United States
Department
Of Agriculture

Natural
Resources
Conservation
Service

SUPPLEMENTAL WATERSHED PLAN No. 6 & ENVIRONMENTAL ASSESSMENT

For Rehabilitation of the
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed
Worcester County, Massachusetts

Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

DRAFT
June 2009

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Supplemental Watershed Plan No. 6 & Environmental Assessment for Rehabilitation of Hop Brook Floodwater Retarding Dam SuAsCo Watershed Worcester County, Massachusetts

Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

In Cooperation With:
Massachusetts Department of Conservation and Recreation

AUTHORITY

The original watershed work plan was prepared, and works of improvement have been installed, under the authority of the Watershed Protection and Flood Prevention Act of 1954 (Public Law 83-566) as amended. The rehabilitation of the Hop Brook Floodwater Retarding Dam is authorized under Public Law 83-566 (as amended), and as further amended by Section 313 of Public Law 106-472.

ABSTRACT

The Hop Brook Floodwater Retarding Dam no longer provides the original protection planned for the watershed due to a greater than planned increase in development of the upstream drainage area. For current and future build-out development conditions, the dam does not meet current Massachusetts or Natural Resources Conservation Service design criteria for a high hazard dam. The local project sponsors have chosen to rehabilitate the dam to address the identified safety deficiencies. The purposes of the proposed rehabilitation of the Hop Brook Dam are to maintain the present level of flood control benefits and comply with current performance and safety standards. Rehabilitation of the site will require the following modifications to the structure: extending the current auxiliary spillway width from 340 feet to 610 feet and armoring the auxiliary spillway to provide scour protection. Project installation cost is estimated to be $1,955,100, of which $1,406,400 will be paid from Small Watershed Rehabilitation funds and $548,700 from local funds.

COMMENTS AND INQUIRIES

For further information, contact Carl Gustafson, State Conservation Engineer, USDA/NRCS, 451 West Street, Amherst, MA 01002-2953, 413-253-4362.
Submit comments by [NRCS insert date 45 days after submittal to IA review] to: Christine Clarke, State Conservationist, USDA/NRCS, 451 West Street, Amherst, MA 01002-2953 or christine.clarke@ma.usda.gov.

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SuAsCo Watershed
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SUMMARY OF WATERSHED PLAN

Project Name: Rehabilitation of Hop Brook Floodwater Retarding Dam[1], SuAsCo watershed
County: Worcester **State**: Massachusetts

Sponsors: Massachusetts Department of Conservation and Recreation (DCR)
Worcester County Conservation District
Middlesex Conservation District
Massachusetts Division of Fisheries & Wildlife (DFW)

Description of Recommended Plan: The weir width of the auxiliary spillway on the Hop Brook Dam would be increased from 340 feet to 610 feet by extending the spillway north onto adjacent Dike A. The auxiliary spillway crest would remain at its existing elevation. The increased capacity of the auxiliary spillway would prevent the dam from being overtopped by the freeboard storm under current land use and watershed build-out conditions. The auxiliary spillway would be armored with articulated concrete blocks to prevent spillway erosion. The principal spillway, the main dam crest and embankment, and Dikes B and C would not be affected by the project. The evaluated life of the rehabilitation structure is 54 years.

Resource Information:

Size of SuAsCo watershed: 241,000 acres (377 square miles)
Drainage area of Hop Brook Dam: 3,145 acres (4.91 square miles)
Land use in Hop Brook Dam drainage area:

	Acres	% of drainage area
Agricultural	153	5
Forest	1,148	36
Developed, residential	1,538	49
Developed, commercial/industrial	57	2
Other (wetlands, open land, water, etc.)	249	8

Land Ownership:

Hop Brook Dam drainage area:	Private 90 %	State-Local 10 %	Federal 0 %
Hop Brook Dam floodplain:	Private 78 %	State-Local 18 %	Federal 4 %

[1] Hop Brook Floodwater Retarding Dam is identified in the original SuAsCo Watershed Plan (NRCS 1958). It is designated as dam A-3-c in the original work plan, as MA303 in the NRCS list of PL-566 dams, as 3-14-215-24 by the DCR Office of Dam Safety, and as MA00998 in the National Inventory of Dams database.

Number of farms (Worcester County): 1,547

Average farm size (Worcester County): 69 acres

Prime and important farmland:

	Drainage area (acres)	Floodplain (acres)
Prime farmland	813	284
Farmland of statewide importance	858	469
Farmland of unique importance	130	824

Project Beneficiary Profile: The primary beneficiaries of the project are residential, industrial, and commercial property owners in the floodplains of Hop Brook and the Assabet River; the towns of Northborough, Westborough, Berlin, Hudson, Stow, and Maynard; the City of Marlborough; and the Commonwealth of Massachusetts.

Characteristic	Northborough	Worcester Co.	Massachusetts	United States
Per capita income	$32,889	$22,983	$25,952	$21,587
Median annual household income	$79,781	$47,874	$50,502	$41,994
Median house value	$228,300	$149,784	$192,978	$120,467
Median age	37	36	36	35
Population	14,013	750,963	6,349,097	281,421,906
Population age 65 & over	9.8 %	13 %	13 %	12 %
Unemployment rate	1.4 %	2.8 %	3.0 %	3.7 %
Poverty level	1.7 %	6.8 %	6.7 %	9.2 %
Minority population	7 %	10 %	15 %	25 %

Note: 2000 Census data.

Wetlands: Estimated wetlands within the dry impoundment area, as interpreted and classified by the Massachusetts Department of Environmental Protection (DEP):

Deep marsh	10.0 acres
Open water	0.7 acres
Shallow marsh, meadow, or fen	0.2 acres
Shrub swamp	4.1 acres
Wooded swamp deciduous	52.9 acres
Wooded swamp mixed trees	7.3 acres
Total	75.2 acres

A shrub swamp wetland of 2.6 acres lies just downstream of the dam. There would be no permanent impacts to wetlands. Temporary wetland impacts (less than one acre) may occur at the toe of the slope of the dam as a result of construction access to embed the proposed armoring system. All temporary wetland impact areas would be restored following construction. All other construction staging and access would occur entirely within existing cleared or previously disturbed upland areas. All disturbed areas would be revegetated and restored after construction is complete.

Floodplains: Land uses within the 3,324-acre floodplain downstream of the dam:

	Acres	% of floodplain area
Agricultural	243	7
Forest	1,058	32
Developed, residential	312	9
Developed, commercial/industrial	297	9
Other (wetlands, open land, water, etc.)	1,414	43

Highly Erodible Land:

Hop Brook Dam drainage area: 310 acres
Hop Brook Dam floodplain: 136 acres

Threatened and Endangered Species: No federally listed species are known to occur in the area. Habitat for the wood turtle (*Glyptemys insculpta*), a Massachusetts listed Species of Special Concern, occurs in the floodplain along Hop Brook, and the species has been documented within the Hop Brook Dam area as recently as 2007 according to the Massachusetts Natural Heritage and Endangered Species Program (NHESP) database. Wood turtles use a variety of riparian habitats but would be most susceptible to impacts when hibernating in the bottom of streams during the winter. Proposed activities would not occur within the stream.

Cultural Resources: No historic properties that are listed on or eligible for listing on the National Register of Historic Places are present in the project's Area of Potential Effect. Construction will occur within the area of previous disturbance for the dam.

Problem Identification: Hop Brook Dam does not meet current dam design and safety criteria. Hydrologic and hydraulic modeling of the freeboard storm predicts that the dam would be overtopped by 1.4 and 1.6 feet for current land use and build-out conditions, respectively. Overtopping of the dam could lead to embankment erosion and dam failure. The models also predict that maximum permissible velocities for the auxiliary spillway would be exceeded, and erosion of the spillway slope could then occur. Dam failure from one or both of these causes would result in flood damages to approximately 380 residences, 89 industrial or commercial properties, 114 roads, 2 schools, 1 fire department, and 1 dam, plus utilities in the floodplain. Dam failure would also potentially cause the loss of life of residents, workers, or motorists.

Alternative Plans Considered:

Alternative 1 – Future Without Project (No Action Alternative)
The dam owner, DCR, has stated that it will rehabilitate the dam to meet current federal dam safety standards if federal funding assistance is not provided. DCR may choose to use rehabilitation methods other than those identified in this plan or develop its own plan to bring the dam into compliance with federal standards.

Alternative 2 – Rehabilitation (NED Alternative)
The dam would be rehabilitated by widening the auxiliary spillway from 340 feet to 610 feet and armoring the spillway. Federal funding assistance would be provided to the project sponsors by the Natural Resources Conservation Service (NRCS).

Project Purpose: Flood prevention. Rehabilitation of the Hop Brook Dam is necessary to meet current state and federal safety and performance standards.

Principal Project Measure: Rehabilitation of the dam involves two primary actions:

- Widening the auxiliary spillway from 340 feet to 610 feet.
- Armoring the spillway with articulated concrete blocks.

Project Cost:

	PL 83-566 funds	Other funds	Total
Structural measures			
Flood prevention	$1,406,400	$548,700	$1,955,100

Project Benefits: Economic benefits of the project are derived from ensuring the continued flood prevention purpose of Hop Brook Floodwater Retarding Dam by meeting current performance and safety standards. Benefits are based on continuing flood protection to the downstream area, which has an annual benefit of $215,000. Rehabilitation would also minimize the risk of loss of life to residents and motorists traveling on downstream roadways within the breach flood area. Net average annual equivalent benefits between the Future with Federal Project (Rehabilitation Alternative) and the Future without Federal Project (No Action Alternative) = $0.

Environmental Values Changed or Lost:

Resource	Impact
Air quality	Short-term impact from construction equipment emissions
Floodplains	No effect; no new structures in floodplain; existing floodplain hydrology maintained
Wetlands	No long-term impact (0 acres affected); potential temporary impacts to wetlands adjacent to construction area (less than 1 acre)—wetlands to be avoided if possible and restored with native vegetation if affected by construction
Fisheries	No effect; existing fisheries maintained
Wildlife habitat	No long-term effect (0 acres affected); temporary disruption near construction area (less than 1 acre)—disturbed areas would be replanted with native vegetation
Threatened and endangered species	No effect
Land use	No effect
Cultural resources	No effect
Prime farmland	No effect

Major Conclusions: Rehabilitation of Hop Brook Floodwater Retarding Dam is necessary to minimize the risk of loss of life and property damage within the potential breach area and to allow the continuance of flood prevention benefits.

Areas of Controversy: There are no known areas of controversy.

Issues to be Resolved: None

Permits: The site-specific need for permits and mitigation, if required, would be determined during final design. The owner (DCR) will be responsible for obtaining the necessary local, state, and federal permits, including (1) National Pollutant Discharge Elimination System (NPDES) general permit for construction, (2) U.S. Army Corps of Engineers (USACE) permit under Section 404 of the Clean Water Act of 1972, (3) Chapter 253 Permit to Construct or Alter a Dam, (4) Chapter 91 Waterways License, (5) Order of Conditions through the Massachusetts Wetlands Protection Act, (6) Section 401 Water Quality Certification, and (7) Massachusetts Endangered Species Act approval through Massachusetts Natural Heritage and Endangered Species Program.

PURPOSE AND NEED FOR ACTION

INTRODUCTION

The Hop Brook Floodwater Retarding Dam (referred to hereafter as the Hop Brook Dam or the dam) is one of ten floodwater retarding dams built between 1962 and 1987 in the watershed of the Sudbury, Assabet, and Concord Rivers (known as the SuAsCo watershed). Nine of those dams, including the Hop Brook Dam, were authorized to provide flood protection benefits in a 48-square-mile subwatershed by NRCS's 1958 *Watershed Work Plan for Watershed Protection and Flood Prevention, SuAsCo Watershed, Middlesex and Worcester Counties, Massachusetts* and five supplemental plans. The Hop Brook Dam was constructed in 1964 in the Town of Northborough, Worcester County, Massachusetts (Figure 1, Appendix C). The dam impounds Hop Brook, a tributary to the Assabet River, during rain events, but then slowly releases the water and has no permanent pool.

PURPOSE AND NEED FOR SUPPLEMENT

The Hop Brook Dam was built under the Watershed Protection and Flood Prevention Act of 1954 (Public Law (PL) 83-566) for the purpose of flood prevention. The dam was constructed in 1964 in a rural setting. Since 1964, urban development upstream of the dam has increased the quantity of stormwater runoff, and the 2005 Hop Brook Dam Assessment Report (USDA-NRCS 2005) determined:

> For current and build-out land use conditions the existing dam is overtopped by 1.4 and 1.6 feet respectively during the routing of the freeboard storm. The maximum permissible velocities are also exceeded in the emergency spillway.

As a result, DCR applied to NRCS in 2005 for funding assistance for rehabilitation of the dam to comply with current standards and ensure continued flood damage protection downstream of the dam.

The purpose of the proposed dam rehabilitation project is to continue to prevent flood damages by complying with current performance and safety standards. Failure of the dam would cause serious damage to homes and commercial facilities downstream of the dam and potentially result in a loss of life. Rehabilitation of the dam is needed to protect downstream properties, public utilities, highways, and a railroad and to reduce the risk of loss of life. Rehabilitation of the dam would extend the service life by 54 years and ensure the continued safe service of the dam throughout its original 100-year evaluation period.

This Supplemental Watershed Plan/Environmental Assessment was prepared to evaluate the rehabilitation of the Hop Brook Dam. The dam was built in accordance with the 1958 SuAsCo Watershed Plan. An amendment to PL 83-566, the Watershed Rehabilitation Amendments of 2000 (PL 106-472), Section 313, authorizes funding and technical assistance to upgrade dams under the U.S. Department of Agriculture (USDA) Watershed Program. The rehabilitation upgrade of the Hop Brook Dam is authorized under this amendment. This supplemental plan

documents the planning process by which the NRCS provided technical assistance to the local sponsors, technical advisors, and the public in addressing resource issues and concerns within the Hop Brook watershed. DCR cooperated in the preparation of the plan by leading the public meeting, reviewing technical studies (hydrology and hydraulic modeling, preliminary engineering), and reviewing the draft plan-EA.

WATERSHED PROBLEMS AND OPPORTUNITIES

Modeling results indicate that the auxiliary spillway does not meet all necessary design criteria for current land use and ultimate watershed build-out conditions. During a freeboard storm, pool elevation would overtop the dam by 1.4 feet under current conditions and 1.6 feet under build-out conditions, potentially leading to failure of the dam. Flow through the auxiliary spillway would exceed NRCS maximum permissible velocities, which would erode the dam slope and potentially lead to failure of the dam.

The Hop Brook Dam provides approximately $215,000 in average annual flood damage reduction benefits for the Hop Brook watershed. The beneficiaries of the structure are the Commonwealth of Massachusetts and the localities of Northborough, Westborough, Berlin, Stow, Hudson, Maynard, and Marlborough.

Primary concerns are the safety of the dam and the potential problems that failure of the dam would cause. Associated downstream hazards include residential, commercial, and industrial developments, recreational facilities, secondary highways, and local roads, as well as utilities along those roads. The Emergency Action Plan (EAP) for the Hop Brook Dam estimates that an uncontrolled breach of the dam would cause flood damages to approximately 380 residences, 89 industrial or commercial properties, 114 roads, 2 schools, and 1 fire department, plus utilities in the floodplain (GZA GeoEnvironmental 2008). The Washington Street Dam in the Town of Hudson would be overtopped and fail because it does not have the hydraulic capacity to pass the flood wave. Catastrophic failure of the Hop Brook Dam would also potentially cause the loss of life of residents, workers, or motorists.

Opportunities that would be realized through the implementation of this watershed rehabilitation plan are:

- Compliance with current dam safety criteria,
- Protection of human health and safety,
- Protection of infrastructure and transportation system,
- Maintenance of flood control benefits, and
- Prevention of increased flooding in the floodplain.

SCOPE OF THE ENVIRONMENTAL ASSESSMENT

A scoping process was used to define project needs, determine important issues, and formulate alternatives. Scoping included a public meeting; written requests for input from state, local, and federal agencies; and coordination meetings with appropriate agencies. A steering committee of

NRCS, DCR, and technical experts was also formed to assist in the formulation and evaluation of alternatives.

Stakeholder agencies that were contacted concerning the proposed project are:

Worcester County Conservation District
Massachusetts DCR
Massachusetts Office of Dam Safety
Massachusetts DFW
Massachusetts Department of Fish & Game, Riverways Program
Massachusetts DEP
Town of Northborough (Selectmen, Conservation Commission, Planning Board, Engineering Department)
Town of Northborough Trails Committee
Organization of the Assabet River
Massachusetts Executive Office of Energy and Environmental Affairs
Massachusetts Executive Office of Energy and Environmental Affairs, Environmental Policy Act Office
U.S. Environmental Protection Agency (EPA) Region 1, Regulatory Section
USACE, Regulatory Division

Table A presents the results of the scoping process.

Table A – Identified Concerns

Economic, social, environmental, and cultural concerns	**Degree of Concern**	**Degree of Significance to Decision Making**	**Remarks**
Dam safety	High	High	Primary concern of sponsors and NRCS
Human health and safety	High	High	Primary concern of sponsors and NRCS
Flood damages	High	High	Primary concern of sponsors and NRCS
Wetlands	Moderate	Moderate	Analysis of effects required by Clean Water Act and Executive Order 11990; potential for minor, temporary impact from construction; no permanent impact.
Threatened & endangered species	Moderate	Moderate	Analysis of effects required by Endangered Species Act; no federally protected species present. State-listed species (wood turtle) habitat occurs in project vicinity. Activities are not proposed for streams where nesting or hibernation occurs.

Table A – Identified Concerns			
Economic, social, environmental, and cultural concerns	**Degree of Concern**	**Degree of Significance to Decision Making**	**Remarks**
Water quality	Moderate	Low	Evaluated for all NRCS projects; minimal, temporary impact.
Fish habitat	Moderate	Low	Massachusetts Dept. of Fish and Game requested consideration of providing fish passage; project purpose does not include fish and wildlife habitat.
Wildlife habitat	Moderate	Low	Evaluated for all NRCS projects; minimal, temporary impact.
Prime farm lands	Moderate	Low	Evaluated for all NRCS projects; none affected by project.
Highly erodible cropland	Moderate	Low	Evaluated for all NRCS projects; none affected by project.
Cultural resources	Moderate	Low	Analysis of effects required by National Historic Preservation Act; no historic sites present in Area of Potential Effect.
Air quality	Low	Low	Minimal, temporary impact
Water quantity	Low	Low	No impact
Aesthetics	Low	Low	Minimal, temporary impact
Sedimentation and erosion	Low	Low	Minimal, temporary impact
Recreation	Low	Low	Minimal, temporary impact

AFFECTED ENVIRONMENT

The area potentially affected by rehabilitation of the Hop Brook Dam is the dam structure itself, the area adjacent to the dam that could be affected by construction, and the flood protection area downstream of the dam. The following discussions of existing conditions focus on these areas, plus the general project vicinity—the Town of Northborough—where appropriate.

EXISTING CONDITIONS

Original Project

The Hop Brook Dam was one of eight floodwater-retarding structures proposed in the 1958 SuAsCo Watershed Plan under the authority of PL 83-566. The dam was constructed in 1964 with federal assistance provided by the U.S. Department of Agriculture, Soil Conservation Service (now the NRCS). Subsequently five supplements to the original plan were prepared and approved between 1964 and 1996. All of the supplements occurred after construction of the Hop Brook Dam and were not concerned with this facility. Through these supplements, two of the

original dams were deleted from the plan and three others were added, and as a result nine floodwater retarding structures were planned and constructed between 1962 and 1974 for watershed protection and flood prevention. The Middlesex Conservation District and the Northeastern Worcester County Conservation District were the original local sponsoring organizations. The three conservation districts in Worcester County have combined into one district, known as the Worcester County Conservation District. Through the supplemental planning process and reorganization of state agencies, by 1996 the local sponsoring organizations also included DFW and the Massachusetts Department of Environmental Management (DEM). Further state reorganizations since 1996 have resulted in renaming DEM as DCR.

Description of Existing Dam

The dam was originally designed and constructed as a federal Class C dam, a hazard classification given to dams whose failure "may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads." The floodwater retarding structure is comprised of six major elements: the earthen embankment or main dam, the drop inlet principal spillway, the auxiliary spillway, and three dikes referred to as Dike A, Dike B, and Dike C. Figure 2 in Appendix C presents a schematic drawing of the Hop Brook Dam.

