage is not a viable solution. Further investigation on

depth (sediment probes or cores) and particle size of the sediments behind the dam will need to be done during the final design phase to confirm the actual elevation difference between the upstream and downstream inverts when the dam is removed.

Calculated velocity increases, upstream of Wiley &Russell Dam for the more frequent flows analyzed, ranged from 3.5-5.7 feet per second for the proposed dam removal. These increased velocities may cause some localized erosion above the dam and redistribution of sediments downstream. However, predicting the amount and location of any sediment redistribution was beyond the scope of this effort.

During the study process, the Corps became aware of remedial work in progress by the Berkshire Gas Company along the reach between the Mill Street Dam and the Wiley & Russell Dam. Coal tar, a polynuclear aromatic hydrocarbon (PAH), is present in the area as a result of an historic coal-gas plant that used to operate in the area south of Mill Street. Berkshire Gas Company, working with the Massachusetts Department of Environmental Protection (DEP), has completed two phases of their remedial plan for the site, including some work in the Green River channel in 2001.

USACE collected samples of sediments from ten locations within the Green River (and Deerfield River) on September 5th and 6th, 2001. "Grab" samples were gathered using push cores and shallow dredges. Nine of the ten samples were collected from within the Green River. The one remaining sample was collected in the Deerfield River immediately downstream of

the confluence with the Green River. Three sediment samples were taken in the immediate vicinity of each target location, and then composited into a single representative sample for the location. Samples were submitted to the analytical laboratory and analyzed for:

- Grain size
- Total organic carbon
- Metals (15)
- Polychlorinated biphenyls (PCBs; 22 congeners)
- PAHs

Grain size and total organic carbon results are used to characterize physical properties of the sediments, whereas the chemistry results are used to characterize potential anthropogenic contamination. Any such contamination may be considered residual, given that coal gas operations ceased in 1958 and discovered between 1971 and 1984.

Concentrations of chemicals detected in sediments may be compared to the *Threshold Effects Criteria* (TEC) provided by DEP as an indication of potential toxicity to aquatic organisms. Such comparisons indicate a general lack of toxicity for PCBs and metals, with the exception of chromium, which slightly exceeded its TEC. Concentrations of PAHs generally exceeded their respective TEC. However, there is uncertainty in the magnitude of these exceedances since they were similar in magnitude to the overstated bias in the reported concentrations of PAHs, as noted above. In light of this uncertainty, it appears that the reported exceedances of TEC are no worse and may be less problematic than indicated by the sample data.

As an additional point of comparison in assessing the health of the Green River environment, a macroinvertebrate study was conducted by the Deerfield Watershed Association in 2004. The findings of that study indicate that conditions in the Green River currently resemble conditions at ecological

health reference locations. It should be noted that this study did not sample directly in the areas of highest PAH contamination, so those results may understate actual effects. In addition, a DEP 2000 Water Quality Assessment report included results of macroinvertebrate surveys conducted in 2000 below the Pumping Station Dam and below the Wiley & Russell dam near Green River Park. The benthic community was not impacted at either of these sites and, in fact, improvement was noted in the macroinvertebrate community at the downstream station from 1995 data.

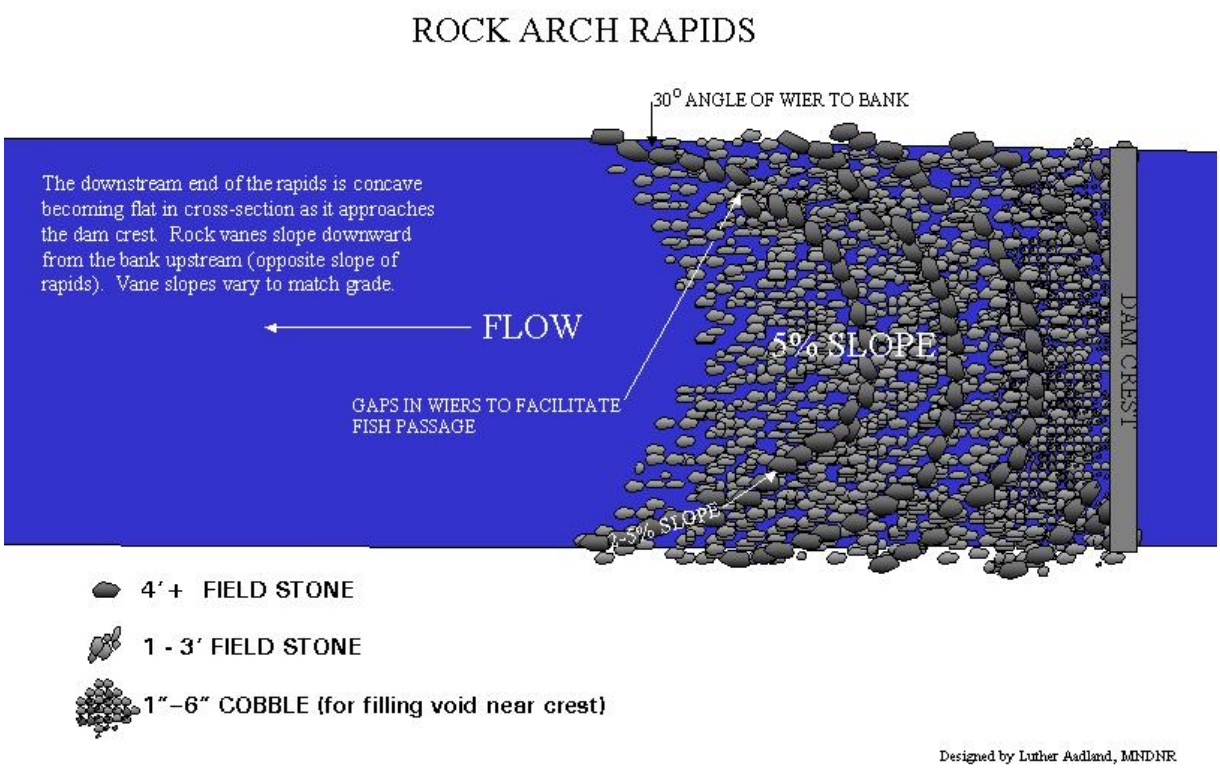
If the Wiley & Russell Dam were removed, the impoundment would be drawn down prior to any demolition activity. At that time, the opportunity would exist for Berkshire Gas Company to remove coal tar contaminated sediment in the “dry” with only a low flow channel flowing through this reach. This could be a much more economical process than if the impoundment remained. The need for further remediation, and the method and timing of that remediation, if any, should be explored through continued coordination with Berkshire Gas Company and DEP.

3.1.1 (c) Fish Ladder

A fish ladder would allow fish to pass upstream of the dam. The USFWS prepared a conceptual fish ladder and fish passage facility design for the Wiley & Russell Dam (Plates 19 and 21). The fish ladder design would optimize the passage of some, but not all species. If means for fish passage were also provided at the Mill Street, Swimming Pool and Pumping Station Dams, a fish ladder at Wiley & Russell Dam would provide access to excellent spawning habitat upstream. The dam is, however, in poor condition as noted in Section 3.1.1 (a) above. The town of Greenfield would have to perform repairs to the dam as a prerequisite for fish ladder construction.