The dam is located on the southeastern side of the impoundment area. The dam embankment has a total structural height of approximately 23 feet, a hydraulic height[2] of approximately 19 feet, and an overall length of approximately 410 feet. Under normal operating conditions, there is no impoundment upstream of the dam. During impoundment conditions with the water level at the crest of the auxiliary spillway, the storage capacity of the dam is estimated to be 1,340 acre-feet, which classifies the dam as a "Large" structure in the DCR Office of Dam Safety classification system (302 CMR 10.00).

The upstream slope of the dam is generally uniform with a slope of 3H:1V. The slope extends from the south abutment to the south side of the auxiliary spillway and is primarily grass covered. The top of the dam is approximately 12 feet wide and grass covered with an elevation of 313.0 feet. The downstream slope also extends from the south abutment to the south edge of the auxiliary spillway and is primarily grass covered with an average slope of approximately 3H:1V. The downstream toe of the slope contains a rock toe drain that consists primarily of an approximately 12-foot-wide by 3-foot-high triangular section of embankment of coarse gravel and rock. A 27-inch reinforced concrete sewer main passes through the south side of the dam. Two relief wells are provided along the length of the connection ditch along the downstream right toe of the dam to convey water from the rock toe drain to the principal spillway stilling basin.

The principal spillway for the dam is located near the north end of the dam embankment. The structure consists of a reinforced concrete riser that leads to a 36-inch-diameter reinforced concrete outlet pipe. Normal flow of the brook enters the riser by means of a 30-inch-diameter

[2] Hydraulic height is defined as the difference between the elevation of the maximum controllable water surface elevation (auxiliary spillway crest) and the elevation of the lowest point in the original streambed.

opening that functions as the lower stage inlet set to elevation 292.0 feet. Upstream of the orifice, a vertical steel slatted rack bolted to the low stage concrete headwall extends upstream of the concrete riser to prevent obstructions from entering the structure. Access to the interior of the intake structure is through a 24-inch-diameter manhole cover on top of the structure. The tops of the side walls of the riser are set to elevation 302.0 feet to act as overflow weirs during high stage impoundment levels, with the openings protected by galvanized steel pipe trash racks and a reinforced concrete anti-vortex cap. Three anti-seep collars are provided along the length of the outlet pipe to limit seepage along the pipe. The downstream end of the pipe is supported by a reinforced concrete cradle and bent constructed with a two stage filter upstream. The discharge at the downstream toe of the dam flows into a 36-foot-long rock riprapped trapezoidal stilling basin and then flows for a short distance through a 35-foot-wide man-made channel before joining the natural stream channel.

The auxiliary spillway is located north of the dam embankment and extends to the west end of Dike A. The auxiliary spillway is a 340-foot-long grass lined channel with a crest elevation approximately 4 feet below the top of the dam (design elevation 309.0 feet). The crest of the spillway is 20 feet wide with the upstream slope of 3H:1V and the downstream slope of 4.5H:1V. Discharge through the auxiliary spillway would spread through the wetland area at the toe of the spillway prior to entering the downstream outlet channel.

The three dikes are located north of the auxiliary spillway. Dike A is approximately 740 feet long running in an easterly direction. Dike B is located approximately 200 feet north of the east side of Dike A and runs for approximately 290 feet in a northerly direction. Approximately 600 feet north of the north end of Dike B, Dike C begins and extends north for approximately 925 feet. The downstream slopes of the dikes are protected with rock toe drains to collect seepage. Seepage waters collected by the toe drain of Dikes B and C flow through separate culverts beneath Route 20, through a connecting ditch on the east side of the road, and through a culvert beneath Tomblin Hill Road before joining flows from the principal spillway at Smith Pond. Each of the three dikes is constructed of a geometry similar to that of the dam embankment, with 3H:1V grassed slopes and a 12-foot-wide crest with a design elevation of 313.0 feet.

In 2005 and 2008, the NRCS sponsored inspections of the Hop Brook Dam. The inspections determined that the dam is in good to satisfactory condition. The DCR is responsible for maintenance of the dam. As of July 2008, deficiencies identified in the 2005 inspection, including wear of vegetative cover and deterioration of the primary spillway trash rack, had been repaired. There was no indication of significant repairs or changes to the dam since the date of construction (H&S Environmental 2009).

Existing Structural Data

Table B provides a summary of the existing structural data for the Hop Brook flood control structure.

Table B – Existing Structural Data—Hop Brook Floodwater Retarding Dam	
Year completed	1964
Drainage area	3,145 acres (4.91 square miles)
Stream	Hop Brook
Purpose	Flood prevention
Dam type	Earthen embankment
Dam height	23 feet
Dam crest length	410 feet
Storage:	
Total, maximum pool	1,928 acre-feet
Total, auxiliary spillway crest	1,340 acre-feet
Sediment	22 acre-feet
Flood	1,318 acre-feet
Principal spillway:	
Type	Reinforced concrete
Lower stage inlet height	0 feet
Lower stage inlet size	30 inches
Upper stage inlet height	10 feet
Outlet conduit size	36 inches
Auxiliary spillway:	
Type	Grass-lined channel
Width	340 feet
Principal spillway crest elevation	302.0 feet
Auxiliary spillway crest elevation	309.0 feet
Top of dam (minimum crest) elevation	313.0 feet

Physical Features and Environmental Factors

Project Location: The Assabet River flows north for 30 miles to its confluence with the Sudbury River in Concord, Massachusetts, where the two rivers form the Concord River, which flows north for 15.5 miles to its confluence with the Merrimack River in Lowell, Massachusetts. The SuAsCo watershed encompasses a large network of tributaries that drain approximately 377 square miles in Middlesex and Worcester Counties. The watershed contains 25 tributary sub-watersheds, one of which is Hop Brook watershed. The drainage area for Hop Brook is approximately 3,145 acres (4.91 square miles) and extends through moderately developed areas within the Town of Northborough west of the dam and areas of residential development within the Town of Shrewsbury.

Climate: The average annual precipitation for Worcester County is 49.2 inches, and the average seasonal snowfall is 59.7 inches. In winter, the average temperature is 26.2 ºF, and the average daily minimum is 18.4 ºF. In summer, the average temperature is 67.7 ºF, and the average daily maximum temperature is 76.9 ºF. The average (50 percent) freeze-free period of 172 days extends from April 27 through October 16 (NRCS 2008a).

Geology and Soils: The project area is generally located at the boundary of the Nasoba Formation (OZn) of metamorphic rock and the Marlboro Formation (Ozm) of Mafic Rocks. The

soils are generally described as Paxton-Woodbridge-Ridgebury banded with Merrimac-Hinckley-Windsor. Paxton-Woodbridge-Ridgebury soils consist of very deep, poorly drained (Ridgebury) to well drained (Paxton) soils on glacial till uplands that formed in firm and very firm glacial till derived from schist, gneiss, and granite. Merriman-Hinckley-Windsor soils consist of very deep, excessively drained soils on outwash plains that formed in glacial outwash derived mostly from granite, gneiss, and schists. These soils are generally centered around the stream channels extending through the area.

According to the NRCS soil survey for Worcester County, several major soil types are located within the area surrounding Hop Brook (Taylor and Hotz 1985). Richfield, Merrimac, Agawam, and Canton fine sandy loams comprise approximately 54 percent of the soils in the area around Hop Brook. Poorly drained Freetown muck accounts for 24.6 percent of the soil type around the Hop Brook Dam. Gravel pits and rocky outcrop complex account for an additional 13.7 percent of the major soil types.

The original design geology as interpreted from the boring logs provided on the as-built drawings indicated a variety of soil materials along the alignment of the dam and dikes. These materials varied from poorly graded sands to well graded silty sand and gravel. Although variation was observed across the site, all soils appeared to represent a granular type material with variable amounts of gravels and silts as is typical of the glacial history of the area (H&S Environmental 2009).

Topography: The SuAsCo watershed lies within an area of previous glaciation, and many glacial features are present. In addition, the watershed is characterized by the prevalence of swamps, ponds, and lakes. The drainage pattern is dendritic with many tributary streams. Within the SuAsCo watershed, the Assabet River has a steeper gradient than the lower Sudbury and upper Concord Rivers and as a result has a more rapid runoff of floodwaters (NRCS 1958).

Prime Farmland: Prime farmland is protected by the Farmland Protection Policy Act in order to "minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses" (NRCS 2008b). Soils that are designated as prime farmland and are present in the Hop Brook Dam drainage area are the Agawam and Merrimac series fine sandy loams (NRCS 2008c). Table C presents the acreages of soils in the Hop Brook Dam drainage area and the downstream floodplain that are designated as prime farmland, farmland of statewide importance, or farmland of unique importance.

Table C – Important Farmland Soils

Soil Designation	Drainage Area (acres)	Floodplain (acres)
Prime farmland	813	284
Farmland of statewide importance	858	469
Farmland of unique importance	130	824

Source: Massachusetts Geographic Information System (MassGIS 2008b)

Highly Erodible Land: As summarized in Table D, less than 10 percent of the Hop Brook Dam drainage area and less than 5 percent of the downstream floodplain are highly erodible lands.

Table D – Highly Erodible Land				
	Drainage Area		Floodplain	
Land Use	**Acres**	**Percent**	**Acres**	**Percent**
Highly erodible land	310	10	136	4.1
Potentially highly erodible land	865	28	426	12.8
Not highly erodible land	1,970	63	2,762	83.1

Source: MassGIS (2008b)

Water Quality: The Organization for the Assabet River (OAR) conducts monthly water quality monitoring of Hop Brook near Otis Street in Northborough. Data from 2008 are presented in Table E (OAR 2008b). OAR rated stream health in Hop Brook as "good" to "excellent" for 12 of the 16 weeks sampled in June to September 2006 (OAR 2007). In its water quality assessment of the SuAsCo watershed, the Massachusetts Division of Watershed Management (DWM 2005) noted "some indications of water quality degradation in Hop Brook," mainly occasional low dissolved oxygen concentrations.

Table E – Water Quality and Stream Health, Hop Brook, June 14, 2008			
Parameter	**Result**	**Parameter**	**Result**
Total nitrogen	0.79	pH	6.77
Total phosphorus	0.087 mg/L	Water temperature	22.16 ºC
Total suspended solids	7 mg/L	Streamflow	3.26 cfs
Dissolved oxygen	4.91 mg/L	Habitat availability (0-20)	18

Note: mg/L = milligrams/liter; cfs = cubic feet per second; ºC = degrees Celsius (centigrade)
Source: OAR (2008b)

Hop Brook discharges into the Assabet River. DWM (2005) summarized water quality in the Assabet River:

> Historically, wastewater discharges and water withdrawals for public supply have deleteriously affected the Assabet River. A nutrient TMDL for the Assabet River was completed in 2004... Implementation of the TMDL requires removal of total phosphorus to 0.1 mg/L in the effluent of the major municipal wastewater treatment plants and evaluation of the feasibility of sediment remediation to reduce phosphorus flux from the sediments.

Hop Brook Dam is not expected to have a significant effect on water quality because it has no permanent impoundment.

Fish and Wildlife Resources: As a mostly developed area, wildlife resources expected to be associated with the area surrounding the Hop Brook Dam would be species tolerant of human activities such as small mammals (gray squirrel [*Sciurus carolinensis*], raccoon [*Procyon lotor*], striped skunk [*Mephitis mephitis*], opossum [*Didelphis virginiana*], and small rodents) and resident and migrant birds (great blue heron [*Ardea herodias*], mallard [*Anas platyrhynchos*], and Canada goose [*Branta canadensis*]).

Fish surveys conducted by DFW at two stations in Hop Brook in 2001 identified nine fish species, as listed in Table F. Banded sunfish, bluegill, and yellow bullhead have been introduced into the Assabet River watershed and are now found in Hop Brook. The other species are native to the area. DWM (2005) determined that the aquatic life use in Hop Brook is supported based primarily on the benthic macroinvertebrate community analysis and excellent habitat quality conditions. The benthos was classified as "slightly impacted…possibly as the result of the upstream impoundment [Smith Pond, which is downstream of Hop Brook Dam] and adjacent land uses." Hop Brook Dam is not expected to have a significant effect on aquatic life because it has no permanent impoundment.

Table F – Fish Species Observed at the Hop Brook Site

Common Name	Scientific Name	# Observed
American eel	*Anguilla rostrata*	2
Banded sunfish	*Enneacanthus obesus*	1
Blacknose dace	*Rhinichthys atratulus*	50
Bluegill	*Lepomis macrochirus*	1
Brook trout	*Salvelinus fontinalis*	7
Chain pickerel	*Esox niger*	3
Fallfish	*Semotilus corporalis*	7
White sucker	*Catostomus commersoni*	9
Yellow bullhead	*Ameiurus natalis*	2
	Total	82

Source: DWM (2005)

Threatened and Endangered Species: In response to a consultation request from NRCS, the U.S. Fish and Wildlife Service (FWS) stated that there are no listed or proposed threatened or endangered species or critical habitat in the project area (FWS 2008). A letter received from the Massachusetts NHESP in response to an information request stated that the wood turtle (*Glyptemys insculpta*) has been found in the vicinity of the project site as recently as 2007 (DFW 2008). Estimated habitat for the wood turtle occurs both upstream and downstream of the dam (Figure 3, Appendix C).

In Massachusetts, the wood turtle is listed as a Species of Special Concern and is protected by the Massachusetts Endangered Species Act. According to NHESP data, wood turtle habitat includes slower moving, mid-sized streams with sandy bottoms and heavily vegetated banks. They overwinter in the stream bottom and muddy banks and nest in sand or gravel substrate near the edge of the stream. The remainder of the year they can utilize a variety of areas including mixed or deciduous forests, fields, riparian wetlands and wet meadows (DFW 2007).

Wood turtles were not observed during site surveys. Vegetated areas immediately adjacent to the dam along Hop Brook appear to be regularly cut to prohibit the overgrowth of vegetation limiting the heavily vegetated banks preferred by the wood turtle. Possible wood turtle habitat was observed farther upstream and downstream of the dam consistent with the habitat delineated by MassGIS NHESP data and outside of the potential construction area. Winter hibernation for

wood turtles occurs in streams and no activity related to the rehabilitation project is planned to occur in the stream below the dam.

Wetlands: A map of freshwater wetlands, as interpreted and classified according to cover type by the Massachusetts Department of the Environment using aerial photographs, was obtained from MassGIS (Figure 4, Appendix C). Wetland types within the floodplain upstream of the dam are listed in Table G. A shrub swamp wetland of 2.6 acres lies just downstream of the dam.

Table G – Wetlands

Wetland Classification	Area (acres)
Deep marsh	10.0
Open water	0.7
Shallow marsh, meadow, or fen	0.2
Shrub swamp	4.1
Wooded swamp deciduous	52.9
Wooded swamp mixed trees	7.3
Total	75.2

Source: MassGIS (2008b)

Wetlands on both sides of the dam where project construction could be located were field-delineated (Figure 5, Appendix C). State-regulated wetland resources identified at the site, as defined in the Massachusetts Wetlands Protection Act Regulations 310 CMR 10.00, include Bordering Vegetated Wetlands (BVWs), Banks, Land Under Water Bodies (LUWB), and Riverfront Area, as described below.

A BVW is located along the western and southeastern portions of the Hop Brook Dam, including Dikes A, B, and C. This BVW meets the definition of a Freshwater Wetland according to the Massachusetts regulations and, therefore, a 100-foot Buffer Zone is applied. The boundary of the BVW is situated either at the toe of slope associated with the fill area for the Hop Brook Dam or is located further downslope away from the dam itself.

The delineated portion of the BVW adjacent to the dam includes forested wetlands dominated by red maple (*Acer rubrum*) and white pine (*Pinus strobus*) and a small emergent wetland along Route 20 dominated by broadleaf cattail (*Typha latifolia*). Understory vegetation in this wetland consists of sweet pepperbush (*Clethra alnifolia*), winter berry (*Ilex verticillata*), arrowwood (*Viburnum dentatum*), reed canary grass (*Phalaris arundinacea*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), and sphagnum moss (*Sphagnum* sp.). Soils are generally comprised of 6 to 20 inches of black (10YR 2/1) muck underlain by approximately 6 inches of black (10YR 2/1) mucky-sandy loam. The 100-foot Buffer Zone associated with the BVW at the site includes forested uplands and existing cleared or previously disturbed land associated with Hop Brook Dam.

Bank wetland resources immediately adjacent to the dam are limited to the banks of Hop Brook. The majority of the Banks on-site are vegetated and comprised of mineral soil material. Woody Bank vegetation includes red maple trees, and sweet pepperbush, winter berry, arrowwood shrubs. Emergent vegetation includes sensitive fern, cinnamon fern, and sphagnum moss.

LUWB immediately adjacent to the dam is limited to land under Hop Brook. This LUWB is generally comprised of mineral soil material.

Riverfront Area is defined as the area of land between a river's mean annual high water line and a parallel line measured 200 feet horizontally from this high water line. Hop Brook is defined as a river as it is a perennial body of water that empties into another river. The boundary of the Riverfront Area associated with Hop Brook extends landward 200 feet from the mean annual high water line. Riverfront Area located within the potential project construction areas consists of existing cleared and previously disturbed land associated with Hop Brook Dam.

Floodplain: The floodplain in Northborough downstream of the Hop Brook Dam is shown in Figure 6, Appendix C. Outside of Northborough, Hop Brook Dam becomes a smaller influence on the floodplain of the Assabet River, which is controlled by multiple other dams in the watershed. The floodplain would not be affected by the rehabilitation of the dam.

Air Quality: Northborough falls within the Boston-Lawrence-Worcester area as defined by EPA, which is a nonattainment area for 8-hour ozone. The area is in attainment for all other criteria pollutants (EPA 2009).

Recreation: The dam and the impoundment area when not flooded are used informally for hiking and biking.

Hazardous Waste: Prior to the acquisition of the land for development of the Hop Brook Dam, portions of the site (approximately 10.5 acres) were used for automobile salvage operations. In addition, to automobile salvage, illegal dumping resulted in the identification of two "automobile burn areas," a "wire dump area," "a bottle dump area," a "municipal burn area," and an "electrical component" dump area when an initial site investigation was completed in 2001 (Rizzo Associates 2005). Soil and sediment analysis in the disposal areas identified elevated concentrations of metals (lead, antimony, and zinc), polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and petroleum hydrocarbons that were primarily surficial. Groundwater sample analysis revealed lead concentrations above the Massachusetts Contingency Plan GW-1 standard. The wire dump area was remediated in 2001; remediation of the remainder of the site was scheduled in 2006 (Rizzo Associates 2005) but has been delayed due to lack of funding. Although these areas fall within the pool area of the dam, rehabilitation of the dam would not affect any of the areas.

Cultural and Historic Resources: The Area of Potential Effect (APE) for the project is the access road into the site and the project construction area. All of the APE was previously disturbed for construction of the dam and Dike A. Other than the dam itself, there are no structures within the APE. No historic properties that are listed on or eligible for listing on the National Register of Historic Places are present in the project's APE (National Park Service 2008). [Note: confirmed verbally; waiting for letter responses to be included in final plan.]

Land Use: In the 1958 watershed plan, the SuAsCo watershed is described as 10 percent developed and 90 percent, cropland, grassland, forest, and open water. In the 50 years since, the

area has developed as a residential area for Boston and Worcester commuters (Town of Northborough 2008). Current land use in the Hop Brook Dam drainage area (based on 1999 data in MassGIS) is summarized in Table H; almost 50 percent of the area is residential, mostly low to medium density. Land in the drainage area is predominantly privately owned (90 percent), with the rest being state- or local government-owned.

Table H also summarizes land use under ultimate build-out, as projected from zoning (Bhatti Group 2005). Residential and commercial/industrial development is projected to increase by about 25 percent in the area and will result in a similar loss of forested land cover and agricultural land. Current and build-out land use maps of the Hop Brook Dam drainage area are presented in Figures 7 and 8 in Appendix C

Table H – Land Use in the Hop Brook Dam Drainage Area

	Current		Ultimate Build-out	
Land Use	**Acres**	**Percent**	**Acres**	**Percent**
Residential	1,538	49	2,134	68
Forest	1,148	36	511	16
Agricultural	153	5	63	2
Commercial, industrial	57	2	257	8
Other (wetlands, open land, water, etc.)	249	8	180	6

Source: Bhatti Group (2005)

Land use in the Hop Brook Dam floodplain is summarized in Table I. Commercial and industrial areas are located south of the dam along the Northborough-Westborough town line and coincide with a development and commercial area along State Route 9 (Turnpike Road), which runs east-west between Northborough and Southborough. A golf course is located along the north bank of Hop Brook, southeast of the dam and prior to the brook's confluence with the Assabet River. Commercial and industrial development is a higher percentage of land use in the floodplain than in the dam drainage area because of the historical growth of towns along the region's rivers. Land in the floodplain is mostly privately owned (78 percent), with smaller proportions of state- or local government-owned (18 percent) and federally owned (4 percent) land. Future land use in the floodplain is not expected to change significantly because of zoning restrictions on floodplain development.