3.1.1 (d) Rock Ramp Fishway

A rock ramp fishway is a specially engineered arrangement of boulders and cobbles that creates step pools with flow patterns sized to allow fish to climb gradually upwards from its toe to its crest and over a dam or other obstacle fronted by the rock ramp (see Figure 1 and Plates 20 and 22). In general, a concrete substructure of stepped cells with gravel fill are constructed in front of the dam at a 20 to 1 slope decreasing from the dam crest to the river invert. The substructure serves to buttress the dam and support the rocks that comprise the face of the ramp. Rows of boulders are arranged in a chevron pattern, angled downstream, where the largest boulders are placed near the river's banks and the remaining boulders in each row become progressively smaller until the river channel centerline is reached. This focuses the low flows to the center of the channel as they go down the rock ramp and gradually spreads higher flows so that there is always a location on the rock ramp where fish can climb successfully.



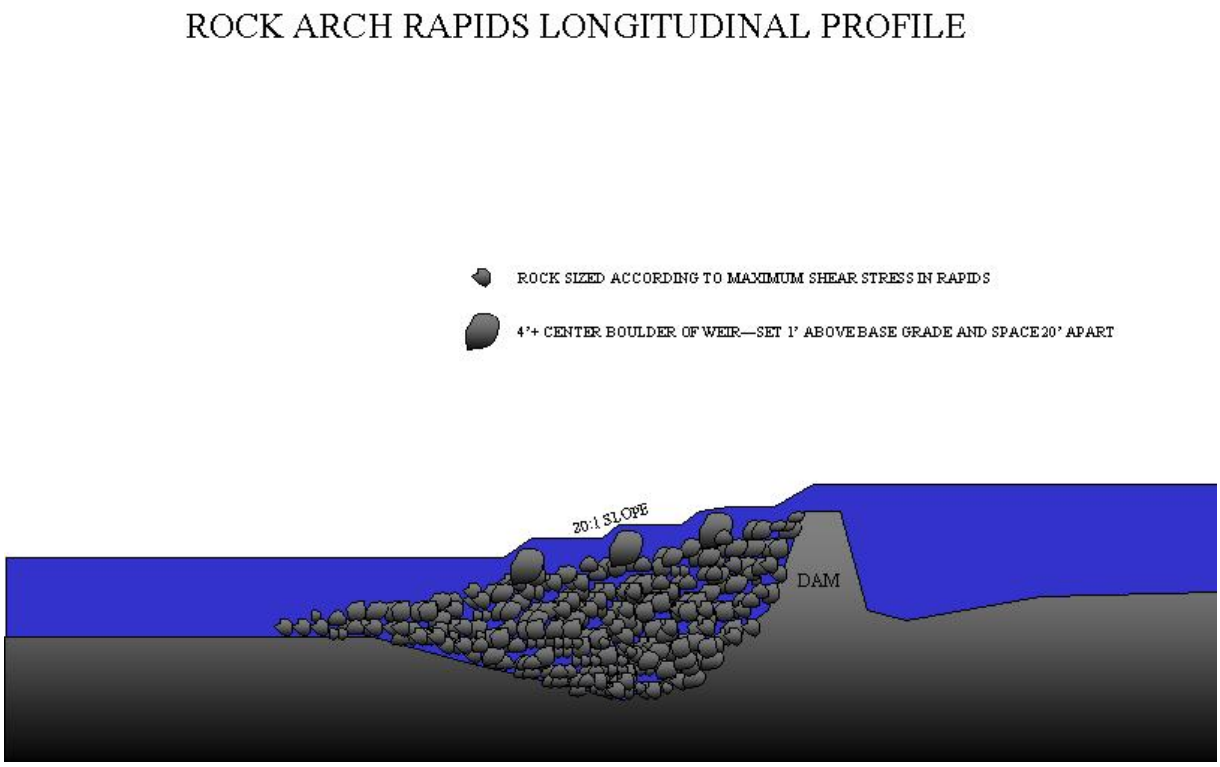


Figure 1 : Plan & Profile of typical Rock Ramp Fishway design; Substructure cell walls not shown

3.1.2 Site 2 – Mill Street Dam

Alternatives:

a) no action (maintain existing condition)
b) remove dam or partial breach of dam
c) construct fish ladder

3.1.2 (a) Maintain Existing Condition

If no project is implemented then the dam will remain as an impediment to upstream fish passage. Repairs to its gate structure and controls should be performed (See photo 6.)

Photo 6: Deteriorated Gate Control at Mill Street Dam

3.1.2 (b) Dam Removal or Partial Breach of Dam

Removing Mill Street Dam would create unimpeded access for fish to travel upstream. Criteria for partial or complete dam removal to allow migrating fish upstream was provided by USFWS. These included removal parameters, allowable flow conditions, and the maximum allowable change in water surface elevations at the dams for natural fish passage.

A partial breach of the Mill Street Dam called for removal of one-third of the spillway length in the middle channel section of the dam (55'wide by 4.5'high). The removal height was determined knowing the maximum allowable difference between the upstream and downstream water surfaces at the dams cannot be greater than 3 feet for a flow of 360 cfs. A 3-foot difference or less would allow migrating fish to access areas upstream naturally without need for a fish passage facility. The same elevation and flow criteria were applied to the complete dam removal alternative, which would return this section of the river to a nearly natural (pre-dam) state (see plate 13).

The HEC-RAS model results for the fish flow determined that for the dam removal alternative the water surface elevation difference was 3.5 feet at Mill Street dam. Again, as described earlier is section 3.1.1 (b), this difference is due to the model's inability to predict the new river bottom elevation after dam removal. This study did not identify the thickness of accumulated sediment behind the dam.

However, topographic surveys determined that ledge outcrops exists along the river bottom just below Mill Street Dam at a low enough elevation to permit natural fish passage. It is highly probable that this ledge outcrop exists under the dam structure at the same elevation and when the dam is removed, sediments will erode (or possibly removed) sufficiently to create a new river bottom at this ledge surface. A notch could be cut to ensure the target species can overcome the ledge if it is found to be a barrier to fish passage. In any event, if the HEC-RAS model were run with this adjusted river profile in place, the water surface elevation difference from upstream to downstream would be less than 3 feet for the dam removal option. Model results of the partial breaching of the dam (5.5 foot difference from upstream to downstream) indicate that this method of fish passage is not a viable solution. Further investigation on depth (sediment probes or cores) and particle size of the sediments behind the dam will need to be done during the final design phase to confirm the actual elevation difference between the upstream and downstream inverts when the dam is removed.

Calculated velocity increases, upstream of Mill Street Dam for the more frequent flows analyzed, ranged from 5.1 – 7.3 feet per second for the proposed dam removal. Plans for the Mill Street Bridge need to be obtained for a final design involving dam removal to be prepared. It is assumed that an 8-inch diameter sanitary sewer line upstream of the Mill Street Bridge would need to be relocated if dam removal is selected. Establishment of a new stable channel with vegetated banks would take time, so erosion of these structures needs to be accounted for in the site design. As with Wiley & Russell, predicting the amount and location of any sediment redistribution when the dam is removed was beyond the scope of this effort.

3.1.2 (c) Fish Ladder

A fish ladder would allow fish to pass upstream of the dam. The USFWS prepared a conceptual fish ladder and fish passage facility design for the Mill Street Dam (see Plates 14, 15, and 16). The fish ladder design would optimize the passage of some, but not all species. In conjunction with similar fish passage structures at the Swimming Pool and Pumping Station Dams, a fish ladder at Mill Street Dam would provide access to excellent spawning habitat upstream. Overall, the dam's concrete spillway appears to be in fair condition and the outlet works are in poor condition. The Town will need to repair the outlet gate structure prior to installation of a fish ladder.