Table I – Land Use in the Hop Brook Dam Floodplain

Land Use	**Acres**	**Percent**
Forest	1,058	32
Residential	312	9
Commercial, industrial	297	9
Agricultural	243	7
Other (wetlands, open land, water, etc.)	1,414	43

Source: MassGIS (2008b) 1999 land use data

Socioeconomic: The Town of Northborough, population 14,013 in 2000, is located in Worcester County, Massachusetts, approximately 10 miles northeast of Worcester and 30 miles west of Boston. Population in the SuAsCo watershed has increased as the area has become more of a

commuter community for the cities of Boston and Worcester. Socioeconomic characteristics of Northborough and Worcester County—plus the state and the nation for comparison—from the United States Census in 2000 are presented in Table J.

Environmental Justice: Executive Order 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* requires that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations" (Council on Environmental Quality 1997). Environmental Justice neighborhoods are defined as neighborhoods with minority, non-English speaking, low-income and/or foreign born populations. According to MassGIS data derived from the 2000 U.S. Census, Northborough has no environmental justice populations that could be affected by project construction (MassGIS 2008a). As shown in Table J, minority groups constitute 7 percent of the population in Northborough, and families in poverty are less than 2 percent of all town families. There would be no adverse effects to environmental justice communities downstream of Northborough, because the project has no adverse effects downstream of the dam and only benefits downstream populations.

Table J - Summary of Socioeconomic Characteristics.								
	Northborough		**Worcester Co.**		**Massachusetts**		**United States**	
Population and Race	14,013		750,963		6,349,097		281,421,906	
White	13,033	93%	672,915	89.6%	5,367,286	84.5%	211,460,626	75.1%
Black/African American	91	0.6%	20,498	2.7%	343,454	5.4%	34,658,190	12.3%
Asian	708	5.1%	19,700	2.6%	238,124	3.8%	10,242,998	3.6%
Other	51	0.4%	22,037	2.9%	236,724	3.7%	15,359,073	5.5%
Native American	11	0.1%	1,896	0.3%	15,015	0.2%	2,475,956	0.9%
Hispanic or Latino of any race	179	1.3%	50,864	6.8%	428,729	6.8%	35,305,818	12.5%
Age								
Median age	37.4		36.3		36.5		35.3	
Over 18 years of age	9,881	70.5%	558,515	74.4%	4,849,033	76.4%	209,128,094	74.3%
Over 65 years of age	1,370	9.8%	97,969	13.0%	860,162	13.5%	34,991,753	12.4%
Language Spoken At Home								
English only	11,887	91.5%	595,964	85.0%	4,838,679	81.3%	215,423,557	82.1%
“less than very well”	321	2.5%	41,876	6.0%	459,073	7.7%	21,320,407	8.1%
Spanish	139	1.1%	42,732	6.1%	370,011	6.2%	28,101,052	10.7%
Indo-European	509	3.9%	42,780	6.1%	529,784	8.9%	10,017,989	3.8%
Asian-Pacific	452	3.5%	13,472	1.9%	171,253	2.9%	6,960,065	2.7%
Other Languages	11	<0.1%	6,209	0.9%	44,522	0.8%	1,872,489	0.7%
Disability Status								
Population five years of age and older	1,348	10.5%	129,290	18.8%	1,084,746	18.5%	54,314,427	19.3%
Education								
High school graduate or higher	93.4%		83.5%		84.8%		80.4%	
High school including GED	1,872	20.3%	149,639	30.2%	1,165,489	27.3%	52,168,981	28.6%
Associates degree	718	7.8%	39,063	7.9%	308,263	7.2%	11,512,833	6.3%
Bachelor’s degree	2,841	30.8%	82,648	16.7%	834,554	19.5%	28,317,792	15.5%
Graduate or professional degree	1,866	20.2%	50,857	10.3%	583,741	13.7%	16,144,813	8.9%
Employment, Class of Worker and Commuter Status								
Labor force pool (over 16 years of age)	7,657	74.4%	383,764	66.3%	5,010,241	78.9%	217,168,077	77.2%
Employed	7,517	73.1%	366,942	63.4%	3,161,087	63.1%	129,721,512	59.7%
Unemployment	140	1.4%	16,324	2.8%	150,952	3.0%	7,947,286	3.7%

Table J - Summary of Socioeconomic Characteristics.								
	Northborough		**Worcester Co.**		**Massachusetts**		**United States**	
Private for-profit workers	5,745	76.4%	264,676	72.1%	2,197,138	69.5%	92,499,904	71.3%
Self-employed workers – includes agriculture, forestry, fishing, hunting	537	7.1%	21,649	5.9%	204,770	6.5%	3,290,170	5.5%
Non-profit workers	554	7.4%	30,731	8.4%	331,510	10.5%	9,294,457	7.2%
Government	660	8.8%	49,621	13.6%	425,573	13.5%	18,923,353	14.6%
Federal	30	0.4%	6,220	1.7%	66,653	2.1%	3,550,266	2.7%
State	168	2.2%	15,309	4.2%	122,041	3.9%	6,153,845	4.7%
Local	462	6.1%	28,092	7.7%	236,879	7.5%	9,219,242	7.1%
Occupation								
Management, professional and related occupations	4,169	55.5%	137,980	37.6%	1,298,704	41.1%	43,646,731	33.6%
Service occupations	737	9.8%	50,834	13.9%	444,298	14.1%	19,276,947	14.9%
Sales and office occupations	1,821	24.2%	93,718	25.5%	818,844	25.9%	34,621,390	26.7%
Production, transportation, and material moving occupations	436	5.8%	53,990	14.7%	356,723	11.3%	18,968,496	14.6%
Construction, extraction, and maintenance occupations	334	4.4%	29,835	8.1%	235,876	7.5%	12,256,138	9.4%
Commuting to Work								
Worked in county of residence	3,820	51.4%	266,814	74.0%	2,067,368	66.6%	94,042,863	73.3%
Worked outside county of residence	3,500	47.1%	84,873	23.6%	934,388	30.1%	29,600,841	23.1%
Worked outside the state of residence	105	1.4%	8,656	2.4%	101,081	3.3%	4,635,524	3.6%
Housing								
Number of households	4,906		284,218		2,443,580		105,480,101	
Number of housing units	5,002		298,159		2,621,989		115,904,641	
Median house value	$228,300		$149,784		$192,978		$120,467	
Occupied	4,906	98.1%	283,927	95.2%	2,443,580	93.2%	105,480.101	91.0%
Owner occupied	4,123	84.0%	182,104	52.6%	1,508,052	61.7%	69,815,753	66.2%
Income								
Median annual household income	$79,781		$47,874		$50,502		$41,994	
Median family income	$90,480		$53,394		$61,664		$50,046	

Table J - Summary of Socioeconomic Characteristics.								
	Northborough		**Worcester Co.**		**Massachusetts**		**United States**	
Per capita income	$32,889		$22,983		$25,952		$21,587	
FT, year-round male median income	$65,437		$42,261		$43,048		$37,057	
FT, year-round female median income	$41,042		$30,516		$32,059		$27,194	
Poverty								
Number of families	65	1.7%	13,100	6.8%	105,619	6.7%	6,620,945	9.2%

Source: 2000 Census data, U.S. Census Bureau (2008)

STATUS OF OPERATION AND MAINTENANCE

DCR is responsible for operation and maintenance of the Hop Brook Dam. A site inspection of the dam on April 18, 2008, found that, in general, the dam was in "Satisfactory" condition, with some eroded paths and exposed embankment soils, deterioration of the downstream end of the principal spillway pipe, some irregularity along the top of dam, and minor damage to the embankment due to animals and unauthorized use of the facility. Maintenance of the dam, particularly along Dike A, has occurred to address areas of eroded paths along the slopes and undulations along the top of the dam. During the site inspection, the surveyed elevations showed no sign of settlement or erosion along the structure that would limit the function of the dam. The 2008 site inspection found that the stilling basin below the dam is well maintained. A video pipe inspection determined that there were no areas of concern or movement within the principal spillway outlet pipe. A drain pipe associated with Dike B could not be accessed due to accumulated sediments; the drain pipe associated with Dike C appeared to be in good condition. The corrugated metal pipe culvert beneath Tomblin Hill Road was also found to be in good condition during the inspection.

SEDIMENTATION

Hop Brook Dam was designed with 22 acre feet of sediment storage capacity for a 50-year period. Sediment accumulation in the pool area has been minimal, and sediment removal has occurred only incidentally to debris removal around the primary spillway. Sediment accumulation is expected to be minimal for the remaining 54-year evaluation period of the dam.

BREACH ANALYSIS AND HAZARD CLASSIFICATION

As defined in Section 520.21(e) of the NRCS Title 210 National Engineering Manual, Hop Brook Dam is classified as a Class C (high hazard) dam "where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads." The original NRCS hazard classification was also a Class C structure. Under Commonwealth of Massachusetts Dam Safety Rules and Regulations, 302 CMR 10.00, the dam is classified as a Class I (High) hazard structure and a "Large" size structure because it has a storage capacity greater than 1,000 acre feet.

Failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highways or railroads. Flooding along Hop Brook and the Assabet River from a dam breach is expected to impact approximately 380 residential and 89 commercial buildings and 114 roadways, as discussed in the *Consequences of Dam Failure* section of this report.

A comprehensive hydrologic and hydraulic analysis was performed to evaluate the capacity of the Hop Brook Dam under current and build-out conditions (see Appendix D, Investigations and Analysis Report). The analysis included development of a Water Resource Site Analysis Integrated Development Environment (SITES IDE) model to predict maximum water surface elevations under a series of design storms. Design storms were established based on NRCS and Massachusetts dam design criteria. The model applies user-specified rainfall, runoff, and

watershed hydrologic data to develop inflow hydrographs. Hydrographs are then routed through the various control structures associated with the dam to predict maximum water level, potential embankment erosion, and other potential structure failures.

Results of the analysis indicated that the auxiliary spillway is undersized under current conditions and does not meet NRCS criteria, as specified in Technical Release 60 (TR-60). With the spillway design hydrograph (SDH), flow passes the auxiliary spillway at a velocity of 10.4 feet per second, which exceeds TR-60 maximum velocity criteria and is erosive to vegetative cover. With the freeboard hydrograph (FBH), pool elevation overtops the dam by 1.4 feet.

For build-out conditions, the auxiliary spillway does not pass TR-60 criteria for freeboard and earthen spillway design. During the SDH storm, flow passes the auxiliary spillway at a velocity of 11.6 feet per second, which can erode vegetative cover and exceeds the TR-60 maximum velocity criteria. During the FBH storm, the water surface elevation overtops the dam by 1.6 feet.

Table K summarizes the hydrologic and hydraulic analyses for the original design and for current and build-out conditions.

Table K – Hydrologic and Hydraulic Analyses Summary

	Original Design	Current Conditions	Build-out Conditions
Comparison elevations			
Riser crest (elevation, feet)	302.0	302.0	302.0
Crest of auxiliary spillway (elevation, feet)	309.0	309.0	309.0
Top of dam low point (elevation, feet)	313.0	313.0	313.0
Bottom width of auxiliary spillway (feet)	340	340	340
PSH (principal spillway hydrograph)[1/]			
Max. water elevation (feet)	302.0	308.8	308.8
Drawdown (days)	—	14.1	14.1
Starting pool elevation for SDH and FBH		300.4	300.4
SDH (spillway design hydrograph)[2/ 3/]			
Max. water elevation (feet)	305.6	310.5	310.8
Max velocity (feet per second)	—	10.4	11.6
FBH (freeboard design hydrograph)[2/]			
Max. water elevation (feet)	312.8	314.4	314.6
Available freeboard (feet)	0.2	-1.4	-1.6

[1/] Source: NRCS 2005. Based on assessment using TR-60 1985 design criteria.
[2/] Source: H&S Environmental 2009. Buildout condition values based on assessment using TR-60 2005 design criteria.
[3/] When adjusted for 24-hour distribution requirement of the 2005 TR-60 update, SDH values for build-out conditions are maximum water elevation = 311.2 feet and maximum velocity = 13.5 feet per second.

A breach analysis was conducted by GZA GeoEnvironmental, Inc. to estimate the inundation areas and corresponding time to flooding downstream as a result of failure of the Hop Brook

Dam (GZA 2008) (see Appendix D for methodology and details of analysis). A National Weather Service computer model (DAMBRK, Version 3.0) was used to predict the hypothetical dam break wave formation at Hop Brook Dam and downstream progression along Hop Brook and the Assabet River. The spillway design flood (SDF) for the dam based on the current size (Large) and hazard classification (High) is the 1/2 probable maximum flood (PMF). The wet weather scenario used a SDF outflow of 5,600 cfs and a water surface elevation set a peak SDF reservoir elevation of 0.8 feet below the top of the dam at the time of dam failure based on the previous hydrologic and hydraulic analysis.

The modeling determined that the maximum discharge through the Hop Brook Dam breach opening is approximately 19,500 cfs and occurs 0.5 hours from the beginning of the simulation. The peak dam flow is expected to be an order of magnitude greater than the 100-year flood for the Assabet River within the Town of Northborough. Peak flood depth over initial conditions ranges from about 4 feet immediately downstream of the dam to about 1 foot downstream of Tyler Dam and approximately 2.5 feet downstream of Washington Street Dam. Inundation maps presenting the results of the DAMBRK modeling are located in Appendix C, Figures 9-11.

Results from the dam breach analysis were used to update the EAP for the Hop Brook Floodwater Retarding Dam. The EAP provides appropriate actions in the case of dam failure and is updated annually by DCR.

POTENTIAL MODES OF DAM FAILURE

Several potential modes of failure for dams were examined for Hop Brook Dam.

Sedimentation: Excessive sedimentation can reduce flood storage volume and clog spillways, reducing the hydraulic efficiency of the dam. Sedimentation of the Hop Brook Dam over the past 45 years has been minimal, and failure due to sedimentation is not probable.

Hydrologic Capacity: Hydrologic failure of a dam can occur by breaching the auxiliary spillway or overtopping the dam during a storm event. The integrity and stability of the auxiliary spillway and embankment is dependent on depth, velocity, and duration of flow; vegetative cover; and resistance to erosion. As discussed in the previous section, *Breach Analysis and Hazard Classification*, the dam does not meet current dam safety design criteria for a high hazard dam. Therefore, the potential for failure due to a deficiency in hydrologic capacity at the dam is considered high.

Seepage: Embankment and foundation seepage can contribute to failure of an embankment by removing (piping) soil material through the embankment or foundation. As the soil material is removed, voids can be created, allowing ever increasing amounts of water to flow through the embankment or foundation until the dam collapses due to the internal erosion. Seepage that increases with an increase in pool elevation is an indication of a potential problem, as is stained or muddy water. Foundation and embankment drainage systems can alleviate the seepage problem by removing the water without allowing soil to be transported away from the dam.

No visible signs of seepage were observed during the inspection conducted in 2008 (H&S Environmental 2009). No sloughing, sinkholes, or other surface anomalies indicative of embankment instability were observed. In the near future, seepage presents a low potential mode of failure for the dam.

Seismic: The integrity and stability of an earthen embankment are dependent on the presence of a stable foundation. Foundation movement through consolidation, compression, or lateral movement can cause the creation of weak zones or voids within an embankment, separation of the principal spillway conduit joints, or in extreme cases, complete collapse of the embankment. Central Massachusetts is not an area of significant seismic risk, and there is low potential for seismic activity to cause the failure of the dam.

Embankment Slope Failure: An embankment slope failure allows increased saturation, weakens the integrity of the dam during large storms, and could result in a catastrophic failure. Slope failure can also create slides and sloughing that lower the top of the dam elevation so that overtopping may occur during large storms.

The Hop Brook Dam shows no visible signs of slope failure, sloughing, or any other noticeable indications of instability on the embankments. The embankments of the dam are grass covered. Recent inspection of the dam noted vehicular ruts degrading the quality of the vegetation but little exposure of embankment soils. Wear, compression, and some damage to grass covering the dam and dikes were observed, but the vegetation was in the process of recovery. Maintenance at the dam includes mowing and control and clearing of woody vegetation along the dam embankments and spillways. A possible slough approximately 7 feet wide that was observed at Dike A during the inspection should continue to be monitored during future inspections. Embankment slope failure presents a low potential mode of failure for Hop Brook dam.

Material Deterioration: Material used in the principal spillway system and fences are common construction materials, but they are subject to weathering and chemical reaction due to natural elements within the soil, water, and atmosphere. As a result of this weathering, concrete components can deteriorate and crack, metal components can rust and corrode, and leaks can develop. Embankment failure can occur from internal erosion caused by these leaks.

Based on the results of the site inspection in 2008 (H&S Environmental 2009), the structure appears to be in good to satisfactory condition with no evidence of deterioration on any of the materials that would require structural repair at this time. The principal spillway outlet pipe appears to be in good condition based on video inspection. Accumulated sediment prevented access of the drain pipe at the toe of Dike B. The pipe associated with Dike C was found to be in good condition. As a result, the potential failure of the existing dam due to deteriorating components is judged to be low. However, the dam should continue to be monitored, especially after significant storm events, because of the age of existing structural components.

CONSEQUENCES OF DAM FAILURE

Historically, pool elevation at the Hop Brook Dam has never reached the level of the auxiliary spillway, and modeling indicates that the auxiliary spillway would not discharge during the 100-

year precipitation event under current or build-out conditions. However, failure of Hop Brook Dam under more-extreme wet weather conditions is anticipated to impact approximately 450 structures, the majority of which are located in the Towns of Northborough and Hudson. Most of these structures would have already experienced the effects of flooding resulting from the ½ PMF storm prior to the dam breach. The structures are primarily private residences but also include commercial and industrial buildings.

Within the Town of Northborough, dam break flooding is anticipated along Hop Brook and the Assabet River. Under the ½ PMF design storm, flooding is expected to impact approximately 100 residential structures, 10 commercial structures, and 22 roadways including Route 135 and Route 20. The Town of Westborough would experience flooding along the Assabet River. The ½ PMF in the Hop Brook Dam drainage area and general wet weather flooding of the Assabet River upstream of Hop Brook in conjunction with the dam failure is anticipated to result in the backwater flooding of the Assabet River just upstream of the confluence of Hop Brook with the Assabet River. Flooding is also expected along the Assabet River downstream of Hop Brook. Approximately 10 commercial structures within the Town of Westborough are anticipated to be impacted; no residential property is expected to be impacted. Four roadways would also be impacted.

Within the City of Marlborough, flooding is anticipated along the Assabet River. Tyler Dam is a flood control dam and has sufficient hydraulic capacity to pass the dam break flood wave as well as wet weather flow in the Assabet River. Tyler Dam is expected to assist in dissipating the peak of the flood wave. No structures should be impacted by the dam failure flood wave. Approximately five roads would be impacted by flooding resulting from the dam failure. Four commercial structures and five residential structures along the Assabet River in the Town of Berlin would experience impacts from flooding. Four streets are also anticipated to be impacted by flooding resulting from a dam breach.

Within the Town of Hudson, the wet weather dam break flood is anticipated to impact approximately 220 residential buildings and 30 commercial buildings along the Assabet River. Two schools, the Hudson Fire Department, and approximately 48 roadways are also expected to experience flooding. The Washington Street Dam, in the Town of Hudson, does not have a hydraulic capacity sufficient to pass the dam break flood wave and is anticipated to be overtopped and fail.

The Town of Stow is anticipated to have approximately 20 commercial structures and 15 residential structures along the Assabet River impacted by flooding as well as six roadways. Within the Town of Maynard, the wet weather dam break flooding is expected to impact approximately 15 commercial structures, 40 residential structures along the Assabet River and approximately 23 roadways.

The damages from a 100-year flood event without the Hop Brook Dam in place are estimated to be $3,582,000. A catastrophic breach of the dam would affect an area larger than the 100-year floodplain, so the damages from a breach would far exceed the damages sustained from a 100-year flood event without the dam in place, and it would also most likely include the loss of lives.

ALTERNATIVES

FORMULATION PROCESS

NRCS and DCR jointly developed a wide range of nonstructural and structural measures for flood protection downstream of Hop Brook Dam. Alternatives were developed that are ineligible for financial assistance under PL 83-566 as amended by PL 106-472 as well as alternatives that are eligible for federal funding. To be eligible for federal assistance, an alternative must meet the requirements of PL 106-472.

The following alternatives were considered:

- Future Without Project—the most probable future conditions to be realized if the federally funded National Economic Development (NED) alternative is not implemented.
- Decommissioning—controlled breaching of the dam so that it no longer stores floodwater.
- Rehabilitation of the dam (NED Alternative).
- Other dam rehabilitation alternatives.
- Relocation of at-risk buildings in the downstream breach inundation area.
- Floodproofing of at-risk buildings in the downstream breach inundation area.

The principal spillway outlet structure and the control elevation of the auxiliary spillway would not be affected by any of the alternatives. The flood profiles of storms less frequent than the design storms would not be affected by proposed rehabilitation measures and were not included in the alternatives analysis.

Alternatives that would provide no additional benefits but would cost substantially more than the NED Alternative were eliminated from detailed analysis. The Future Without Project Alternative was used to evaluate the remaining feasible rehabilitation alternative, which is the NED Alternative.

The alternatives evaluation period was established as 54 years to provide continuing safe service for the original 100-year SuAsCo watershed planning period. The period of analysis is 55 years to allow for 1 year of design and construction. All alternatives were developed to function for a minimum of 54 years with proper maintenance.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Structural and nonstructural measures that were considered but eliminated from detailed study are described in the following paragraphs:

Decommissioning

Decommissioning would require taking the dam out of service through a full or partial breach of the dam. Decommissioning would eliminate flood storage behind the dam and eliminate the flood protection provided by the dam. Without further mitigation, downstream properties would be subject to increased flooding, increased property damage, and increased risk of loss of life. There would be construction costs and impacts related to the dam breach, but there would be no long-term dam maintenance and repair costs.

Decommissioning would not meet the sponsors' objective to maintain the downstream flood damage reductions provided by the existing project. To meet this objective, decommissioning would have to be supplemented by other measures such as floodproofing or relocation. The costs of relocation and floodproofing would exceed the structural cost of rehabilitation by more than 400 percent, so the decommissioning alternative was eliminated from detailed study because it was not considered to be a reasonable alternative due to cost.

Increase Height of Dam

The height of the dam could be increased to meet the federal freeboard design criteria. The cost of raising the dam by 1.6 feet and armoring the auxiliary spillway to meet freeboard and spillway design criteria would be approximately $2.2 million. This alternative would also require additional costs for purchasing properties to accommodate the increased pool elevation and providing upstream dikes along the northern project area perimeter. The cost of this alternative, therefore, would exceed the cost of the structural alternative considered for final analysis by more than 50 percent and provide no additional benefits. This alternative would also create additional environmental impacts in the areas of project construction—the dam and additional perimeter dikes. Raising the dam is not considered a reasonable alternative because of the substantially higher cost and greater environmental impact.

Armor the Embankment and Spillway

The upstream slopes, crests, and downstream slopes of the dam and the three dikes could be armored to protect against erosion of the structures when flood flows pass over the auxiliary spillway crest or over the dam/dike crest. The construction cost of this alternative is estimated at $5.8 million, which is almost four times the cost of the NED Alternative. This alternative, therefore, is not considered to be reasonable because of excessive cost.

Construct Additional Auxiliary Spillway and Armor Both Auxiliary Spillways

This alternative would be similar to Alternative 2 described below, except the additional 270 feet of auxiliary spillway would be constructed on Dike B, separate from the existing auxiliary spillway. Armoring would be placed on both the existing and the new auxiliary spillways. Locating the additional auxiliary spillway on Dike B would require modification to the existing drainage swales as well as the drainage ditch along the east side of Route 20. Spillage over this location would flow directly over Route 20. With this potential impact to Route 20 and a cost

about 25 percent greater than the cost of the NED Alternative, this alternative is not considered to be reasonable.

Relocation

Land downstream of the dam that would be affected by failure of the dam would be purchased and the residences or businesses relocated out of the flood area. The Hop Brook Dam provides approximately 12.5 percent of the flood damage reduction benefits in the SuAsCo watershed. A major property that would be affected if the dam were to fail is Clock Tower Plaza/Place, which is valued at approximately $40 million. The proportioned cost of that property to the Hop Brook Dam is then $5 million (12.5 percent of $40 million). When costs for protecting roads and other infrastructure, other property purchases, and relocation are added to this cost, the cost of this nonstructural alternative far exceeds the cost of structural alternatives to rehabilitate.

Floodproofing

To protect areas that would be affected by failure of the dam, individual properties could be floodproofed or floodwalls could be constructed along the river downstream of the dam. A 3,000-foot-long floodwall would be required to protect just the approximately $40 million complex at the Clock Tower Plaza/Place, and the cost of the property needed for the structure would exceed $2 million. Several miles of floodwalls would also be required for Routes 20, 9, 135, 290, and 495 and for multiple developed properties along Hop Brook. The cost of these floodwalls is estimated at $6.0 million. This alternative is unreasonable, because the cost is more than 400 percent higher than the cost of the structural alternative considered for final analysis, there are no additional flood-protection benefits, and the environmental impacts of project construction would be greater.

DESCRIPTION OF ALTERNATIVE PLANS

The following alternatives were developed in detail and are evaluated in this Watershed Plan/EA.

Alternative 1 - Future Without Project (No Action Alternative)

The Future Without Project Alternative or No Action Alternative depicts the most probable future conditions to be realized in absence of any of the alternative plans studied. DCR, the owner of the dam, and the agency under which the Commonwealth's dam regulations are implemented, has determined that it would rehabilitate the dam to meet current federal dam safety standards without federal funds. DCR may use other alternative rehabilitation methods identified in the Phase II report (H&S Environmental, 2009) or develop its own plan to bring the dam into compliance with federal standards, but for the purposes of comparing this alternative to the NED Alternative, it is assumed that DCR would implement the same plan as described in Alternative 2. This assumption was made because the recommended plan is the most cost-effective and least environmentally damaging of all plans considered.

Alternative 2 – Rehabilitation (NED Alternative): Widen and Armor Auxiliary Spillway

The width of the auxiliary spillway could be increased from 340 feet to 610 feet to bring the structure into compliance with the federal freeboard design criteria and prevent overtopping of the dam. However, exit velocity in the auxiliary spillway would still exceed federal design criteria and be erosive to the existing grass-covered slope. The auxiliary spillway, therefore, would be armored to protect against erosion and stabilize the structure. The armoring would provide scour protection for the predicted velocity of 9.8 feet per second (fps), which exceeds the allowable velocities for earthen spillways. Articulated concrete blocks (ACBs) are cost-effective solutions that decrease the impact to the structure (i.e., shallow depth of construction, limited staging areas required) and improve ease of maintenance through the ability to replace damaged pieces and maintain or improve current aesthetics. ACBs are suited for channel velocities in excess of 20 fps.

Construction of an ACB type system requires the removal of the vegetation and organic topsoil layers, excavation to the subgrade elevation to enable installation of the bedding layer, installation of the drainage layer, placement of the ACBs which are typically fashioned into mats, and placement of infill materials. The drainage layer, which is an integral part of the system typically, consists of a geotextile designed to filter the embankment soils, and a crushed stone drainage media. Grading and placement of this layer is critical so as to enable the proper placement of the ACBs in intimate contact with the drainage layer. Should flow occur between the drainage layer and the ACB units, laboratory testing has shown that the blocks can lift and degrade the system.

The limited disturbance required for installation, low frequency of use leading to reduced maintenance costs, overall cost savings, and the ability to cover the ACBs with a layer of sacrificial loam and seed to maintain the natural appearance of the area are significant benefits to using ACBs in this location.

In order to widen the auxiliary spillway to the necessary 610 feet, the auxiliary spillway will need to extend onto filled portions of the dam embankment. Standard NRCS design requirements specify that the auxiliary spillway be cut into native ground. However, this is not a practical option because of the configuration of the site and the general topography surrounding the impoundment. The area along the south abutment is a steep slope, which would require significant excavation and regrading. The recommended plan is to widen the existing auxiliary spillway by extending it onto the south side of Dike A, as shown on Figure 2 in Appendix C.

COMPARISON OF ALTERNATIVES

Table L summarizes and compares the two alternative plans. Refer to the *Environmental Consequences* section for additional information on the effects of each alternative.

Table L – Summary and Comparison of Candidate Plans		
Effects	**Alternative 1 Without Project**	**Alternative 2 (NED)**
Measures	Widen auxiliary spillway by 270 feet; armor spillway with ABCs	Widen auxiliary spillway by 270 feet; armor spillway with ABCs
Project investment	$1,955,100	$1,955,100
National Economic Development Account[1/]		
Beneficial, annual	—	$112,300
Adverse, annual	—	$112,300
Net beneficial	—	$0
Environmental Quality Account		
Wetlands	0 acres of permanent effects on wetlands above or below dam. Potential for <1 acre disturbance during construction; will be avoided if possible and restored if not avoided.	0 acres of permanent effects on wetlands above or below dam. Potential for <1 acre disturbance during construction; will be avoided if possible and restored if not avoided.
Threatened and endangered species	0 acres federally protected habit affected; 0 take of federally protected species. 0 acres of nesting/hibernation habitat for wood turtle, state species of special concern, affected	0 acres federally protected habit affected; 0 take of federally protected species. 0 acres of nesting/hibernation habitat for wood turtle, state species of special concern, affected
Regional Economic Development Account		
ARRA[2/] funds to stimulate local economy	$0	$1,406,400
Other Social Effects Account		
Dam safety	Reduced threat of dam failure	Reduced threat of dam failure
Human health and safety	Reduced threat to life from dam failure	Reduced threat to life from dam failure
Flood damages	Reduced threat of flood damages from dam failure	Reduced threat of flood damages from dam failure

[1/] Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G), U.S. Water Resources Council, March, 1983, allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (Adverse, annual) as adverse beneficial costs (Beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

[2/] American Recovery and Reinvestment Act of 2009

ENVIRONMENTAL CONSEQUENCES

The following is a description of the effects that each alternative will have on the natural and human environment, focusing on concerns identified during the scoping process determined to be of moderate or high significance to decision making (see Table A). Resources or concerns that were rated of low significance to decision making or that are not affected by either alternative (e.g., climate, geology) are not included in this section. For each resource topic, the present conditions are summarized to provide a better understanding of the effects. Because the dam would be rehabilitated under both alternatives (by DCR with no federal funding under Alternative 1 and by the sponsors with partial federal funding under Alternative 2), the effects of the alternatives are the same for all resource categories.

DAM SAFETY

- **Present Conditions:** The dam does not meet current safety standards for a dam in this location and there is a risk of the dam failing from overtopping during a large storm. The pool elevation would overtop the dam by 1.4 to 1.6 feet in current and build-out conditions, respectively, for the freeboard storm. Modeling results indicate that the auxiliary spillway does not meet all necessary design criteria for current and ultimate build-out conditions, and discharge velocity would create erosive forces on the spillway slope. The risk of failure is low, but the consequences of failure would be catastrophic.
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** Widening the auxiliary spillway would reduce pool elevation during freeboard storm events and prevent overtopping of the dam. Armoring the auxiliary spillway would prevent erosion of the spillway if storm flows pass down the spillway. The rehabilitation would bring the dam into compliance with federal and state criteria, and the threat of the dam failing during large storms would be reduced.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

HUMAN HEALTH AND SAFETY

- **Present Conditions:** The dam is structurally safe; however, there is a threat of failure from overtopping of the dam or erosion of the auxiliary spillway during large storms. There is a significant threat from dam failure to human life and safety for residents, motorists, and other people using downstream facilities.
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** The threat of loss of life or unsafe conditions from the dam failing would be reduced through rehabilitation designed to bring the dam into compliance with safety criteria. Flood protection would continue for residents, motorists, and other persons using downstream facilities.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

FLOOD DAMAGES

- **Present Conditions:** Failure of the dam also poses a significant threat of damages to private property, roads, and utilities in the breach inundation area.

- **Alternative 1—Future Without Project (Rehabilitation by DCR):** The threat of property damage from the dam failing would be reduced through rehabilitation designed to bring the dam into compliance with safety criteria. Flood protection would continue for private property, roads, and utilities in the breach inundation area.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

WATER QUALITY

- **Present Conditions:** Water quality in Hop Brook is generally good, with some occurrences of low dissolved oxygen. Hop Brook Dam has little influence on water quality because it does not permanently impound water.
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** The proposed rehabilitation of Hop Brook Dam would have minor, temporary impacts on water quality during construction. Turbidity in Hop Brook would be minimized by using best management practices for sediment and erosion control. DCR or its contractor would be required to obtain an NPDES general permit for construction, which would require preparation of an erosion and sediment control plan and installation of best management practices to minimize sediment discharge to the brook.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

WETLANDS

- **Present Conditions:** Wetland resources identified at the Site include BVWs, Banks, LUWB, and Riverfront Area. These wetland resources are associated with, or adjacent to, Hop Brook. Bordering vegetated wetlands are located on both sides of the dam/Dike A in the area where the auxiliary spillway would be widened.
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** No permanent wetland impacts are expected. Temporary wetland impacts may occur at the toe of the slope of the dam as a result of construction access to embed the proposed armoring system. It is estimated that temporary wetland impacts would be less than one acre. All temporary wetland impact areas would be restored following construction.
  All other construction staging and access would occur entirely within existing cleared or previously disturbed upland areas. All disturbed areas would be revegetated and restored after construction is complete.
  State-regulated wetland resources delineated at Hop Brook are not located in the area where construction associated with the rehabilitation would occur, except at the toe of the slope where embedding of the proposed armoring system would occur. Portions of the 100-ft Buffer Zone associated with BVW, and Riverfront Area associated with Hop Brook are located within potential work areas; however, these areas are comprised of existing cleared or previously disturbed portions of the site. Best management practices would be used during construction to reduce erosion and sediment movement into the downstream wetlands during construction.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

FISH AND WILDLIFE HABITAT

- **Present Conditions:** Hop Brook Dam has little effect on fish and wildlife because it does not have a permanent impoundment. The preserved area for the floodwater pool upstream of the dam provides wildlife habitat.
- **Alternative 1—Future Without Project (Rehabilitation by DCR)**: No permanent impacts are anticipated. Less than 1 acre will be disturbed during construction outside the existing maintained dam footprint. Turbidity in Hop Brook and the Assabet River would be minimized through the use of best management practices for sediment and erosion control. Impacts would be minor and temporary.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

THREATENED AND ENDANGERED SPECIES

- **Present Conditions:** There are no federally protected species in the area potentially affected by project construction, but habitat for a state species of special concern, the wood turtle, lies along Hop Brook upstream and downstream of the dam.
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** Construction would not affect wood turtle nesting or winter hibernation habitat, which would lie adjacent to or in Hop Brook itself. Construction would also not affect the riparian forests or wetlands along the stream where the turtle could forage during the rest of the year. Because the construction area lies within areas designated as turtle habitat, however, DCR would have to consult with NHESP as the final design is developed.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

AIR QUALITY

- **Present Conditions:** The project area falls within the Boston-Lawrence-Worcester area as defined by EPA, which is a nonattainment area for 8-hour ozone (EPA 2009).
- **Alternative 1—Future Without Project (Rehabilitation by DCR):** No permanent impacts are anticipated. Minor, temporary impacts are expected due to emissions from construction equipment.
- **Alternative 2—NED Rehabilitation Plan:** Same as Alternative 1.

RECREATION

- **Present Conditions:** The dam and the impoundment area when not flooded are used informally for hiking and biking.
- **Alternative 1—Future Without Project (Rehabilitation by DCR)**: No permanent impacts are expected. Minor, temporary impacts to recreation would occur during construction because there would be reduced access to the area for hiking and biking.
- **Alternative 2—NED Rehabilitation Plan**: Same as Alternative 1.

CUMULATIVE IMPACTS

Construction of the Hop Brook Dam in 1964 had minor, long-term, direct effects on the environment through the excavation and filling of the structure. Rehabilitation of the dam under either alternative would occur within the area disturbed for construction of the existing structure and, therefore would have no cumulative impact on the environment other than the minor, temporary, construction-related impacts described above.

Since construction, the dam has indirectly affected the natural environment by temporary inundation of the floodplain upstream of the dam during rain events and by trapping sediment that would otherwise move downstream during rain events. The dam has also altered the hydrology of Hop Brook and the Assabet River by reducing downstream flows during storm events, and consequently protecting property and people in otherwise floodprone areas. Rehabilitation of the dam under either alternative would not change the hydrology of Hop Brook or the Assabet River except for protecting the downstream area from catastrophic flooding that could occur if the dam were to fail. There would be no long-term, cumulative effects from the rehabilitation project.

Future actions in the watershed not related to this project include continued changes to upstream and downstream land use as a result of residential, industrial, and commercial development. Rehabilitation of the Hop Brook Dam would not affect future development, but it would allow the dam to safely pass storm flows under build-out conditions.

CONTROVERSY

There are no known areas of controversy.

RISK AND UNCERTAINTY

The areas of risk and uncertainty associated with this project lie in the accuracy of predicting flood flows and flood elevations, estimating costs associated with each alternative, estimating property values and damage costs and benefits. The uncertainty of flood flows and water surface elevations has the potential for increased damages as development of residential and commercial property alters land use. It is possible that these uncertainties could lead to increased risk to human life in the event of a dam breach regardless of rehabilitation or no action. Hydrologic methods and computer modeling used in this analysis are consistent with the standards of practice at this time. The potential impacts for each alternative are estimated using techniques that relate potential damage to lost opportunity. However, these methods are in part based on professional judgment, and actual experiences could be different.

Uncertainties with the analysis of environmental impacts lie with the identification of wetland areas and wood turtle habitat and the risk of invasive species colonizing areas of revegetation. Trained wetland specialists identified wetland areas using standard, well-accepted protocols. The sponsors will be responsible for verifying wetlands and consulting with DEP as required

before construction. Native species will be used for planting to minimize introduction of invasive species, but introduction could occur from adjacent areas.

Within the context of this study, all alternatives were considered on a comparable basis. There does not appear to be any area that would have resulted in a different decision by using different procedures or conducting more intensive studies.

CONSULTATION AND PUBLIC PARTICIPATION

PROJECT SPONSORS

Local sponsoring organizations of the SuAsCo watershed plan and supplement no. 6 are Worcester County Conservation District, Middlesex Conservation District, DCR, and DFW.

PLANNING TEAM

An interdisciplinary planning team provided for the administration of this project through the NRCS nine-step planning process according to the procedures in the NRCS National Planning Procedures Handbook. Some of the tasks undertaken by the planning team include preliminary investigations, hydrologic and engineering analysis, economic analysis, formulation and evaluation of alternatives, and preparation of the Supplemental Plan/EA. The planning team included representatives of the NRCS Massachusetts state office, the NRCS National Water Management Center, DCR, and technical consultants under contract to NRCS.

The planning team toured the project site on November 28, 2007, and conducted an initial project planning meeting on November 29, 2007. Additional team meetings or conference calls were held in April, May, September, and November 2008.

PUBLIC PARTICIPATION

A public meeting was held in Northborough on November 20, 2008, to explain the Watershed Rehabilitation Program, obtain public input on the project, and scope resource problems, issues, and concerns of local residents associated with the Hop Brook Dam project area. The meeting was widely advertised to reach everyone in the watershed, including minorities. NRCS distributed a press release that resulted in an article about the meeting in the Worcester Telegram & Gazette on November 12, 2008, and a notice that ran on the Northborough cable TV community access channel for two weeks before the meeting.

Potential alternative solutions to bring the Hop Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Two members of the public attended the meeting; no verbal or written comments were received at the meeting or in the intervening time to the publishing of this Plan.

AGENCY CONSULTATION

Consultation under the Endangered Species Act was completed in August 2008 with a letter from FWS indicating that no federally listed threatened or endangered species or critical habitat are present in the project area. It was determined from MassGIS that habitat for a state-protected species lies in the Hop Brook floodplain. Subsequent consultation with Massachusetts NHESP in September 2008 indicated that a state-listed species of special concern, the wood turtle, has been found in the area. Consultation with NHESP is continuing; ultimately, DCR is responsible for completing the consultation and obtaining any permits that may be required.

A site visit was held with USACE and EPA to discuss the project and permit requirements.

Consultations with the Massachusetts State Historic Preservation Officer (SHPO) and Tribal Historic Preservation Officer(s) (THPOs) were conducted to determine the presence of any cultural or historic resources within the proposed project area. [Note: confirmed verbally; waiting for letter responses to be included in final plan.]

PROVISIONS OF THE PREFERRED ALTERNATIVE

PREFERRED ALTERNATIVE

Alternative 2 – Rehabilitation of the Hop Brook Dam is the preferred alternative. The auxiliary spillway would be modified to meet current safety standards for a high hazard dam and maintain the service life and flood prevention purpose of the dam for the original 100-year planning period. The rehabilitation will consist of (1) widening the auxiliary spillway from 340 to 610 feet to increase the capacity of the spillway and prevent overtopping of the dam during freeboard storm events and (2) armoring the spillway to safely pass the SDH and FBH discharge flows. Estimated construction cost is $1,464,000.