3.1.3 Site 3 – Swimming Pool Dam

a) no action (maintain existing condition)
b) construct fish ladder

3.1.3 (a) Maintain Existing Condition

The Swimming Pool Dam is used by the town to create a seasonal recreational swimming area and it is, therefore, not a candidate for removal. If no project is implemented then the dam will remain as an impediment to upstream fish passage.

3.1.3 (b) Fish Ladder

A fish ladder would allow fish to pass upstream of the dam during periods where the flashboards are in place and a notch created in one bay of the dam would be effective at all other times. The USFWS prepared a conceptual fish ladder and fish passage facility design for the Swimming Pool Dam (see Plate 9, 10, and 11). The fish ladder design would optimize the passage of some, but not all species. In conjunction with a fish passage structure at the Pumping Station Dam, a fish ladder at Swimming Pool Dam would provide access to excellent spawning habitat upstream.

3.1.4 Site 4 – Pumping Station Dam

Alternatives:

a) no action (maintain existing condition)
c) construct fish ladder

3.1.4 (a) Maintain Existing Condition

The town uses the Pumping Station Dam to create a backup municipal water supply and it is, therefore, not a candidate for removal. If no project is implemented then the dam will remain as an impediment to upstream fish passage.

3.1.4 (b) Fish Ladder

A fish ladder would allow fish to pass upstream of the dam and access to excellent spawning habitat upstream. The USFWS prepared a conceptual fish ladder and fish passage facility design for the Pumping Station Dam (see Plates 5, 6, and 7). The fish ladder design would optimize the passage of some, but not all species.

3.1.5 Site 5 – Leyden Woods

After dropping steeply over the first 1.5 miles below the Pumping Station Dam, the invert of the Green River becomes less steep. At about 2.3 miles below the dam, near the Leyden Woods apartments, the river is characterized by old oxbows, eroding riverbanks and depositional bars.

3.1.5 (a) In-stream Work for Habitat Restoration

Habitat improvements would consist of the placement of rock weirs extending from the banks in order to create pool and riffle sequences beneficial for resident trout and other species in a

section of the Green River near the Leyden Woods apartments, and the stabilization of some of the severely eroded banks nearby.

3.1.6 Site 6 – Reach Between Mill Street and Meridian Street

The short, gently curving river segment between Mill Street and Meridian Street would benefit from channel alterations to improve fish habitat if the Wiley & Russell dam were removed and the lacustrine habitat reverted to a riverine one. These restoration measures include the placement of rock weirs extending from the banks to create slight meanders in the new low flow channel and also direct low flows away from areas such as the foot of the slide from the cemetery.

3.1.6 (a) In-stream Work for Habitat Restoration (only if Wiley & Russell dam removed)

Habitat improvements would consist of the placement of rock weirs extending from the banks in order to create pool and riffle sequences beneficial for resident trout and other species in the section of the Green River between Mill Street and Meridian Street.

3.2 Formulated Alternatives

The alternative measures considered for a given site are summarized in Table 1. Based upon known criteria for fish passage and recognizing prevailing site conditions and other planning constraints, the alternative measures discussed above were combined to create alternative plans for further study. Ten alternative plans were evaluated, including the “No Action” plan, by the study. These combinations are summarized in Table 2. Plates 4 through 22 that follow depict the existing conditions and the conceptual plans and details for the proposed alternative fish passage measures.

TABLE 1 DEERFIELD RIVER GI STUDY GREEN RIVER HABITAT IMPROVEMENT
GREENFIELD, MA ALTERNATIVE MEASURES
CONSIDERED BY SITE

SITE NO.	SITE	DESCRIPTION OF WORK PROPOSED	TYPE OF BENEFIT	SPECIFIC MEASURE	*ESTIMATED CONSTRUCTION COST	CONSTRUCTION ACCESS / REAL ESTATE NEEDS	NOTES
1	**Wiley & Russell Dam**	Consider dam removal for fish passage, rock ramp fishway for fish passage or fish passage structure.	increase anadromous fish access to habitat	Wiley & Russell Dam complete removal	$380,000	Municipal ownership. Temporary easements required for public & private land.	Analysis showed partial breach at this location to be unfeasible.
				Wiley & Russell Dam partial breach	N/A		
				Wiley & Russell Dam rock ramp fishway	$370,000		
				Wiley & Russell Dam denil fish ladder	$470,000		
2	**Mill Street Dam**	Consider dam removal for fish passage, partial dam breach for fish passage or fish passage structure.	increase anadromous fish access to habitat	Mill Street Dam complete removal	$530,000	Municipal ownership. Temporary easements required for public & private land.	Analysis showed partial breach at this location to be unfeasible.
				Mill Street Dam partial breach	N/A		
				Mill Street Dam denil fish ladder	$610,000		
3	**Swimming Pool Dam**	Consider fish ladder for fish passage.	increase anadromous fish access to habitat	Swimming Pool Dam steeppass fish ladder	$280,000	Municipal ownership. Temporary easement required on public land.	
4	**Pumping Station Dam**	Consider fish ladder for fish passage.	increase anadromous fish access to habitat	Pumping Station Dam denil fish ladder	$530,000	Municipal ownership. Temporary easement required on public land.	

5	**River channel in the vicinity of Leydon Woods**	Construct J-vanes and boulder groups in river channel to create riffle/pools.	improve fish habitat	Construct J-vanes and boulder groups in river channel.	$20,000	Access and staging area require easements on private land.	
6	**River channel Mill Street to Meridian Street**	Construct J-vanes and boulder groups in river channel to create riffle/pools.	improve fish habitat	Construct J-vanes and boulder groups in river channel.	$30,000	Access and staging area require easements on private land.	

* Doesn't include costs for developing Plans & Specifications, Permits, and Construction Phase Project Management and Value Engineering Study and Demobilization.

Plate 3 List of Plates Depicting Existing Conditions and Alternative Measures:

Plate 4 Site Plan – Existing Condition – Pumping Station Dam

Plate 5 Site Plan – Fish Ladder – Pumping Station Dam

Plate 6 Pumping Station Dam – Fishway Plan & Profiles

Plate 7 Pumping Station Dam – Sections

Plate 8 Site Plan – Existing Condition – Swimming Pool Dam

Plate 9 Site Plan – Fish Ladder – Swimming Pool Dam

Plate 10 Swimming Pool Dam – Plan, Section & Profile

Plate 11 Swimming Pool Dam – Sections & Details

Plate 12 Site Plan – Existing Condition – Mill Street Dam

Plate 13 Site Plan – Remove Existing Dam – Mill Street Dam

Plate 14 Site Plan – Fish Ladder – Mill Street Dam

Plate 15 Mill Street Dam – Sections & Details

Plate 16 Mill Street Dam – Sections & Details

Plate 17 Site Plan – Existing Condition – Wiley & Russell Dam

Plate 18 Site Plan – Remove Existing Dam – Wiley & Russell Dam

Plate 19 Site Plan – Fish Ladder – Wiley & Russell Dam

Plate 20 Site Plan – Rock Ramp Fishway – Wiley and Russell Dam

Plate 21 Wiley & Russell Dam – Fish Ladder Plan, Profiles, Section & Details

Plate 22 Wiley & Russell Dam – Rock Ramp Fishway Sections

3.3 ENVIRONMENTAL CONSEQUENCES

This section summarizes the environmental consequences of plans developed to restore anadromous fish passage and riverine habitat to the Green River. A more complete discussion of the consequences of the various plans can be found in the Environmental Assessment. The purpose of this project is to restore the natural continuity of the river and provide fish access to habitat that the dams have excluded for many species. All plans except the no action plan involve construction of fish ladders at the Pumping Station Dam and the Swimming Pool Dam. Except for short-term negative effects, this project will primarily have positive effects on the environment. The habitat available to anadromous fish will be increased. A list of the most important environmental consequences is presented below.

- Restored access to the habitat will contribute to increased numbers of anadromous fish;
- The value of the restored river segments for fish and wildlife will be increased; and
- Recreational opportunities along the lower Green River will be improved.

The specific effects of the project are described in detail in the following sections.

3.3.1 Fish

Construction Phase Effects

The project will have minor effects on finfish during construction. Since fish are mobile they can avoid the relatively small area of increased turbidity that may result from construction. Fish that are close to and downstream of the two lower dams during construction may be exposed to higher turbidity levels as a result of sediment mobilization during construction. The dam removals will be scheduled for low flow periods and not during the time of anadromous fish runs.

Long Term Effects

The project will have a positive long-term effect on fisheries. The alternatives, with the exception of the no action alternative, will all have a positive effect on fish communities due to the increase in anadromous fish habitat and the removal of limited and segmented habitat for other resident species of fishes. Restoring fish passage beyond the four dams on the Green River is expected to have an overall benefit to the cultural and economic resources of the town of Greenfield. The restoration of anadromous fish to the Green River is expected to enhance recreational and/or cultural activities in several ways. These include fish viewing, since the up migrating fish will be visible in the restored river channel at Wiley & Russell and Mill Street, and in the fish ladders at Swimming Pool and Pumping Station Dams, as well as improved recreational fishing, since the influx of blueback herring into the system can improve the overall productivity of the existing fisheries in the river. Additional value will be added to the Deerfield and Connecticut River Ecosystems, and the Natural Heritage Status of the Connecticut River, as well as the as to the productivity of the Connecticut River estuary, by the restoration (i.e. return) of blueback herring to the ecosystem.

3.3.2 Wildlife

Construction Phase Effects

For all types of wildlife, there will be temporary disturbance of habitat during the estimated 9-month construction period. Some species may temporarily leave the area. Overall there will be a minor temporary decrease in the capacity to support wildlife populations during the construction time frame.

Long Term Effects

Effects of the project on particular wildlife species are summarized in the Environmental Assessment. The quality of wildlife habitat is based on the interrelationship (juxtaposition and interspersion) between three key elements (food, cover, and water). Juxtaposition refers to the distribution between the requirements of a species (i.e., food, cover and water) in relation to each other and the area normally traveled by the species. Interspersion refers to the distribution of habitat components in relation to the habitat as a whole or the pattern of mixing of habitat types.

The relationship between habitat elements will change with the restoration project. As a result, there will be a change in the relative abundance of the various species of wildlife using the site. However, none of the vegetation types on the site will be completely eliminated, or reduced so significantly that they no longer provide habitat as a result of the project. All of the species presently using the site are expected to remain, although at different population levels. Of course the target anadromous fish species are expected to reappear along the opened migration corridor.

3.3.2 (a) Birds

The unique location of the Green River, with its close proximity to the Connecticut and Deerfield Rivers, provides habitat for numerous avian species. Approximately eighty-one species of birds have been reported to use the various habitat types (i.e. hardwood and coniferous forests, scrub-shrub and meadows) within the Green River watershed for nesting, breeding and feeding (S. Laughlin, Atlas of Breeding Birds in Vermont, as cited in Green River Survey Course, 1999). Of these, approximately seventy-seven species are migratory, and twenty nine of these migratory species located in or near the Green River watershed use rivers and their adjacent shoreline brush as nesting habitat as opposed to open meadows, forested lands, etc. Although some of these birds can use other habitat types, all twenty-nine are known to be associated with a clean river or stream. Most of these eighty-one species occur in the more undeveloped sections of the Green River in Vermont, where the National Park Service has classified the river as an undeveloped river corridor.

Species that have been observed within the specific project area include various finches, swallows, and woodpecker species within riparian and upland areas; and great blue heron, common merganser, mallard duck, snowy egret associated with the wetlands. These birds have been specifically observed in the associated wetlands upstream from the Mill Street Dam discussed previously. In addition, the Connecticut River, which forms the eastern boundary of Greenfield provides habitat to numerous migratory and non-migratory avian species, which

utilize the riparian corridor for migration, as well as various waterfowl species. These include the pied-billed grebe, sedge wren, black duck and possibly the least bittern (Watershed Rarity

Ranks for Species of Special Emphasis, in the Silvio O. Conte National Wildlife Refuge, Turner's Falls MA).

The change from lacustrine to riverine habitat with the loss of the impoundments behind the two lower dams will result in an increase in bird species that nest and feed in or around rivers.

3.3.2 (b) Mammals

The proposed project is generally not expected to have any long-term negative effects on terrestrial wildlife inhabiting the riparian areas of the Green River. The actual construction footprints (for both dam removal and fish ladder construction) will be limited to the areas immediately abutting each of the dams. These areas have been previously disturbed, and in the case of the Wiley & Russell and Mill Street Dams, (proposed for removal), are in urban settings adjacent to paved parking areas, roadways, and concrete bridges which are habitat impediments. Temporary construction access structures and roadways (as described for the Water Supply Dam) are planned to traverse the previously disturbed sections and/or existing components of the dams as much as possible in order to minimize any habitat disturbances. Most terrestrial wildlife species that may inhabit the immediate project footprint areas are expected to temporarily relocate. Any impacts that may occur will be temporary, and of short duration, lasting only until the project is completed.

The passage of migratory fish beyond the four Dams into the upper sections of the Green River is expected to have an overall positive effect upon the wildlife population in these areas. Both the upstream migration of pre-spawning adult alewives and shad, as well as the downstream migration of the juveniles, will provide beneficial forage to resident wildlife species, to include birds, as well as other predatory terrestrial wildlife. Many avian species including, herons, loons, and raptor species eat fish, as well as terrestrial mammals such as river otter and to a lesser extent raccoons, and black bear, all of which have previously been found in the areas of the Green River watershed.

3.3.2 (c) Threatened and Endangered Species

Recent coordination with the U.S. Fish and Wildlife Service has indicated that there are no federally listed or proposed, threatened or endangered species under its jurisdiction are known to occur in the study area, with the exception of occasional transient bald eagles (*Haliaeetus leucocephalus*). Coordination with the National Marine Fisheries has also indicated that there are no threatened or endangered species expected to be present within that region of the Connecticut River Watershed. Although shortnose sturgeon occupy the more downstream sections of the Connecticut River in the latitude of the Green River, they have not been documented in the Green River (see Environmental Assessment letters dated February 19, 2003 and February 11, 2003).

Coordination with the Commonwealth of Massachusetts Division of fisheries and Wildlife Natural Heritage and Endangered Species Program (NHESP) has indicated that the several plant

fish and reptile species listed by the state as endangered and/or Special Concern occur within the study area. The plant species include Barren Strawberry (*Waldsteinia fragariodes*), Black Maple (*Acer nigrum*), both considered to be species of Special Concern; the fish species is Northern Redbellydace (*Phoxinus eos*), listed as Endangered; and reptile species, Wood Turtle (*Clemmys insculpta*). Barren Strawberry occurs in a diverse range of habitats, including a variety of forest types, wet thickets, clearings, dry sandy woods, barrens, slopes and rock outcrops. It has generally been found in rich wooded to semi-open banks in Massachusetts, as well as in rich mesic-shade forest on old floodplains with humus-rich soil. It has been associated with sugar maple, white ash, white pine, hickories, and ironwood, which often provide shade for it. The Natural Heritage and Endangered Species indicated that Priority Habitat for this species exists along the Green River in the study area.