Table M compares structural data from the original as-built structure, the existing structure, and the planned rehabilitation.

Table M – Comparison of Structural Data

Hop Brook Floodwater Retarding Dam	Unit	As Built	Existing Conditions	Planned
Surface area (principal spillway crest)	acres	13	13	13
Surface area (auxiliary spillway crest)	acres	146	146	146
Elevation, top of dam (effective)	feet	313.0	313.0	313.0
Length of dam and Dike A	feet	1,150	1,150	1,150
Principal spillway	type	standard drop inlet	standard drop inlet	standard drop inlet
Elevation, principal spillway crest	feet	302.0	302.0	302.0
Pipe diameter, principal spillway	inches	36	36	36
Auxiliary spillway	type	grass-lined	grass-lined	armored

		channel	channel	with ACBs with sacrificial grass cover
Elevation, auxiliary spillway	feet	309.0	309.0	309.0
Bottom width, auxiliary spillway	feet	340	340	610
Storage, permanent pool	acre-feet	0	0	0
Storage, auxiliary spillway crest	acre-feet	1,340	1,340	1,340
Storage, maximum pool	acre-feet	1,928	1,928	1,928

RATIONALE FOR ALTERNATIVE PREFERENCE

Alternative plans were formulated as required by NRCS policy, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G) (U.S. Water Resources Council 1983), and the National Environmental Policy Act. According to P&G, an alternative that reasonably maximizes net national economic development benefits is to be formulated. This alternative is to be identified as the NED Plan. Alternative 2 is the NED Plan.

Alternative plans were formulated in consideration of the purposes of the project and concerns expressed during the public scoping process. Formulation of the alternative plans gave consideration to four criteria: completeness, effectiveness, efficiency, and acceptability. Alternatives 1 and 2 are the same project, with the only difference being the use of federal funds for a portion of project costs, and both alternatives meet all four of these criteria. Both alternatives maintain the present level of flood control benefits and comply with current performance and safety standards. Both alternatives produce the same monetary benefits, but the net average annual equivalent benefits between the Future with Federal Project (NED Alternative) and the Future without Federal Project (No Action Alternative) is $0.

PERMITS, COMPLIANCE, AND REQUIREMENTS PRIOR TO CONSTRUCTION

Potential Permits Needed

Permitting needs will be determined in final design. Federal and state permitting requirements may include: (1) NPDES general permit for construction, (2) USACE permit under Section 404 of the Clean Water Act of 1972, (3) Chapter 253 Permit to Construct or Alter a Dam, (4) Chapter 91 Waterways License, (5) Order of Conditions through the Massachusetts Wetlands Protection Act, (6) Section 401 Water Quality Certification, and (7) Massachusetts Endangered Species Act approval through Massachusetts Natural Heritage and Endangered Species Program. DCR is responsible for obtaining all permits.

Compliance with Local, State, and Federal Laws

The sponsors will comply with all applicable local, state, and federal laws in the installation of this project. Under the conditions of the NPDES general permit for construction, the sponsors or

their contractor will prepare a stormwater pollution and prevention plan, including an erosion and sediment control plan. In the event that cultural resources are discovered during project installation, construction will be halted in that area, and the resources will be evaluated in accordance with NRCS General Manual 420 part 401.

Mitigation

It is expected that most construction activities would be confined to the existing disturbed and cleared areas. Temporary wetland impacts may occur during the installation of the armoring system at the toe of the slope of the dam. Upland vegetation removal may also be required for storage/stockpile areas or for access along the toe of the dam embankments. Disturbed areas would be re-planted with native vegetation. Final design of the project will avoid the wetlands near the toe of the dam embankments to the extent possible. If wetlands cannot be avoided entirely, impacts would be minimized, and areas disturbed during construction would be re-graded to pre-construction contours and planted with native wetland species. No permanent wetland impacts are anticipated.

Operation, Maintenance, and Replacement

The project will be operated and maintained by the owner. A new Operation and Maintenance (O&M) Agreement will be developed for the remaining 54-year program life of the structure and signed by DCR before the Project Agreement is signed. O&M activities include but are not limited to inspection, maintenance, and repair of the principal spillway, dam, vegetation, and the auxiliary spillway. Based on data from DCR, it is estimated that O&M activities and replacement costs will total about $13,700 per year.

Project Agreement

DCR and NRCS will enter into a Project Agreement in accordance with the NRCS National Contract Grants and Agreement Manual before any work is initiated by either the owner or the NRCS.

Emergency Action Plan

DCR has prepared an EAP for the Hop Brook Dam for the case where the dam is compromised and/or likely to fail. The EAP identifies areas at risk and dam conditions that would initiate emergency notification procedures. It outlines appropriate actions in the event of a potential failure of the dam and designates the parties responsible for those actions. The owner will review and update the EAP annually, in consultation with local emergency response officials. NRCS, if requested, may provide technical assistance in updating the EAP.

COST, INSTALLATION, AND FINANCING

The construction associated with the project will be financed jointly by DCR and NRCS. NRCS will use funds appropriated for this purpose. The eligible project costs including construction, engineering, and project administration to be paid by DCR and NRCS are as follows:

	DCR	NRCS	Estimated Project Cost
Rehabilitation of Hop Brook Floodwater Retarding Dam	$548,700	$1,406,400	$1,955,100

NRCS costs will not exceed 100 percent of the construction cost or 65 percent of the total cost. An amount up to the percentage rate specified may be satisfied by DCR through the cost of engineering (permitting) and construction. Real property acquisition could also be used as a portion of DCR's cost-share, but is not expected to be required for this project. The decision on specific DCR-funded components will be negotiated between DCR and NRCS and will be included in the Project Agreement executed before implementation.

NRCS is responsible for the engineering services and project administration costs it incurs. These costs are not used in the calculation of the federal cost share, but they are included in the Estimated Construction Cost (Table 1, Appendix A). Also, costs of federal, state, and local permits are the responsibility of DCR and are not counted toward the local cost share. See Table 2 in Appendix A for a complete description of the total rehabilitation costs.

The furnishing of financial and other assistance by NRCS is contingent on the continuing availability of appropriations by Congress from which payment may be made and shall not obligate NRCS if Congress fails to so appropriate.

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LIST OF PREPARERS

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Michael Misslin, P. E. Deputy Chief Engineer	BS, Civil Engineering	30
Massachusetts Office of Dam Safety		
William Salomaa, P. E. Director Office of Dam Safety	BS, Civil Engineering	20
EA Engineering, Science, and Technology		
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H&S Environmental		
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INDEX

APPENDIX A

ECONOMIC AND STRUCTURAL TABLES

Table 1 – Estimated Installation Cost
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Installation Cost Item	Estimated Cost[2/]		
	PL 83-566 Funds	Other Funds	Total
Structural measures to rehabilitate Hop Brook Floodwater Retarding Dam	$1,406,400	$548,700	$1,955,100
Total Project	**$1,406,400**	**$548,700**	**$1,955,100**

[1/] Price base: 2009 May 2009

[2/] "PL 83-566 Funds" include NRCS Engineering and Project Administration ($432,000), and "Other Funds" include sponsors' Engineering (permitting) ($24,000), neither of which are included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1,499,100.

Table 2 – Estimated Cost Distribution – Structural and Nonstructural Measures
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars) [1/]

	Installation Cost – PL 83-566 Funds [2/]				**Installation Cost – Other Funds**				**Total Installation Cost**
	Construction	Engineering	Project Administration	Total PL 83-566	Construction	Permitting	Project Administration	Total Other	
Structural measures: Hop Brook Floodwater Retarding Dam	$974,400	$333,000	$99,000	$1,406,400	$489,700	$24,000	$35,000	$548,700	$1,955,100
Nonstructural measures	$0	$0	$0	$0	$0	$0	$0	$0	$0
Grand total	$974,400	$333,000	$99,000	$1,406,400	$489,700	$24,000	$35,000	$548,700	$1,955,100

[1/] Price base: 2009 May 2009

[2/] Federal Engineering and Project Administration costs and sponsors' Engineering (permitting) costs ($456,000) are not included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1,499,100.

Table 3 – Structural Data – Dams with Planned Storage Capacity
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts

Item	Unit	Hop Brook Dam
Class of structure		C
Seismic zone		2
Total drainage area	mi^2	4.91
Runoff curve number (1-day) (AMC II)		73 existing development 78 ultimate build-out
Time of concentration (T_c)	hr	3.97
Elevation top dam	ft	313
Elevation crest auxiliary spillway	ft	309
Elevation crest principal spillway	ft	302
Elevation sediment pool	ft	296
Auxiliary spillway type		armored with articulated concrete blocks covered by sacrificial soil/grass layer
Auxiliary spillway bottom width	ft	610
Auxiliary spillway exit slope		5H:1V
Maximum height of dam	ft	23
Volume of fill (rehabilitation)	yd^3	0[1/]
Total capacity (auxiliary spillway crest)	ac-ft	1,340
Sediment pool aerated	ac-ft	22
Floodwater retarding	ac-ft	1,318
Surface area		
Sediment pool	acre	13
Floodwater retarding pool	acre	146
Principal spillway		
Rainfall volume (1-day)	in	6.5
Rainfall volume (10-day)	in	13.0
Runoff volume (10-day)	in	8
Capacity	ft^3/s	228
Diameter of conduit	in	36
Type of conduit		standard drop inlet; reinforced concrete
Frequency of operation—aux. spillway[2/]	% chance	less than 1
Auxiliary spillway hydrograph[3/]		
Rainfall volume	in	9.98
Runoff volume	in	0.60
Storm duration	hr	6
Velocity of flow (V_e)	ft/s	9.8
Max. reservoir water surface elevation	ft	310.4

Item	Unit	Hop Brook Dam
Freeboard hydrograph[3/]		
Rainfall volume	in	25
Runoff volume	in	1.83
Storm duration	hr	6
Max. reservoir water surface elevation	ft	313.0
Capacity equivalents		
Sediment volume	in	0.1
Floodwater retarding volume	in	5.1

May 2009

[1/] Approximately 2,600 cubic yards of fill will be removed from the existing dam for widening the auxiliary spillway; original volume of fill was 83,500 cubic yards.

[2/] The frequency of use is based on the 24-hour duration, Type III distribution storm event.

[3/] SDH is based on the 6-hr storm; the FBH is based on the most critical condition from the 6-hr and 24-hr storms.

Table 4 – Estimated Average Annual NED Costs
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Project Outlays		Total
	Amortization of Installation Cost [2/]	Operation, Maintenance and Replacement Cost [3/]	
Hop Brook Floodwater Retarding Dam	$98,600	$13,700	$112,300
Grand Total	$98,600	$13,700	$112,300

[1/] Price base 2009 May 2009
[2/] Amortized over 55 years at 4.625%
[3/] Includes O&M of $10,000 and replacement cost of $3,700

Table 5 – Estimated Average Annual Flood Damage Reduction Benefits
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Item	Estimated Average Annual Damage		Damage Reduction Benefit[3/]
	Without Project[2/]	With Project[2/]	
Floodwater			
Crop and Pasture	$0	$0	$0
Other Agricultural	$0	$0	$0
Nonagricultural (Road and Bridge)	$2,100	$2,100	$0
Nonagricultural (Urban)	$212,900	$212,900	$0
Subtotal	$215,000	$215,000	$0
Sediment			
Overbank Deposition	$0	$0	$0
Erosion			
Floodplain Scour	$0	$0	$0
Grand Total	**$215,000**	**$215,000**	**$0**

[1/] Price Base: 2009 May 2009
[2/] Original downstream damages updated using the Consumer Price Index for Nonagricultural (Roads and Bridges) and average tax receipt increases for Nonagricultural (Urban).
[3/] Damage reduction benefits resulting from the recommended plan equal zero as compared to the No Action (future without project) Alternative because they are the same in scope, cost, and effects, and therefore yield equivalent benefits. Positive benefits will accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allow for the abbreviated procedures.

Table 6 – Comparison of NED Benefits and Costs
Hop Brook Floodwater Retarding Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Benefits				
	Average Annual Benefits		Average Annual Benefits	Average Annual Cost[3/]	Benefit/Cost Ratio
	Agriculture-related[2/]	Nonagricultrue[3/]			
Hop Brook Floodwater Retarding Dam	$0	$112,300	$112,300	$112,300	1.0:1.0
Total	**$0**	**$**112,300	**$**112,300	**$**112,300	**1.0:1.0**

[1/] Price Base: 2009 May 2009
[2/] From Table 5
[3/] From Table 4. The costs and the benefits for the future with project plan are the same as those for the future without project plan. To maintain consistency with the display in Table 4, the costs associated with the No Action Alternative (Future Without Project) are tracked as a benefit of the preferred alternative. Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative is displayed within a zero-based accounting context that credits local costs avoided as "other" benefits consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

APPENDIX B

COMMENTS RECEIVED DURING INTERAGENCY REVIEW OF THE SUPPLEMENTAL WATERSHED PLAN AND ENVIRONMENTAL ASSESSMENT

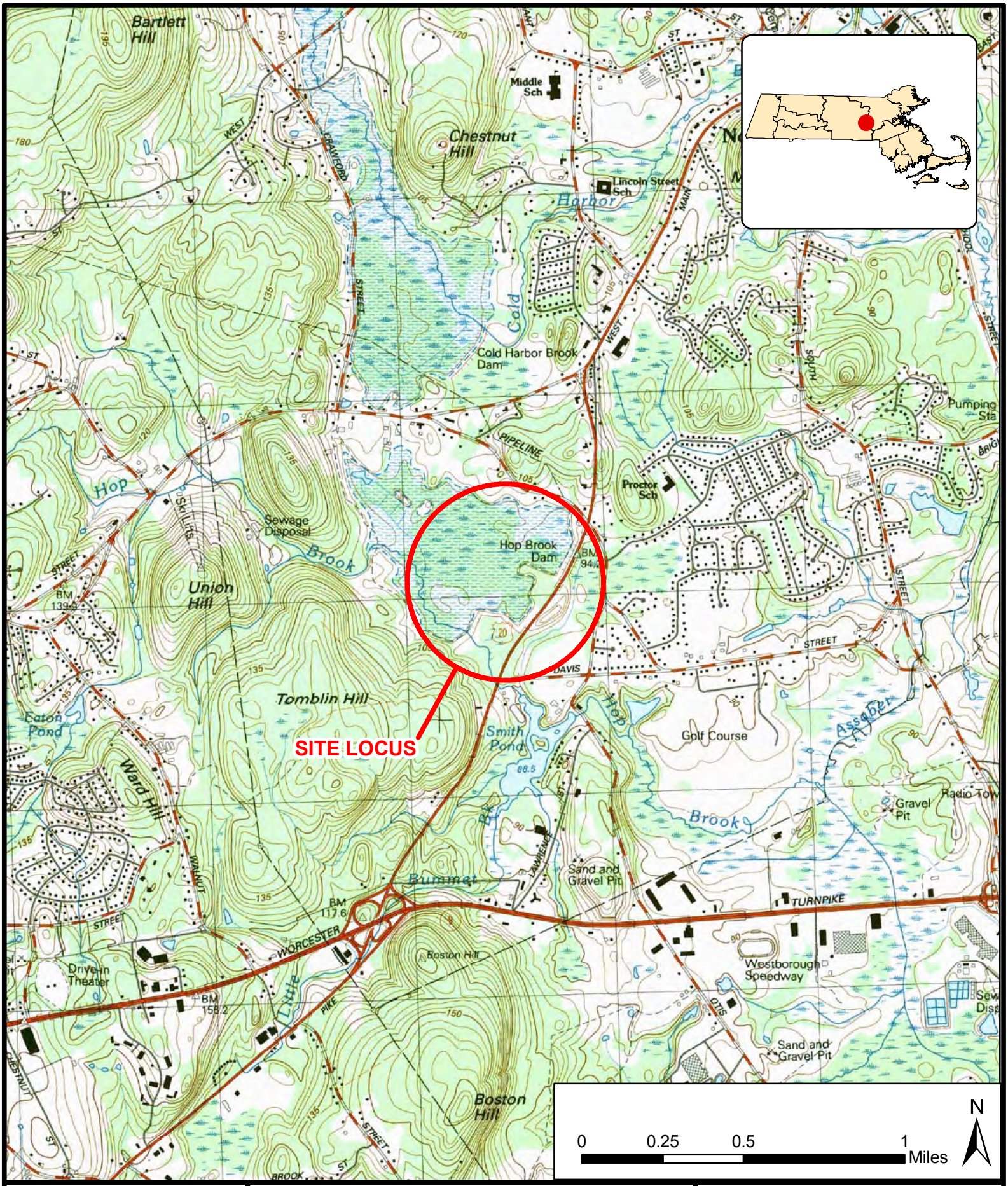
Discussion and Disposition of Comments from letters received on the Draft Supplemental Watershed Plan and Environmental Assessment

Comment:

Response:

APPENDIX C

SUPPORT MAPS

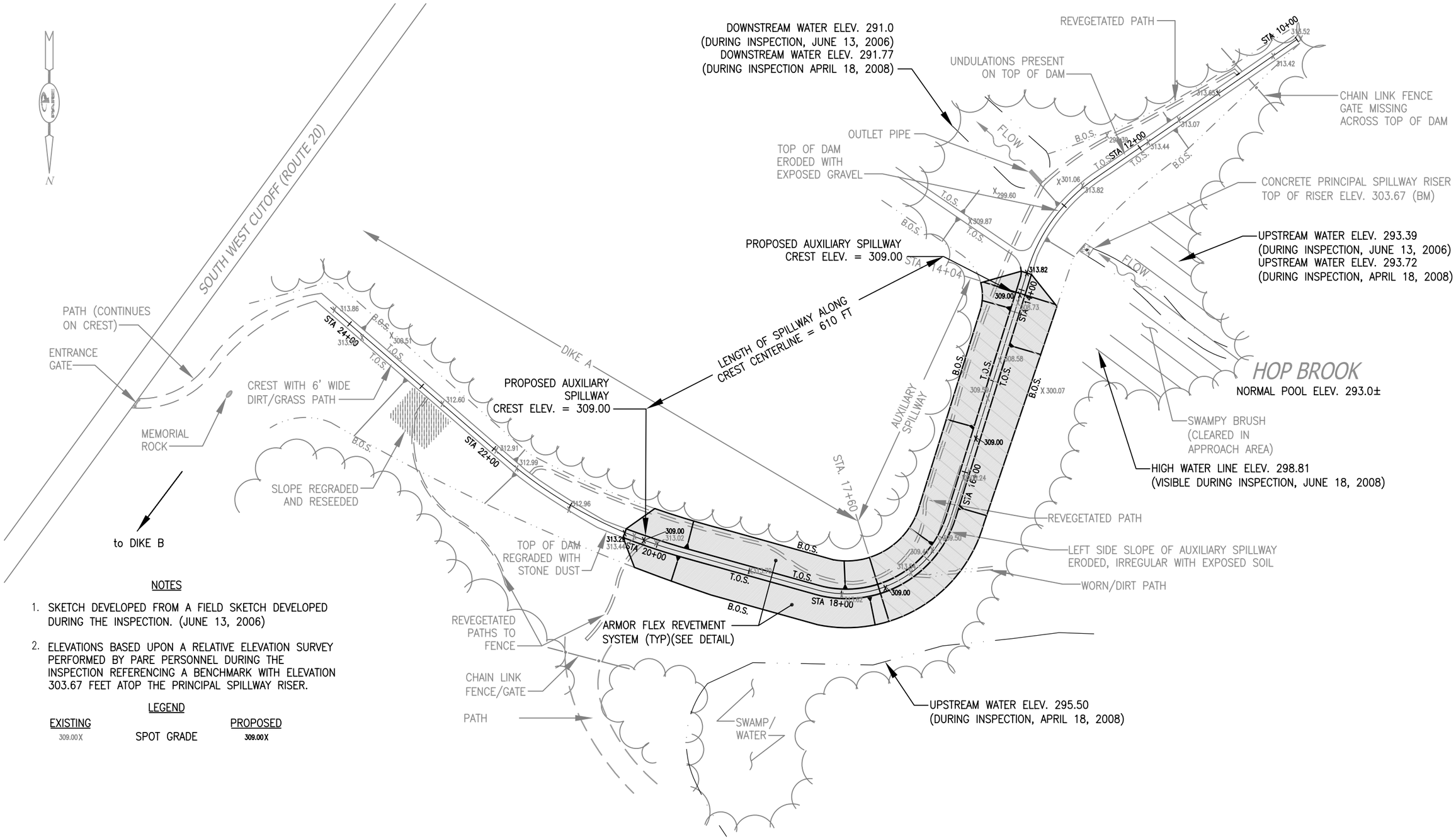


NRCS

VICINITY MAP
HOP BROOK DAM
NORTHBOROUGH, MASSACHUSETTS

FIGURE 1
VICINITY MAP

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE:
JE	PT	PT	JE	AS SHOWN	APRIL 2009	62028.23	VICINITY_MAP.MXD



NOTES

1. SKETCH DEVELOPED FROM A FIELD SKETCH DEVELOPED DURING THE INSPECTION. (JUNE 13, 2006)
2. ELEVATIONS BASED UPON A RELATIVE ELEVATION SURVEY PERFORMED BY PARE PERSONNEL DURING THE INSPECTION REFERENCING A BENCHMARK WITH ELEVATION 303.67 FEET ATOP THE PRINCIPAL SPILLWAY RISER.