Black Maple occurs in rich moist soil in association with alluvial hardwood forests, and is highly tolerant of shade. In Massachusetts, all of the sites where it has been found have moderately moist, or mesic, soils with either shade or filtered light conditions. Specific habitat types in Massachusetts where this species has been found include floodplain forests, forested rocky slopes, and outcrops, and rich wood communities. In Massachusetts it is commonly found growing with sugar maple, (Acer saccharum), basswood (*Tilia Americana*), white and green ash (*Fraxinus americana and F. pennsylvanica*), sycamore, *(Platanus occidentalis*), American elm (*Ulmus Americana*), bitternut hickory (*Carya cordiformis*), hop hornbeam (*Ostrya Virginiana*), and various species of birch, (*Betula*), leatherwood (*Dirca palustris*), and wild leek (*Allium tricoccum*).

The Wood Turtle inhabits riparian areas, and is considered the most terrestrial of the North American turtles utilizing both aquatic and terrestrial habitats during its lifetime. It can feed in both of these habitats, and is considered semi-aquatic, although the terrestrial habitat occupied by this species is generally within a few hundred meters (approximately 1000 feet) from a stream or river system. It utilizes aquatic habitat for over wintering, where it burrows into either a muddy stream bottom, or muddy bank for hibernation. It becomes active in the spring when it leaves its burrow and begins its terrestrial activity, moving up onto the riverbank to bask in the sun, and eventually during the spring and summer occupying meadows and upland forests. By late summer it returns to the streams and/or rivers to mate and over-winter. It is omnivorous and in the terrestrial environment can feed on insects, carrion, worms, blackberries, dandelions, grasses sedges, mushrooms, and in the aquatic environment on fish, tadpoles, mollusks and filamentous algae. Their range is generally limited to within a few hundred meters (approximately 1000 feet) of the river, and moving linearly along the riparian corridor a distance of approximately a mile, although some individuals have been known to move greater distances using the riparian corridors for dispersal. Wood turtles are often found in riparian areas characterized by sandy-bottomed streams with slower moving water and heavily vegetated stream banks. They are generally attracted to tangles of vegetation.

Northern Redbelly Dace are generally found in quiet, cool, boggy stream and lakes, and in Massachusetts they are found in clear streams and spring-fed seepage pools. This species has been observed in the Green River in areas of the river that contain groundwater seeps, and areas of upwelling through the gravel bars. The river segment below the residential development at Leyden Woods is one such area they have been observed.

As noted, all of the above endangered and species of special concern have been found in priority habitats that are found along the Green River in the vicinity of Greenfield MA. A final determination by NHESP of what impacts to these species will occur, if any, and what steps are necessary to mitigate those impacts will take place during the design phase of this project.

3.3.3 Wetlands, Vegetation, and Cover Types

General

In general, the effect of the project on the vegetation community will minimal. Wetland and upland vegetation will populate the new channel fringes where the impoundments are now located. If the Mill Street Dam were removed, the effect on the wetlands upstream of Mill Street, specifically the pond and two historic oxbow segments, could be partially mitigated by the placement of a control weir in the ditch that connects the pond to the Green River.

Construction Phase Effects

There will be temporary impacts to wetland, riverbank, and upland vegetation during the construction period. Vegetation removal in the staging and access areas will temporarily disturb upland vegetation. The size of disturbance of the staging area and access roads will be limited to the minimum necessary for construction access and a line of erosion control devices will be established along the perimeter. The affected areas, other than those already cleared or paved, will be allowed to revegetate following construction and areas with severe slopes or disturbed soils with a high potential to impact water quality will be replanted to minimize erosion.

3.3.4 Water Quality

There may be a temporary short-term increase in turbidity and suspended solids in the vicinity of the project during construction and, in particular, mobilization of sediment load could temporarily affect water quality as a new channel is established. The amount and nature of the sediments behind both Wiley & Russell and Mill Street dams is not know at this time. Some of that material may be removed during the actual removal of the dam structure. Some of the sediments left in place during dam removal may be eroded over time and redistributed to downstream reaches of the river. However, predicting the amount and location of any sediment redistribution when a dam is removed was beyond the scope of this effort.

To minimize potential construction phase water quality impacts, temporary construction access roads will be constructed of clean granular material. Geotextile will be used for separation and strength and to facilitate removal of the temporary roads after the majority of work is complete. Appropriate controls on erosion and sedimentation will be employed throughout construction to isolate areas of disturbed soils and construction activity.

3.3.5 Air Quality

The project will have no long-term impacts on air quality. During construction, equipment operating on the site will emit pollutants including nitrogen oxides that can lead to the formation of ozone. In order to minimize air quality effects during construction, construction activities will comply with applicable provisions of the Massachusetts Air Quality Control Regulations pertaining to dust, odors, construction, noise, and motor vehicle emissions.

3.3.6 Sediment Quality

In 2001, sediment samples were collected by the Corps from ten locations along the river from its confluence with the Deerfield River, to just below the Water Supply Dam. Sampling locations are shown in Appendix C. The samples were analyzed for grain size, Total Organic Carbon, metals, PCB's and PAH's.

No PCB's were detected in any of the samples collected. However, elevated concentrations of PAH's were found adjacent to and downstream from the Berkshire Gas Company, which is located between the Wiley & Russell and Mill Street dams; upstream from the Mill Street Dam and below the railroad bridge at the Mohawk trail; and at the confluence of the Green and Deerfield Rivers. The lowest total PAH concentrations were found below Mill Street Dam and below the Pumping Station Dam, where out of a total of 27 PAH's screened for in the samples, 23 were in concentrations below detection limits. PAH's that were detected in the highest concentrations included Pyrene and Flouranthene. Pyrene was detected at 450

micrograms/kilogram (ug/Kg) and Flouranthene at 380 ug/Kg adjacent to and downstream from the Berkshire Gas Company. Concentrations of Benzo[a]anthracene, chrysene, and Benzo[a]pyrene were also elevated at this location.

Various criteria have been developed to determine levels of contaminants in sediments where biological effects can be expected to occur in benthic organisms. Among these are the Ontario Ministry of the Environment (OME) Sediment Quality Guidelines which were developed to protect aquatic life (Persaud, 1993). The OME guidelines were established as three levels of effect - the No Effect Level, Lowest Effect Level (LEL) and Severe Effect Level (SEL). The No Effect Level is that at which chemicals in the sediment do not affect fish or sediment-dwelling organisms. No transfer of chemicals through the food chain and no effects on water quality are expected at this level. The LEL is the level of a contaminant where no effect would be expected on the majority of sediment-dwelling organisms, and the sediment is considered clean to marginally polluted. The Severe Effects Levels (SEL) is applied to sediment containing concentrations of contaminants where a pronounced disturbance of the sediment-dwelling community can be expected. This is considered the concentration of a compound in the sediment that would be detrimental to the majority of benthic species, and the sediment would be classified as heavily polluted and likely to affect the health of sediment dwelling organisms.

More recently, the Commonwealth of Massachusetts Department of Environmental Protection developed a set of Recommended Freshwater sediment Screening Values (DEP, 2002). These are consensus based threshold effect concentrations (TEC's) for 28 chemicals for use in screening freshwater sediment for risk to benthic organisms. They are based on data from a

variety of sources including the OME guidelines noted above. These TECs for a given contaminant are defined as the concentrations below which harmful effects on sediment dwelling organisms are not expected to occur, however, they are not necessarily protective of higher trophic level organisms exposed to bio-accumulating chemicals.

At the sampling station between the Wiley & Russell and Mill Street Dams, adjacent to the Berkshire Gas Company, Flouranthene was found in the highest concentration compared to all of the stations (380 ug/Kg), although it was below the Commonwealth of Massachusetts TEC level of 423 ug/Kg. However, concentrations of Pyrene, Benzo[a]anthracene, chrysene, and Benzo[a]pyrene from this station were all above these TEC levels. In addition, concentrations of Pyrene from below the railroad bridge and of Benz[a]anthracene from the confluence of the Green and Deerfield River were above the TEC screening concentrations. These results are summarized in Table 3. Results from all of the stations are presented in Appendix C.

The concentrations of the contaminants that are above the TECs suggest that harmful effects can be expected in the benthic organisms exposed to them. Since the concentrations of contaminants found in the Wiley & Russell impoundment exceed TECs, it may be necessary to remove or stabilize these sediments to prevent them from moving downstream in the event of a significant flow event and/or dam removal at Wiley & Russell.

TABLE 3. Concentrations of selected Polynuclear Aromatic Hydrocarbons from the three most contaminated stations on the Green River, Greenfield Massachusetts, relative to the Massachusetts DEP Threshold Effect Concentrations (TEC) for benthic organisms.

Compound	Confluence of Deerfield/Green Rivers (ug/Kg)	Adjacent To Berkshire Gas Company (ug/Kg)	Below Railroad Bridge (ug/Kg)	TEC (ug/Kg)
Flouranthene	210	380	260	**423**
Pyrene	190	**450**	**210**	**195**
Benz[a]anthracene	**110**	**220**	100	**108**
Chrysene	110	**210**	130	**166**
Benzo[a]pyrene	96	**190**	110	**150**

As noted previously, the sediment that was collected from the 9 stations described above was analyzed for the following 15 metals: Silver (Ag), Arsenic (As), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury, (Hg), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Titanium (Ti), Vanadium (V), and Zinc (Zn). Results of the analyses from all stations are presented in Appendix C. Of these 15 metals, consensus based TECs have been developed for eight - Arsenic, Cadmium, Chromium, Copper Lead, Mercury, Nickel, and Zinc. Generally, the concentrations of these metals are well below the TECs, with the exception of Chromium and Mercury. The mean Chromium concentrations calculated for all of the sampling stations noted above was 43.9 milligrams/kilogram (mg/Kg) which slightly exceeds the consensus based TEC of 43.4 mg/Kg. Individual chromium concentrations range from 35.9

mg/Kg, measured upstream from the Mill Street Dam, to 56.8 mg/Kg, measured at the area immediately downstream from the Pumping Station Dam.

Reasons for these elevated levels are not known, although when compared to other rivers where there is relatively little watershed development, chromium concentrations have been found within a similar range. Some examples of these include several New England U.S. Army Corps of Engineer flood control reservoirs which are considered to have relatively pristine sediments due to the minimal watershed development. They are Ball Mountain and Townshend Lakes in Vermont, Barre Falls Dam in Massachusetts, Hancock Brook Lake in Connecticut, and Otter Brook Lake in New Hampshire, where chromium concentrations in sediments have ranged from 2.6 mg/Kg to 40 mg/kg (NAE, 1998; NED, 1993a, 1995, 1997b from NAE, 1999, French River Projects Priority Pollutant Scan). However as noted for the PAH results, the fact that these concentrations exceed the Massachusetts TECs suggests that biological effects to benthic organisms exposed to this sediments would be expected. These results are summarized in Table 4, and compared with the Massachusetts consensus based TECs. Results from all of these stations are presented in Appendix C.

TABLE 4. Chromium concentrations in sediments collected from all stations on the Green River in 2001, relative to Massachusetts DEP Threshold Effect Concentrations (TEC) for benthic organisms.

Station	Chromium (mg/Kg)	TEC (mg/Kg)
Confluence Deerfield/Green Rivers	38.8	43.4
Below Treatment Plant Outfall	**49.2**	43.4
Below Wiley & Russell Dam	**45.7**	43.4
Wiley & Russell Impoundment	39.9	43.4
Adjacent To Berkshire Gas Company	39.9	43.4
Below Mill Street Dam	**52.8**	43.4
Upstream Mill Street Dam Impoundment	35.9	43.4
Below Railroad Bridge	36.9	43.4
Below Water Supply Dam	**56.8**	43.4

Concentrations of Mercury (Hg) in sediment were below the detection levels at all sampling locations with the exception of the station just below the Wiley & Russell Dam where it measured 0.239 mg/Kg. This concentration exceeds the Commonwealth of Massachusetts Consensus Based TEC level of 0.18 mg/Kg. It is not known why this location was the only one where the mercury was not only detected, but exceeded threshold effects concentrations. Concentrations of Mercury from all stations on the Green River are presented in Appendix C.

Grain size analyses are presented in Appendix C, and generally indicate the sediment at the sampling locations ranging from 78% medium sand and 3% gravel in the impoundment behind the Wiley & Russell Dam to approximately 26% coarse sand, 34% medium sand, and 9% Gravel sand at the sampling station just below the Mill Street Dam. Generally, coarser material (including sand) is less likely to accumulate organic contaminants than finer materials.

A macroinvertebrate assessment in the Green River, conducted in the fall of 2004 by the Deerfield River Watershed Association, can be used to help ascertain the relative severity of the sediment contaminant results. A total of six sampling sites were examined along the stretch of the river extending from its confluence with the Deerfield River, to upstream of the Pumping Station Dam. Generally the study indicated that the macroinvertebrate communities at the sample sites are currently non-impacted relative to the regional reference location (i.e. the Cold River, a tributary of the Deerfield). It should be noted that the sampled locations for this study did not correspond directly with the areas of where the highest concentrations of PAH's were found. So it is possible that there may be local areas where the benthic community may be showing effects of the elevated concentrations of PAHs noted above. However, the fact that the river generally does not appear to be impacted indicates that the elevated levels noted at the specific locations above, are confined to those areas, and do not appear to be affecting the downstream communities.

3.3.7 Changes To River Levels

Alternatives that include removal of the Wiley & Russell Dam, the Mill Street Dam, or both structures would eliminate the existing impoundments and lower the river within the areas now influenced by the dams. Water levels at the two upstream impoundments will not be affected by the installation of fish ladders.

3.3.7 (a) Flooding and Bank Erosion

The project will not increase the flooding potential of surrounding developed areas. The existing impoundments behind the Wiley & Russell and Mill Street dams are relatively small and do not contribute to local flood control.

Two of the main issues with dam removal are the potential erosion of the dewatered riverbanks and release of the sediments stored behind the dam. The affected riverbanks are mainly fine granular soils where localized sloughing of the riverbanks during drawdown would be the primary concern. To minimize any potential sloughing, the storage pools behind the dams should be drawn down slowly to permit the finer bank materials to drain and gain strength, this will also allow time for natural vegetation to develop on its own.