LEGEND

EXISTING		PROPOSED
309.00 X	SPOT GRADE	309.00 X

REVISIONS				REVISIONS			
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION

HOP BROOK DAM AND DIKE A

MA 00998 / 3-14-215-24
NORTHBOROUGH, MASSACHUSETTS

MASSACHUSETTS DEPARTMENT OF CONSERVATION AND RECREATION

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

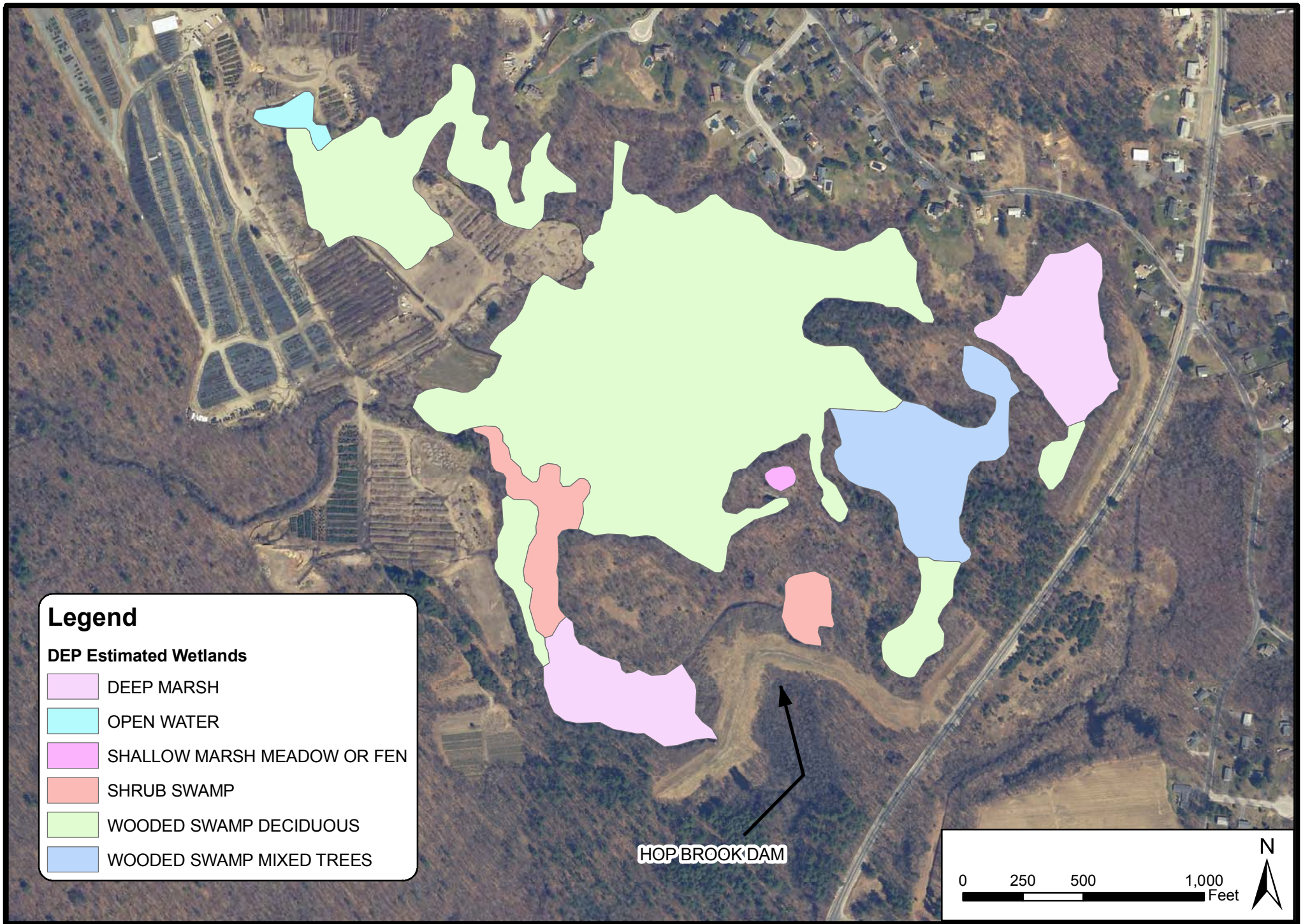
PARE CORPORATION
ENGINEERS ▪SCIENTISTS ▪ PLANNERS
10 LINCOLN ROAD, SUITE 103
FOXBORO, MA 02035
508-543-1755

Figure 2. Project Schematic

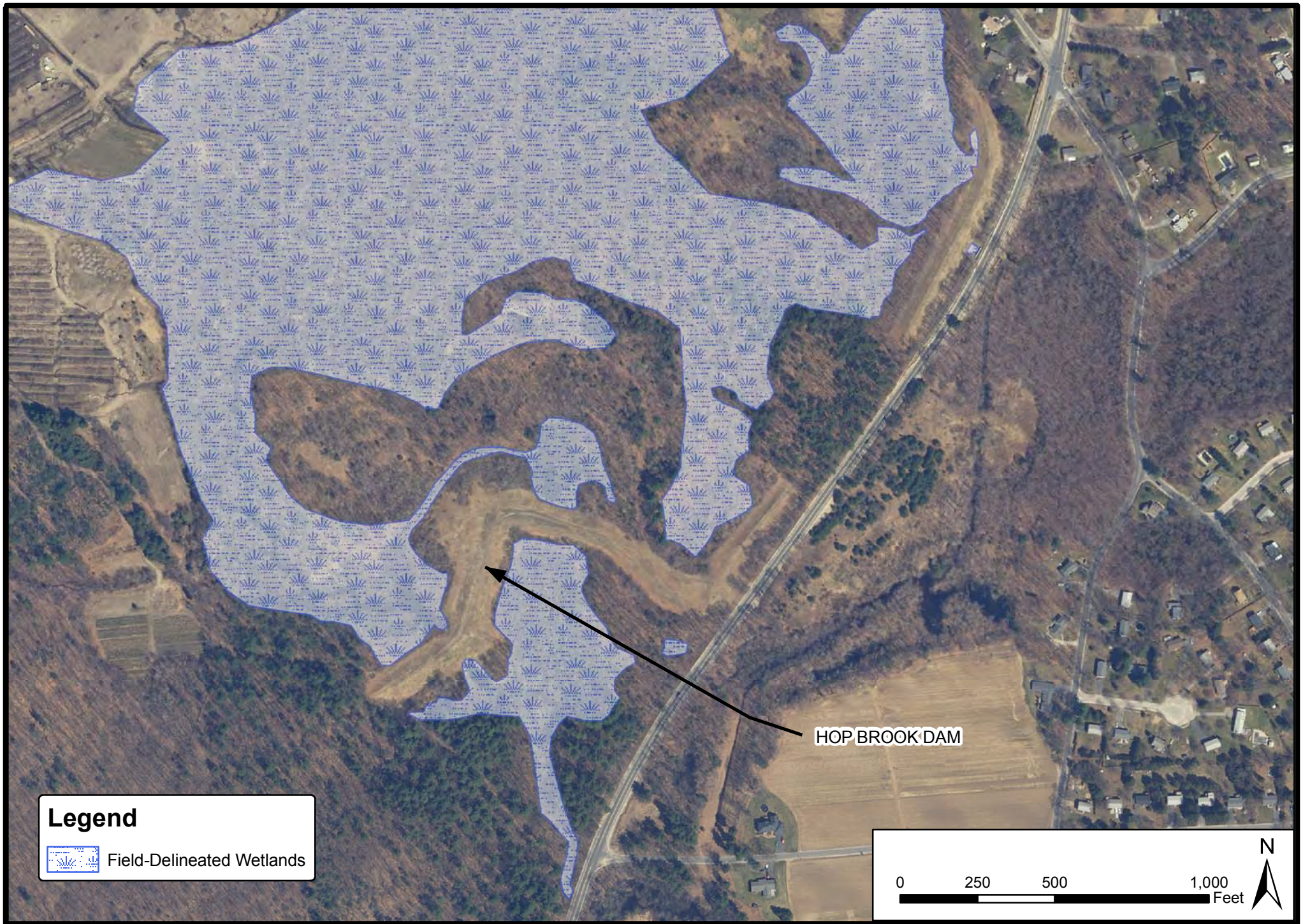
DESIGNED BY:	DATE:	DRAWN BY:	DATE:	CHECKED BY:	DATE:
		TGP	AUG 2008	JMB	AUG 2008

SCALE: 1" = 100'±
PROJ. NO. 08147.00
FIGURE NO.

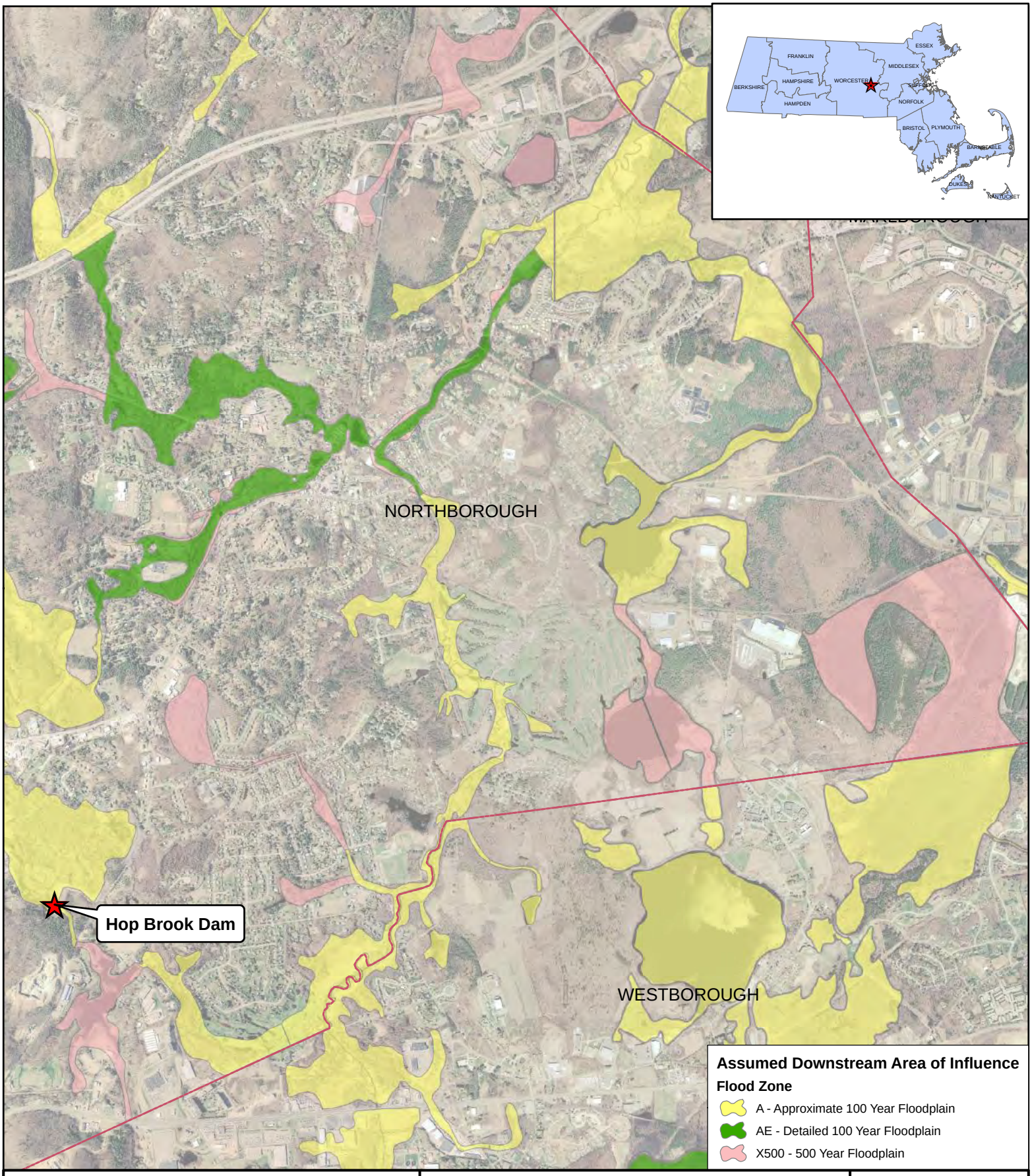
NRCS	WOOD TURTLE HABITAT HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 3 WOOD TURTLE HABITAT
		JE	MR	PT	JE	AS SHOWN	APRIL 2009	62028.23	



NRCS	DEP ESTIMATED WETLANDS HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 4 DEP ESTIMATED WETLANDS
		JE	MR	MR	JE	AS SHOWN	APRIL 2009	62028.23	



NRCS	FIELD-DELINEATED WETLANDS HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 5 FIELD-DELINEATED WETLANDS
		JE	MR	MR	JE	AS SHOWN	APRIL 2009	62028.23	



BGI

ENSR INTERNATIONAL

0 1,375 2,750 5,500 Feet

1 inch equals 2,750 feet

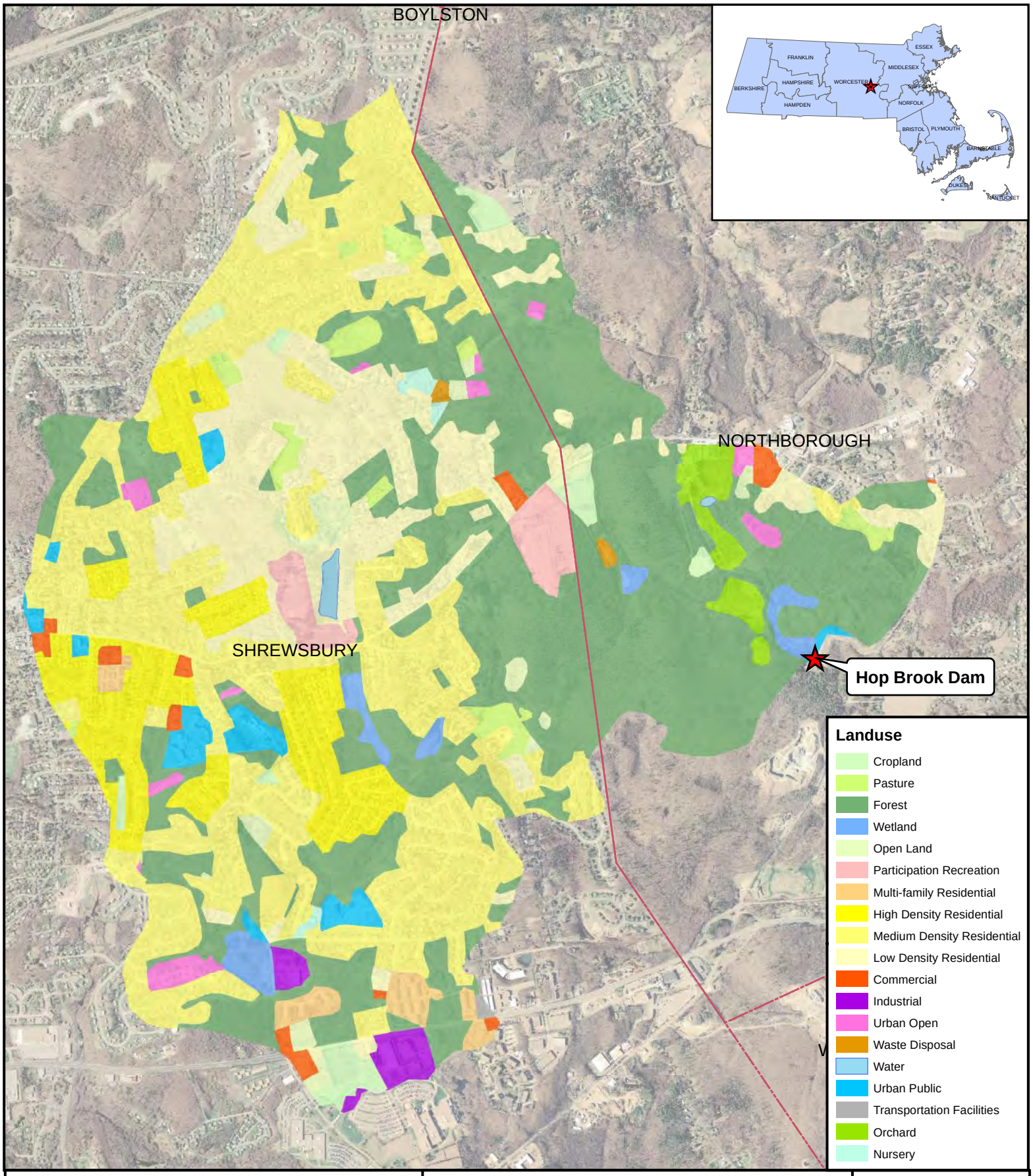
N W E S

Hop Brook Dam
Downstream Floodplain Area
Natural Resources Conservation Service
Northborough and Westborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Zones A, AE, X500 downstream of dam, from FEMA Q3 data layer

FIGURE

6



BGI

ENSR INTERNATIONAL

0 2,125 4,250 Feet

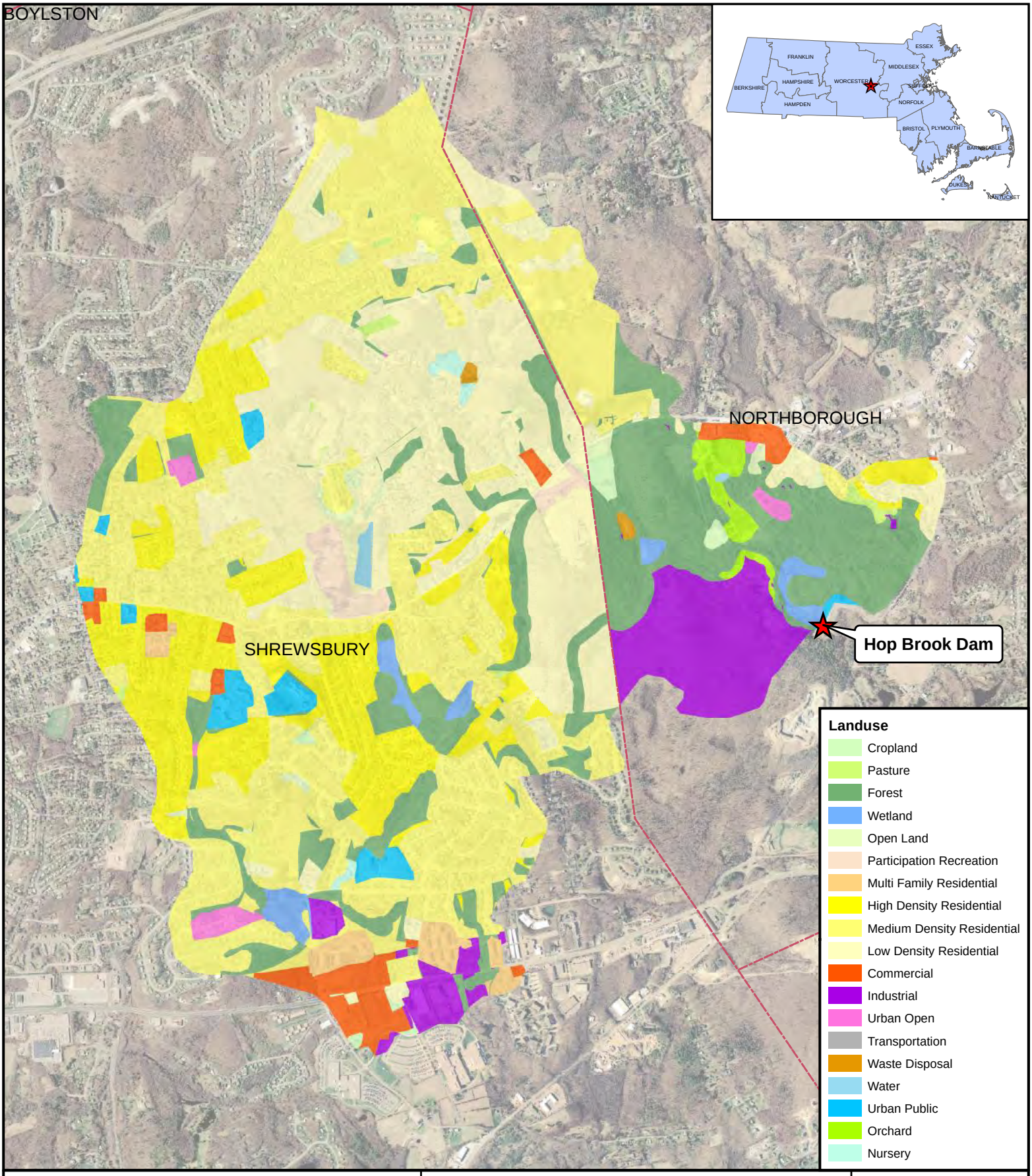
N W E S

1 inch equals 2,125 feet

Hop Brook Dam
Current Conditions Landuse
Natural Resources Convservation Service
Northborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Watershed Landuse taken from MassGIS landuse data layer