The Town of Greenfield identified the river segment adjacent to the Green River Cemetery as an area of concern and requested that any changes to the river levels as a result of removing Wiley and Russell Dam be evaluated. The cemetery is located along the western riverbank at the upper end of the impoundment, about 1000 feet upstream of the Wiley and Russell Dam. The natural hillside slopes around the cemetery have historically experienced slope stability failures. At this upstream location removal of the dam would only lower the river level by about 1-foot and only increase average flow velocity by about ½-foot under lower-flow conditions and would have no effects under high flow conditions, this minor change would not affect the historical slope stability problems at the cemetery. A site inspection was conducted to observe several slope failures along the northern and eastern edges of the cemetery. The cemetery is located on a elevated plateau about 120 feet above the river valley that is comprised of fine-grained glacial lake silt and clay deposits overlain with medium to fine sands. A localized groundwater surface is present at about a 40-foot depth, or about 80-feet above the river valley, occurring at the fine

sand and silt interface. During our site inspection on October 18, 2002, we observed water seeping from the slope at this level in the more recent slope failure areas, and water could also be heard running below the surface in several of the older slope failure areas. Most of the hillside around the cemetery is scarred from a series of slope failures that have probably occurred over many years. Some of these slope areas have mature trees up to 2-feet in size growing in the old failure areas. The slope failure areas all appear to be similar in configuration with a steep upper slope in the top 40-feet of sandy materials then flattening slightly when the groundwater and silty materials are encountered, with the lower half of the slide being comprised of an erosion gully up to 15-feet in depth through the clayey slope materials. These failures appear to be a flow type of slope failure with the upper materials loosing strength and flowing toward the bottom of the hillside and then into the river channel. The failure mechanism is probably a combination of rainfall, saturated upper slope materials, elevated groundwater levels, surcharges along the top of the slope (slope steepness, debris, fill materials, and trees) and deepening of the erosion gullies in the lower half of the slope from saturation and surface runoff. The historical slope failures being experienced at the cemetery are not the result of erosion along the riverbank but are the result of localized loading and groundwater conditions in the upper fine-grained slope materials. Removal of Wiley and Russell Dam should have no additional affects on these slopes.

The Mill Street Bridge is another potential problem area where erosion could possibly have unsatisfactory results. The bridge abutments are located immediately adjacent to the Mill Street Dam and at the edge of the existing river channel. Removal of the dam would result in the lowering of the riverbed by about 7-feet under the bridge which would also extend upstream a short distance. Since the bridge abutments were designed and built with the dam in place and no record bridge plans were available to review, it is only prudent to assume that erosion and

undermining of the bridge abutments may be a possibility. In addition, undermining of the riverbanks upstream of the bridge is also a possibility that may adversely affect private property located along the western riverbank about 700 feet upstream of the dam. A portion of this property is currently being scoured and eroded from natural river flows along the outside of a bend in the river. Under the dam removal scenario, additional investigation into the bridge abutment construction and upstream impacts is recommended during the project design phase. Placement of stone protection materials may be required in the river channel in order to protect the bridge abutments and riverbanks from being undermined.

Detail design and construction considerations for removing the dams should address site access and sequencing, lowering of the impoundments, sediment erosion or removal, wet vs. dry breaching of the dams, dewatering and diversion requirements, working during low-flow periods, long-term site stabilization, and temporary erosion control measures.

3.3.7 (b) Groundwater, Wells and Septic Systems

The proximity of wells and septic systems in the area was judged not to be a concern due to the distances and changes in elevation from the locations of the current impoundments to occupied dwellings and business establishments. In certain locations, the surrounding uplands will provide groundwater and runoff that will recharge water table in areas close to the river. The construction phase of the project would likely take place during the summer months that coincide

with low flows. The impoundments at each dam would be drawn down to the extent possible. Potential for flooding during the Construction Phase is expected to be minimal based on statistical record of monthly rainfall.

3.4 INCREMENTAL COST COMPARISON OF PLANS

The costs and anticipated environmental benefits of the restoration measures that were combined to form the alternatives were estimated and compared in incremental cost analyses. The anticipated environmental benefits were assessed by estimating the benefits to various water-related habitats, including general riverine habitat, anadromous fish habitat (including that of alewife and blueback herring), riparian corridor, native wetlands species habitat, and waterfowl habitat. Costs ranged from $0 for the no-action alternative to over $1.3 million for Alternative 7 with fish ladders at all four dams and construction of in-stream works to create riffle-pool sequences in the channel near Leyden Woods. Anticipated environmental benefits ranged from 95.08 habitat units (effective habitat acres) for the no action alternative to 128.5 effective habitat acres for Alternative 6. The incremental analysis used "bare" costs associated with the actual construction, or, in the cases of dam removal, demolition, as a basis of comparison between the plans. Construction cost elements such as site preparation and erosion control that were common to all of the alternatives at each site were not included and have no negative effect on the analysis.

The first step in an incremental cost analysis is to determine what alternatives are cost effective. The incremental cost analysis shown in Appendix 4 demonstrated that alternatives 1, 2, 4, and 6 are cost effective (see Table 2 for description of alternatives). An alternative is considered cost effective if no other plans provide the same or greater number of habitat units for less cost.

TABLE 5 - INCREMENTAL COST COMPARISON OF PLANS

ALTERNATIVE	COST ($000)	HABITAT UNITS	COST EFFECTIVE PLAN	BEST BUY PLAN	INCREMENTAL COST	INCREMENTAL OUTPUT
1	0.0	95.08	YES	YES	---	
2	1,140.7	128.26	YES	YES	1,140.7	33.18
3	1,289.7	120.32	NO	NO	N/A	
4	1,128.9	118.94	YES	NO	47.3	
5	1,222.8	116.16	NO	NO	N/A	
6	1,205.4	128.50	YES	YES	64.7	0.24
7	1,324.0	120.45	NO	NO	N/A	
8	1,163.2	119.04	NO	NO	N/A	
9	1,257.1	116.26	NO	NO	N/A	
10	1,195.8	120.46	NO	NO	N/A	

The second step of the incremental cost analysis is to identify the best buy plans. Best buy plans are cost effective plans that have the lowest cost per habitat unit when compared to the no action plan. A plan is considered a best buy plan if there are no other plans that will give the same or more output at a lower incremental cost when all plans are compared to the no action alternative.

It was determined that Alternative 4 is not a best buy plan because Alternative 2 has a lower incremental cost per incremental habitat unit and greater HU in comparison to the no action plan. This leaves three best buy plans: alternatives 1, 2 and 6 (see Table 5).

These three best buy alternatives constitute the incremental cost curve. Development of the incremental cost curve facilitates the selection of the best alternative. The question that is asked at each increment is: is the additional gain in environmental benefit worth the additional cost? Of these three plans, Alternative 2 is the better plan as it has a much lower incremental cost/incremental habitat unit gained (34.4) versus Alternative 6 (269.6).

Table 6 below summarizes the total construction costs ("bare" costs plus site preparation and erosion control costs) for each alternative plan. It also includes the habitat unit gained and the results of the incremental cost analysis.