FIGURE
7



BGI

ENSR INTERNATIONAL

0 1,125 2,250 4,500 Feet

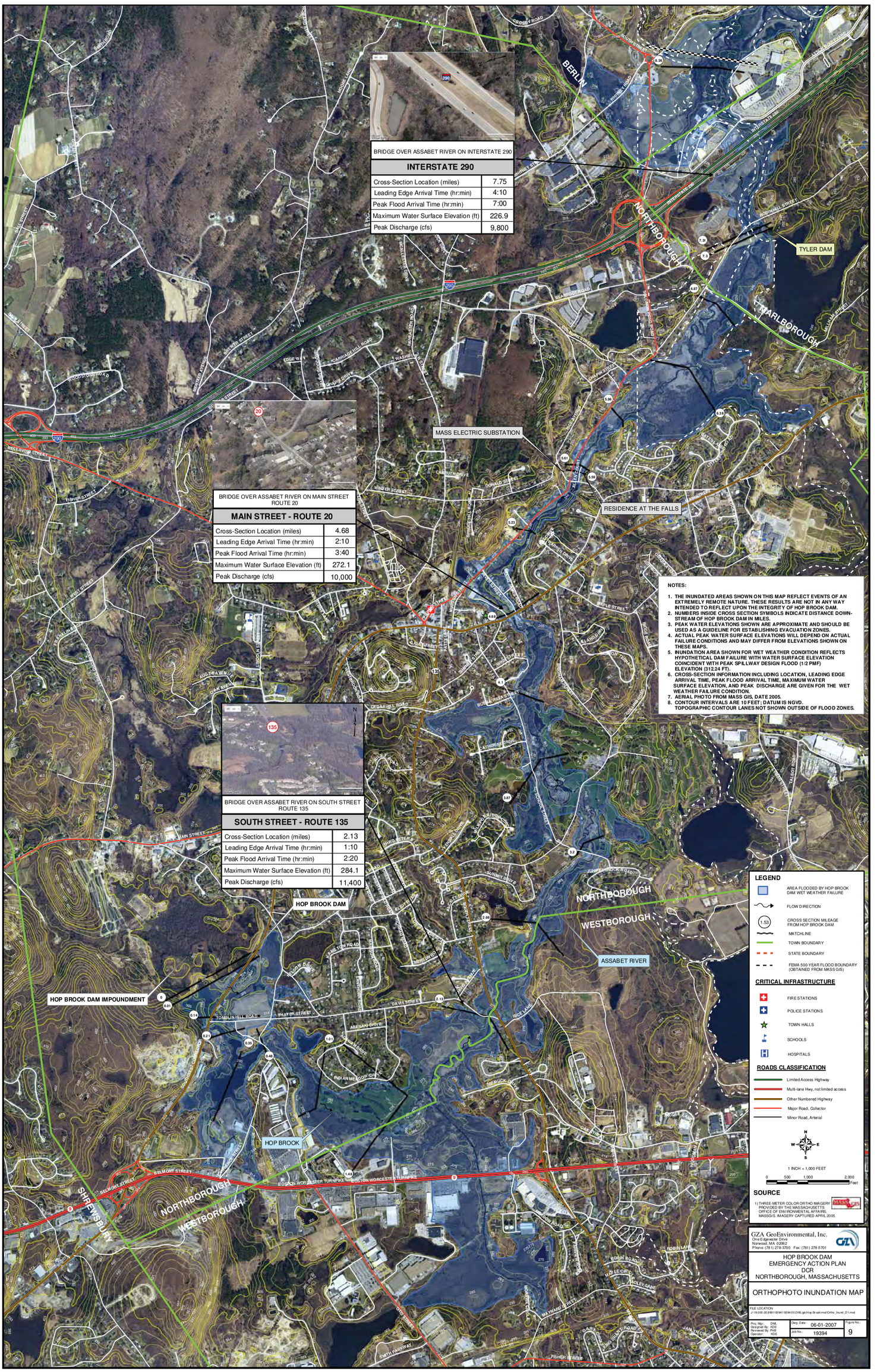
1 inch equals 2,250 feet

N W E S

Hop Brook Dam
Ultimate Buildout Conditions Landuse
Natural Resources Conservation Service
Northborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Watershed Landuse modified from MassGIS landuse data layer and EOEA landuse data layer

FIGURE
8


BRIDGE OVER ASSABET RIVER ON INTERSTATE 290
INTERSTATE 290
Cross-Section Location (miles) 7.75
Leading Edge Arrival Time (hr:min) 4:10
Peak Flood Arrival Time (hr:min) 7:00
Maximum Water Surface Elevation (ft) 226.9
Peak Discharge (cfs) 9,800
BRIDGE OVER ASSABET RIVER ON MAIN STREET ROUTE 20
MAIN STREET - ROUTE 20
Cross-Section Location (miles) 4.68
Leading Edge Arrival Time (hr:min) 2:10
Peak Flood Arrival Time (hr:min) 3:40
Maximum Water Surface Elevation (ft) 272.1
Peak Discharge (cfs) 10,000
BRIDGE OVER ASSABET RIVER ON SOUTH STREET ROUTE 135
SOUTH STREET - ROUTE 135
Cross-Section Location (miles) 2.13
Leading Edge Arrival Time (hr:min) 1:10
Peak Flood Arrival Time (hr:min) 2:20
Maximum Water Surface Elevation (ft) 284.1
Peak Discharge (cfs) 11,400
NOTES:
1. THE INUNDATED AREAS SHOWN ON THIS MAP REFLECT EVENTS OF AN EXTREMELY REMOTE NATURE. THESE RESULTS ARE NOT IN ANY WAY INTENDED TO REFLECT UPON THE INTEGRITY OF HOP BROOK DAM.
2. NUMBERS INSIDE CROSS SECTION SYMBOLS INDICATE DISTANCE DOWNSTREAM OF HOP BROOK DAM IN MILES.
3. PEAK WATER ELEVATIONS SHOWN ARE APPROXIMATE AND SHOULD BE USED AS A GUIDELINE FOR ESTABLISHING EVACUATION ZONES.
4. ACTUAL PEAK WATER SURFACE ELEVATIONS WILL DEPEND ON ACTUAL FAILURE CONDITIONS AND MAY DIFFER FROM ELEVATIONS SHOWN ON THESE MAPS.
5. INUNDATION AREA SHOWN FOR WET WEATHER CONDITION REFLECTS HYPOTHETICAL DAM FAILURE WITH WATER SURFACE ELEVATION COINCIDENT WITH PEAK SPILLWAY DESIGN FLOOD (1/2 PMF) ELEVATION (312.24 FT).
6. CROSS-SECTION INFORMATION INCLUDING LOCATION, LEADING EDGE ARRIVAL TIME, PEAK FLOOD ARRIVAL TIME, MAXIMUM WATER SURFACE ELEVATION, AND PEAK DISCHARGE ARE GIVEN FOR THE WET WEATHER FAILURE CONDITION.
7. AERIAL PHOTO FROM MASS GIS, DATE 2005.
8. CONTOUR INTERVALS ARE 10 FEET; DATUM IS NGVD. TOPOGRAPHIC CONTOUR LANES NOT SHOWN OUTSIDE OF FLOOD ZONES.
LEGEND
AREA FLOODED BY HOP BROOK DAM WET WEATHER FAILURE
FLOW DIRECTION
CROSS SECTION MILEAGE FROM HOP BROOK DAM
MATCHLINE
TOWN BOUNDARY
STATE BOUNDARY
FEMA 500-YEAR FLOOD BOUNDARY (OBTAINED FROM MASS GIS)
CRITICAL INFRASTRUCTURE
FIRE STATIONS
POLICE STATIONS
TOWN HALLS
SCHOOLS
HOSPITALS
ROADS CLASSIFICATION
Limited Access Highway
Multi-lane Hwy, not limited access
Other Numbered Highway
Major Road, Collector
Minor Road, Arterial
1 INCH = 1,000 FEET
0 500 1,000 2,000 Feet
SOURCE
1) THREE-METER COLOR ORTHO IMAGERY PROVIDED BY THE MASSACHUSETTS OFFICE OF ENVIRONMENTAL AFFAIRS, MASSGIS. IMAGERY CAPTURED APRIL 2005.
MASS GIS
GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, MA 02062
Phone: (781) 278-3700 Fax: (781) 278-5701
HOP BROOK DAM
EMERGENCY ACTION PLAN
DCR
NORTHBOROUGH, MASSACHUSETTS
ORTHOPHOTO INUNDATION MAP
FILE LOCATION
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Proj. Mgr: DIA
Designed By: KDS
Reviewed By: PHS
Operator: KDS
Dwg. Date: 06-01-2007
Job No.: 19394
Figure No.: 9
HOP BROOK DAM IMPOUNDMENT
HOP BROOK DAM
HOP BROOK
ASSABET RIVER
TYLER DAM
MASS ELECTRIC SUBSTATION
RESIDENCE AT THE FALLS
NORTHBOROUGH
WESTBOROUGH
MARLBOROUGH
BERLIN
BOSTON WORCESTER TURNPIKE
MASSACHUSETTS TURNPIKE

LEGEND

- AREA FLOODED BY HOP BROOK DAM WET WEATHER FAILURE
- FLOW DIRECTION
- CROSS SECTION MILEAGE FROM HOP BROOK DAM (e.g. 1.53)
- MATCHLINE
- TOWN BOUNDARY
- STATE BOUNDARY
- FEMA 500-YEAR FLOOD BOUNDARY (OBTAINED FROM MASS GIS)

CRITICAL INFRASTRUCTURE

- FIRE STATIONS
- POLICE STATIONS
- TOWN HALLS
- SCHOOLS
- HOSPITALS

ROADS CLASSIFICATION

- Limited Access Highway
- Multi-lane Hwy, not limited access
- Other Numbered Highway
- Major Road, Collector
- Minor Road, Arterial

N W E S

1 INCH = 1,000 FEET

0 500 1,000 2,000 Feet

SOURCE

1) THREE-METER COLOR ORTHO IMAGERY PROVIDED BY THE MASSACHUSETTS OFFICE OF ENVIRONMENTAL AFFAIRS, MASSGIS. IMAGERY CAPTURED APRIL 2005.

GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, MA 02062
Phone: (781) 278-3700 Fax: (781) 278-5701

HOP BROOK DAM
EMERGENCY ACTION PLAN
DCR
NORTHBOROUGH, MASSACHUSETTS

ORTHOPHOTO INUNDATION MAP

FILE LOCATION:
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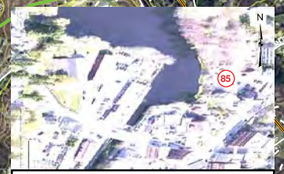
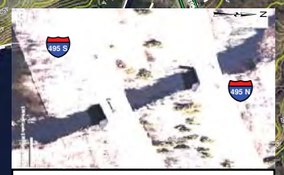
Proj. Mgr.: DML	Designed By: KDE	Reviewed By: PHB	Operator: KDE	Org. Date: 06-01-2007	Job No.: 19394	Figure No.: 10



BRIDGE OVER ASSABET RIVER ON WASHINGTON STREET- ROUTE 85

WASHINGTON STREET- ROUTE 85	
Cross-Section Location (miles)	12.69
Leading Edge Arrival Time (hr:min)	6:20
Peak Flood Arrival Time (hr:min)	6:20
Maximum Water Surface Elevation (ft)	225.0
Peak Discharge (cfs)	14,400

WASHINGTON STREET DAM



BRIDGE OVER ASSABET RIVER ON INTERSTATE 495

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Cross-Section Location (miles)	10.27
Leading Edge Arrival Time (hr:min)	5:20
Peak Flood Arrival Time (hr:min)	6:45
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BERLIN
HUDSON
MARLBOROUGH
STOW
NORTHBOROUGH

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Proj. Mgr.: DML	Dwg. Date: 06-01-2007	Figure No.
Designed By: KDE	Job No.: 19394	11
Reviewed By: PHB		
Operator: KDE		

APPROXIMATE LIMIT OF IMPACT DUE TO DAM BREAK FLOOD WAVE. MAXIMUM WATER SURFACE ELEVATION IS WITHIN TWO FEET OF THE FEMA 500-YEAR FLOOD ELEVATION.

BRIDGE OVER ASSABET RIVER ON GREAT ROAD ROUTE 117

GREAT ROAD- ROUTE 117	
Cross-Section Location (miles)	21.67
Leading Edge Arrival Time (hr:min)	9:30
Peak Flood Arrival Time (hr:min)	14:50
Maximum Water Surface Elevation (ft)	175.2
Peak Discharge (cfs)	11,800

APPENDIX D

INVESTIGATION AND ANALYSIS

Environmental: Initial assessment of potential environmental impacts was based on review of natural resources information in MassGIS and consultations with U.S. Fish and Wildlife Service and Massachusetts Natural Heritage and Endangered Species Program. Sensitive features in the project area were identified as Hop Brook, wetlands in the Hop Brook floodplain, and wood turtle habitat. There are no federally protected threatened or endangered species in the project area.

A field survey was conducted by EA Engineering, Science, and Technology to delineate wetlands along the upstream and downstream sides of the dam and to evaluate habitat suitability for wood turtles in the potential construction area. Based on these surveys and the conceptual project design, construction for dam rehabilitation will occur within the existing area disturbed for construction of the dam and maintained as mowed grass, and there will be no impacts to sensitive resources.

Water quality of Hop Brook may be affected by temporary construction-related disturbance resulting in erosion and sedimentation. Compliance with state laws, application of BMPs, and revegetation of the disturbed area would minimize impacts. Construction activity would also result in minor impacts affecting the aesthetics of the area as vegetation is removed and machinery is in place and active. At the completion of construction, equipment would be removed and the disturbed area would be revegetated.

A walking survey of the Hop Brook flood storage area confirmed that there is minimal sediment accumulation from the past 45 years. Previous minor accumulations at the principal spillway have been removed by DCR during routine maintenance.

There are no historic sites on the dam property, and no archeological sites would be affected by construction, which would be limited to the existing disturbed area. The Massachusetts SHPO and the THPOs concurred with a determination of no effect on historic resources. [Note: confirmed verbally; waiting for letter responses to be included in final plan.]

The following table displays the effects of the recommended plan on particular types of resources that are recognized by certain Federal policies.

Effects of the Recommended Plan on Resources of National Recognition		
Types of Resources	**Principal Sources of National Recognition**	**Measurement of Effects**
Air quality	Clean Air Act, as amended (42 USC 7401 et seq.)	No long-term effect; temporary emissions during construction
Areas of particular concern within the coastal zone	Coastal Zone Management Act of 1972, as amended (16 USC 1451 et. seq.)	Not applicable--project area not in coastal zone.
Endangered and threatened species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.)	No effect—no federally protected species in project area
Fish and wildlife habitat	Fish and Wildlife Coordination Act (16 USC Sec. 661 et seq.)	No effect—project will not involve work in stream/river.
Floodplains	Executive Order 11988, Flood Plain Management	No long-term effect; temporary construction in floodplain.
Historical and cultural properties	National Historic Preservation Act of 1966, as amended (16 USC Sec. 470 et seq.)	No effect—no historic resources present in project area
Prime and unique farmland	Council on Environmental Quality Memorandum of August 1, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act, Farmland Protection Policy Act of 1981.	No effect—construction only within existing dam mowed area
Water quality	Clean Water Act of 1977 (33 USC 1251 et seq.)	No long-term effect; temporary impact during construction mitigated by erosion and sediment control BMPs
Wetlands	Executive Order 11990, Protection of Wetlands; Clean Water Act of 1977 (33 USC 1251 et seq.) Food Security Act of 1985	No long-term effect; possible temporary impact during construction; area returned to existing condition after construction
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq.)	Not present in project area

Breach Analysis: A breach analysis was conducted by GZA GeoEnvironmental, Inc. to estimate the inundation areas and corresponding time to flooding downstream as a result of failure of the Hop Brook Dam (GZA 2008). A National Weather Service computer model (DAMBRK, Version 3.0) was used to predict the hypothetical dam break wave formation at Hop Brook Dam and downstream progression along Hop Brook and the Assabet River. The model used input from riverine geometry in the form of cross sections to simulate the response of a flood wave traveling downstream and produced data on peak flow, maximum water surface elevations,

arrival time of the leading edge and maximum flood stage to identify key damage centers and other areas inundated by the flood wave. The model also computed the outflow from the breached dam in conjunction with breach characteristics (size and shape of the breach opening over time, including spillway characteristics) and estimated the time and extent of flooding downstream.

Because the normal pool elevation (292 feet) corresponds to an empty impoundment at Hop Brook, a fair weather scenario was not evaluated. The wet weather scenario was based on the hydrologic and hydraulic analysis. The spillway design flood (SDF) for the dam based on the current size (Large) and hazard classification (High) is the 1/2 probable maximum flood (PMF). The wet weather scenario used a SDF outflow of 5,600 cfs and a water surface elevation set a peak SDF reservoir elevation of 0.8 feet below the top of the dam at the time of dam failure based on the previous hydrologic and hydraulic analysis.

A detailed river model for the areas downstream of the dam used information gathered from MassGIS topographic data. Cross section locations were selected to approximate natural and man-made changes in the geometry of the downstream river valley and were spaced closer together in portions of the valley where changes in bed slope and flow regime occurred and where side slopes alternated from narrow and constricted to wide flood plains. Manning's 'n' roughness coefficients necessary for modeling were 0.04 for the channel areas and 0.08 for the overbank areas, which are consistent with the range of values use in the Federal Emergency Management Agency (FEMA) Flood Insurance Studies for the Town of Northborough and downstream communities.

The riverine portion of the Hop Brook DAMBRK model was calibrated to the published FEMA 100-year flood. Water surface elevations and discharges for the 100-year flood were obtained from the FEMA studies for the Towns of Northborough, Westborough, Berlin, Stow, Hudson and Maynard. Water depths were calibrated to the 100-year flood by adjusting Manning's n coefficient values, streambed invert elevations, and cross section geometries. Hypothetical dam breach parameters were estimated in accordance with the recommended range of values in Federal Energy Regulatory Commission guidelines. The maximum average breach width selections were based on U.S. Army Corps of Engineers guidelines with the hypothetical failure occurring at the deepest section. The average breach width chosen for the dam was a typical value for earthen dams (3 times the hydraulic height) and a corresponding time to failure of approximately 0.5 hours. The average breach width for the dam was estimated to be 69 feet.

The downstream limit of the model was the Assabet River approximately 24 miles downstream of the dam and was based on prior analysis which determined that the flood wave is not expected to propagate beyond that point. Two other downstream dams on the Assabet River, Tyler Dam and Washington Street Dam, were included in the model.

The results of wet weather scenario modeling determined that the maximum discharge through the Hop Brook Dam breach opening is approximately 19,500 cfs and occurs 0.5 hours from the beginning of the simulation. The peak dam flow is expected to be an order of magnitude greater than the 100-year flood for the Assabet River within the Town of Northborough. The arrival time of the leading edge along the 1.5 miles of Hop Brook varies from 20 minutes to

approximately 45 minutes. The arrival time of the leading edge along the Assabet River varies from approximately 45 minutes to 12 hours. Peak flood depth over initial conditions ranges from about 4 feet immediately downstream of the dam to about 1 foot downstream of Tyler Dam and approximately 2.5 feet downstream of Washington Street Dam. Inundation maps presenting the results of the DAMBRK modeling are located in Appendix C, Figures 9-11.