TABLE 6 DEERFIELD RIVER GI STUDY GREEN RIVER HABITAT IMPROVEMENT GREENFIELD, MA
COST & BENEFIT COMPARISON OF ALTERNATIVE PLANS

ALTERNATIVE PLAN NUMBER	ALTERNATIVE PLAN DESCRIPTION	ESTIMATED CONSTRUCTION COST	BENEFIT EXPRESSED AS HABITAT UNITS	NET BENEFIT EXPRESSED AS HABITAT UNITS	RANK OF COST EFFECTIVE PLANS
1	**No Action**	$0.00	95.08	0	N/A
2	**Remove Wiley & Russell Dam** **Remove Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam**	$1,720,000.00	128.26	33.18	1
3	**Construct Fish Ladder At Wiley & Russell Dam** **Construct Fish Ladder At Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam**	$1,890,000.00	120.32	25.24	Not cost effective
4	**Construct Rock Ramp Fishway At Wiley & Russell Dam** **Remove Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam**	$1,710,000.00	118.94	23.86	3
5	**Construct Fish Ladder At Wiley & Russell Dam** **Remove Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam**	$1,860,000.00	116.16	21.08	Not cost effective
6	**Remove Wiley & Russell Dam** **Remove Mill Street Dam.** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam** **Construct J-vanes and boulder groups in river channel downstream of Mill Street and near Leyden Woods**	$1,770,000.00	128.5	33.42	2
7	**Construct Fish Ladder At Wiley & Russell Dam** **Construct Fish Ladder At Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam** **Construct J-vanes and boulder groups in river channel near Leyden Woods**	$1,940,000.00	120.45	25.37	Not cost effective
8	**Construct Rock Ramp Fishway At Wiley & Russell Dam** **Remove Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam** **Construct J-vanes and boulder groups in river channel near Leyden Woods**	$1,760,000.00	119.04	23.96	Not cost effective
9	**Construct Fish Ladder At Wiley & Russell Dam** **Remove Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam** **Construct J-vanes and boulder groups in river channel near Leyden Woods**	$1,910,000.00	116.26	21.18	Not cost effective
10	**Construct Rock Ramp Fishway At Wiley & Russell Dam** **Construct Fish Ladder At Mill Street Dam** **Construct Fish Ladder At Swimming Pool Dam** **Construct Fish Ladder At Pumping Station Dam**	$1,790,000.00	120.46	25.38	Not cost effective

Note: Alternatives 2 & 6, 3 & 7, 4 & 8, and 5 & 9 have common fish passage measures.

SECTION 4 – RECOMMENDED ALTERNATIVE

4.1 PROJECT DESCRIPTION AND COSTS

The removal of both Wiley & Russell and Mill Street Dams and installation of fish passage structures at Swimming Pool Dam and Pumping Station Dam maximizes the environmental benefits, and in essence, offers the greatest degree of habitat restoration for each dollar invested in a project. The restoration project would extend migratory habitat and spawning habitat for anadromous fish over a distance of 30 river miles. The project will also improve riverine habitat quality (represented in the study by a gain of 33 habitat units compared to the existing conditions). It is a cost-effective plan that reasonably optimizes environmental benefits that are in the national interest and consistent with Corps regulations. The estimated construction cost for the recommended plan is $1,600,000. See Appendix 6 for a detailed breakdown of the construction cost estimate.

The future implementation cost of the project would include the cost of preparing plans and specifications (about $250,000); the cost of permits/planning (about $60,000); Value Engineering study (about $40,000); total construction costs, including contract administration and oversight of $1,600,000; and real estate requirements valued at $103,000. The total of those figures is $2,053,000.

This project would be cost shared 65 percent Federal and 35 percent non-Federal. The Federal share of the total project costs would be approximately $1,334,500. The non-Federal share would be approximately $718,500. Additionally, operations and maintenance (O&M) costs are estimated at $12,000 per year for a 50-year life of the project. Operations and maintenance at each of the new fish passage structures is a non-Federal responsibility. Operation & maintenance responsibility at each location typically consists of monitoring and control during fish operations and periodic maintenance and cleaning.

4.2 IMPLEMENTATION SCHEDULE

Implementation of the recommendation contained in this report is subject to the Corps review, approval and funding processes and sponsor participation, including execution of a Project Cooperation Agreement (PCA). Upon receiving project approval from North Atlantic Division, the New England District must prepare plans and specifications prior to solicitation of bids and contract award.

4.3 FINANCIAL ANALYSIS

The non-Federal sponsor, the Commonwealth of Massachusetts Executive Office of Environmental Affairs (EOEA), has indicated its willingness to execute a Project Cooperation Agreement (PCA) for this project. EOEA is capable of meeting the financial obligations of a project sponsor and acquiring lands and easements necessary to construct a project.

4.4 REAL ESTATE CONSIDERATIONS

The real estate requirements identified for the recommended plan are spread over the four project locations. Credit for the real estate will be determined through the fair market appraisals perform after execution of a Project Cooperation Agreement (PCA). For planning purposes, a breakdown of ballpark values prepared by the New England District is as follows:

Wiley & Russell Dam: Three parcels of land, totaling approximately 3.77 acres of land, are required. The town of Greenfield owns two of the parcels in fee and the other is under private ownership. The value of a 1-year easement over 3.77 acres is $14,000.

Mill Street Dam: Two parcels of land, encompassing approximately one acre of land, are required. Both parcels are under private ownership. The value of a 1-year easement is $20,000.

Swimming Pool Dam: About 1.75 acres of land, a portion of a 20.1-acre parcel, are required for this project area. The land is owned in fee by the town of Greenfield. The value of a 1-year easement is $5,000 and the value of a fish ladder easement is $1,000.

Pumping Station Dam: About 1.5 acres of land, portions of two parcels, are required for the work to be done at this site; both parcels are owned in fee by the town of Greenfield. The value of a 1-year easement is $7,000. The value of a fish ladder easement is $3,000.

The administrative costs associated with the temporary easement acquisitions, such as title work, mapping, and closing, are estimated to be $5,000 per ownership. The sponsor has been informed that detailed records have to be kept in order to receive credit for these costs.

Following are the estimates costs for this project:

Temporary easements over 10.77 acres (4 sites) for 1 year	$46,000
Permanent easements at 2 sites	$ 4,000
Contingency, 25%	$12,500
Total land costs, rounded	$62,500
Total acquisition costs for 8 parcels	$40,000
Total real estate costs	$102,500
Total Estimated Real Estate Costs, rounded	$103,000

The Real Estate Planning Report appears in Appendix 5 of this report.

4.5 VIEW OF SPONSOR

The Massachusetts Executive Office of Environmental Affairs (EOEA) supports the plan for fish passage at their Green River dams. The Town of Greenfield also supports the plan. They recognize the value of restored anadromous fisheries and increased recreational potential on the Green River that the project will provide.

4.6 AGENCY COORDINATION

The U.S. Fish and Wildlife Service indicated their support for the project in a letter dated February 19, 2003. The National Marine Fisheries Service indicated its support for the project in a letter dated February 11, 2003.

SECTION 5 – CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The study team's analysis showed that the environmental benefit for each dollar spent is maximized for the alternative that removes the two downstream dams and constructs fishways at the two upstream dams in Greenfield. Implementation of the recommended plan will result in the removal of the Wiley & Russell Dam and the Mill Street Dam, construction of a steeppass fishway at the town's Swimming Pool Dam and construction of a denil fishway at the Pumping Station Dam in Greenfield.

5.2 RECOMMENDATIONS

I recommend that the project described in this report be approved and implemented. In my judgment, the project is a justifiable expenditure of Federal funds and appropriate for implementation under the authority provided by Section 206 of the Water Resources Development Act of 1996, P.L. 104-303, as amended. Section 206 provides programmatic authority for the USACE to carry out aquatic ecosystem restoration projects that improve environmental quality, are in the public interest, and are cost effective. The restoration plan is consistent with current administration policy and could provide measurable environmental benefits to the Green River, Deerfield River and Connecticut River watersheds through modification of the Green River dams in Greenfield, Massachusetts.

It is also recommended that no further study be conducted under this General Investigation authority at this time.

The recommendations contained herein reflect the information available at this time and current Department of the Army policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, recommendations may be modified before they are authorized for implementation funding.

Date	Curtis L. Thalken Colonel, Corps of Engineers District Engineer