Hydrology: NRCS prepared an assessment report on the Hop Brook Floodwater Retarding Dam in 2005, based on a dam assessment study by the Bhatti Group. The Bhatti Group completed a comprehensive study of the hydrologic conditions of the Hop Brook Dam for existing and future watershed build-out conditions. The study evaluated the hydrological parameters of the Hop Brook watershed using NRCS and TR-55 methods, with NRCS runoff curve numbers for existing and future build-out conditions of 73 and 78, respectively, and a time of concentration of approximately 4 hours.

Using the SITES model, Hop Brook was evaluated against TR-60 criteria and was determined to be a Class (C) structure in accordance with federal standards and a Class I (High) hazard potential structure in accordance with Massachusetts standards. The Principal Spillway Storm was the 100-year frequency with 1-day and 10-day storm durations. The Auxiliary Spillway Design Storm used a precipitation amount greater than the 100-year event and less than the Probable Maximum Precipitation (PMP) and a 6-hour design storm for developing the Auxiliary Spillway Hydrograph. The 2005 Dam Assessment Report indicated that the Hop Brook Flood Control Structure does not meet TR-60 design criteria for the freeboard and auxiliary spillway design under existing or the future build-out conditions. In general, the spillway is undersized.

The SITES model results indicated that under both the existing and future watershed build-out conditions, the exit velocity in the existing auxiliary spillway will cause the vegetative cover to fail, concentrated flow to develop, and the spillway to breach during both the SDH and FBH design storms.

Engineering: NRCS contracted H&S Environmental to complete phase I and phase II engineering studies of the Hop Brook Dam in 2008-2009. Several alternatives were screened out from further analysis because of cost, constructability, or environmental impacts:

- Breach dam
- Purchase/relocate flooded properties
- Install downstream floodwalls
- Increase height of dam
- Increase width of existing auxiliary spillway

Structural alternatives evaluated in detail were:

- Armor dam embankment and auxiliary spillway
- Increase width of existing auxiliary spillway and armor spillway
- Construct an additional auxiliary spillway

The project team performed a spillway integrity analysis to determine whether the existing auxiliary spillway would withstand the exit velocities estimated for the SDH and FBH design storms for the future watershed build-out condition. The project team used the SITES IDE model version 2005.1.3 to evaluate the stability of the auxiliary spillway. The project team developed a soil profile of the auxiliary spillway using information from the soil boring descriptions and Unified Soil Classification System designations described in the as-built plans for Hop Brook Dam. The SITES model indicated that the width of the auxiliary spillway could be increased to prevent an overtopping of the spillway during the FBH, but the exit velocity in the auxiliary spillway will cause the vegetative cover to fail, concentrated flow to develop, and the spillway to breach during both the SDH and the FBH design storms. An armoring system of articulated concrete blocks was recommended to provide scour protection to the spillway.

Socioeconomic Conditions: Sources for the data included in the social and economic conditions section of this supplement include the U.S. Census Bureau, Department of Commerce, 2000 Census, and interviews conducted with local contacts.

Economic Analysis: The NRCS National Watershed Manual was used as a reference for the economic analysis along with two economic analysis guidance documents: "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G), U.S. Water Resources Council, March, 1983, and the "Economics Handbook, Part II for Water Resources," USDA Natural Resources Conservation Service, July, 1998. These guidance documents were used to evaluate potential flood damages, and estimate project benefits and associated costs. P&G was developed to define a consistent set of project formulation and evaluation instructions for all federal agencies that carry out water and related land resource implementation studies. The basic objective of P&G is to determine whether or not benefits from proposed actions exceed project costs. P&G also requires that the "National Economic Development" or NED Alternative, which maximizes monetary net benefits, be selected for implementation unless there is an overriding reason for selecting another alternative based on federal, state, local or international concerns related to the social and environmental accounts. The allowance for exceptions to the NED plan recognizes the fact that not all project considerations or benefits can be quantified and monetized when it comes to some ecological system and social effects.

Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (Adverse, annual) as beneficial costs (Beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

Positive benefits will accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Project flood-prevention benefit estimates were updated to 2009 dollars

from the 1958 watershed plan. The Consumer Price Index was used for updating reduction benefits for roads and bridges. Original downstream damage reduction benefits for residential and commercial properties were updated using the average increase in tax receipts. Values for selected commercial properties that constitute a major portion of the benefit calculations were updated to reflect current market values. These benefit estimates were not used to compare alternatives, because both alternatives provide the same benefit, but they show the ongoing value to the Commonwealth of Massachusetts and the local towns of the flood prevention provided by Hop Brook Dam.

All costs of installation and operation and maintenance were based on 2009 prices. One year was assumed for development, review, and approval of the final design and installation of the proposed rehabilitation project. Structural measures were assumed to have a 54-year useful life. Thus, a 55-year period of analysis was used along with the mandated 4.625 percent discount rate for all federal water resource projects for FY09 to discount and amortize the anticipated streams of costs and benefits.

References not listed in main report reference list:

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Berlin, MA, Worcester County – Community Number 250294, December1979.

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Hudson, MA, Worcester County, June 1979.

Federal Emergency Management Agency (FEMA), Flood Insurance Study City of Marlborough, MA, Worcester County – Community Number 250203, July 6, 1981.

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Maynard, MA, Worcester County, December 1978.

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Northborough, MA, Worcester County, May 1979.

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Stow, MA, Worcester County, February 1979.

Federal Emergency Management Agency (FEMA), Flood Insurance Study Town of Westborough, MA, Worcester County, November 1979.

APPENDIX E

CONSULTATION AND PUBLIC SCOPING PROCESS

Stakeholder agencies that were contacted concerning the proposed project are:

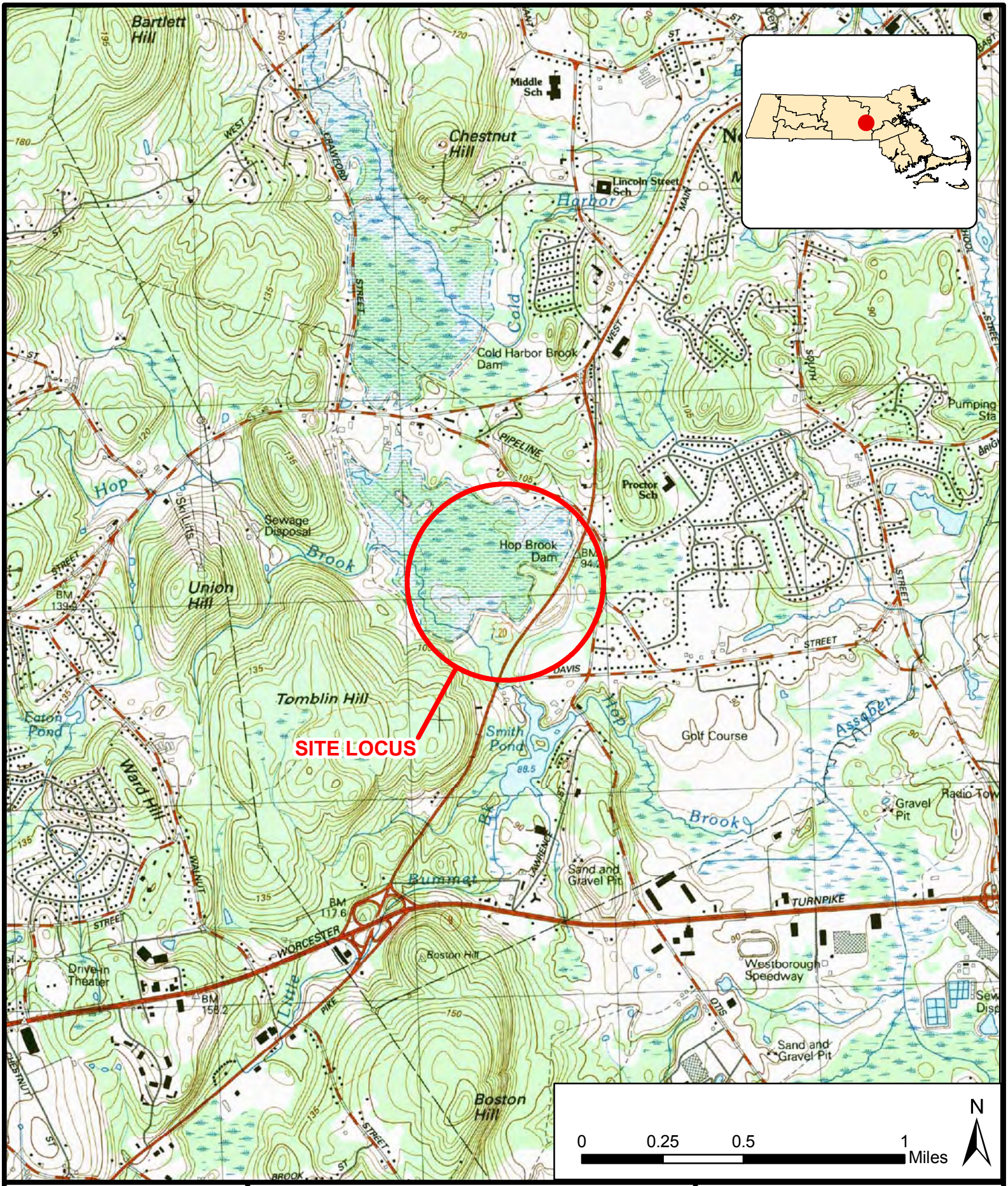
- Worcester County Conservation District
- Massachusetts Department of Conservation and Recreation
- Massachusetts Department of Fish & Game, Division of Fisheries and Wildlife
- Massachusetts Department of Fish & Game, Riverways Program
- Massachusetts Department of Environmental Protection
- Town of Northborough (Selectmen, Conservation Commission, Planning Board, Engineering)
- Town of Northborough Trails Committee
- Organization of the Assabet River
- Massachusetts Executive Office of Energy and Environmental Affairs
- Massachusetts Executive Office of Energy and Environmental Affairs, MEPA
- EPA Region 1, Regulatory
- USACE, Regulatory Division
- MA Office of Dam Safety

Consultations with the Massachusetts SHPO and THPO(s) were conducted to determine the presence of any cultural or historic resources within the proposed project area. [Note: confirmed verbally; waiting for letter responses to be included in final plan.]

A consultation letter for threatened or endangered species was sent to FWS, which responded that no federally listed species are known from the area. It was determined from MassGIS that habitat for a state-protected species lies in the Hop Brook floodplain. Subsequent consultation with Massachusetts NHESP indicated that a state-listed species of concern, the wood turtle, has been found in the area. Consultation with NHESP is continuing; ultimately, DCR is responsible for completing the consultation and obtaining any permits that may be required.

Public scoping also included a public meeting held in Northborough on November 20, 2008, to explain the Watershed Rehabilitation Program and to obtain comments on resource problems, issues, and concerns of local residents associated with the Hop Brook Dam project area. NRCS distributed a press release that resulted in an article about the meeting in the Worcester Telegram & Gazette on November 12, 2008, and a notice that ran on the Northborough cable TV community access channel for two weeks before the meeting.

Potential alternative solutions to bring the Hop Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Two members of the public attended the meeting; no verbal or written comments were received at the meeting or in the intervening time to the publishing of this Plan.



NRCS

VICINITY MAP
HOP BROOK DAM
NORTHBOROUGH, MASSACHUSETTS

FIGURE 1
VICINITY MAP

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE:
JE	PT	PT	JE	AS SHOWN	APRIL 2009	62028.23	VICINITY_MAP.MXD

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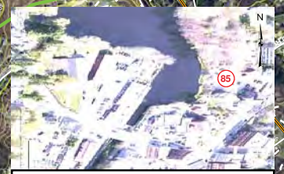

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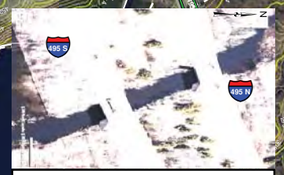

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NORTHBOROUGH, MASSACHUSETTS

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Proj. Mgr.: DML	Dwg. Date: 06-01-2007	Figure No.
Designed By: KDE	Job No.: 19394	11
Reviewed By: PHB		
Operator: KDE		

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BRIDGE OVER ASSABET RIVER ON GREAT ROAD ROUTE 117

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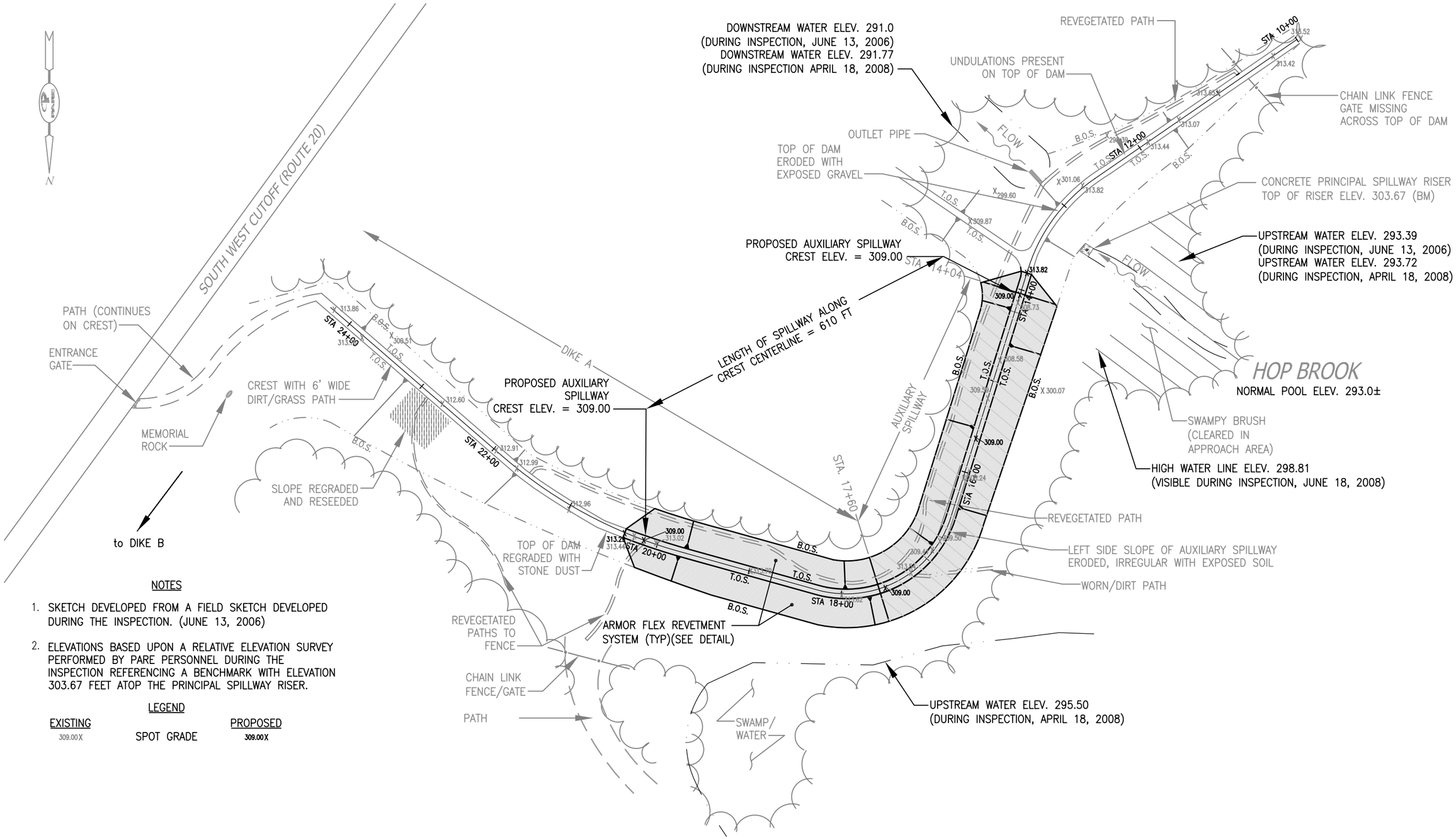


NOTES

1. SKETCH DEVELOPED FROM A FIELD SKETCH DEVELOPED DURING THE INSPECTION. (JUNE 13, 2006)
2. ELEVATIONS BASED UPON A RELATIVE ELEVATION SURVEY PERFORMED BY PARE PERSONNEL DURING THE INSPECTION REFERENCING A BENCHMARK WITH ELEVATION 303.67 FEET ATOP THE PRINCIPAL SPILLWAY RISER.

LEGEND

EXISTING		PROPOSED
309.00 X	SPOT GRADE	309.00 X

REVISIONS				REVISIONS			
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION

HOP BROOK DAM AND DIKE A

MA 00998 / 3-14-215-24
NORTHBOROUGH, MASSACHUSETTS

MASSACHUSETTS DEPARTMENT OF CONSERVATION AND RECREATION

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

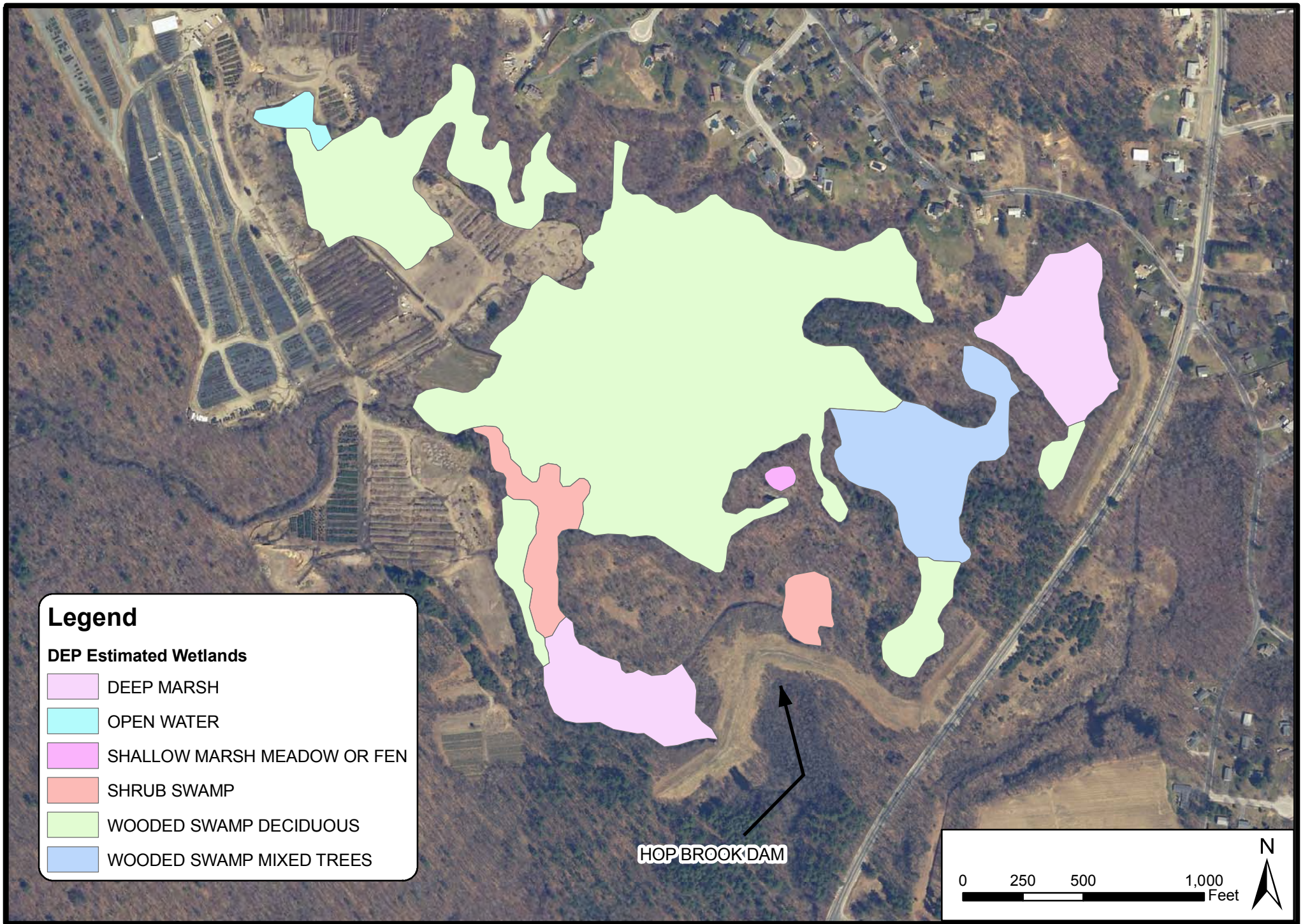
PARE CORPORATION
ENGINEERS -SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 103
FOXBORO, MA 02035
508-543-1755

ALTERNATIVE 4 - STRUCTURAL A-1
LENGTHEN AUXILIARY SPILLWAY

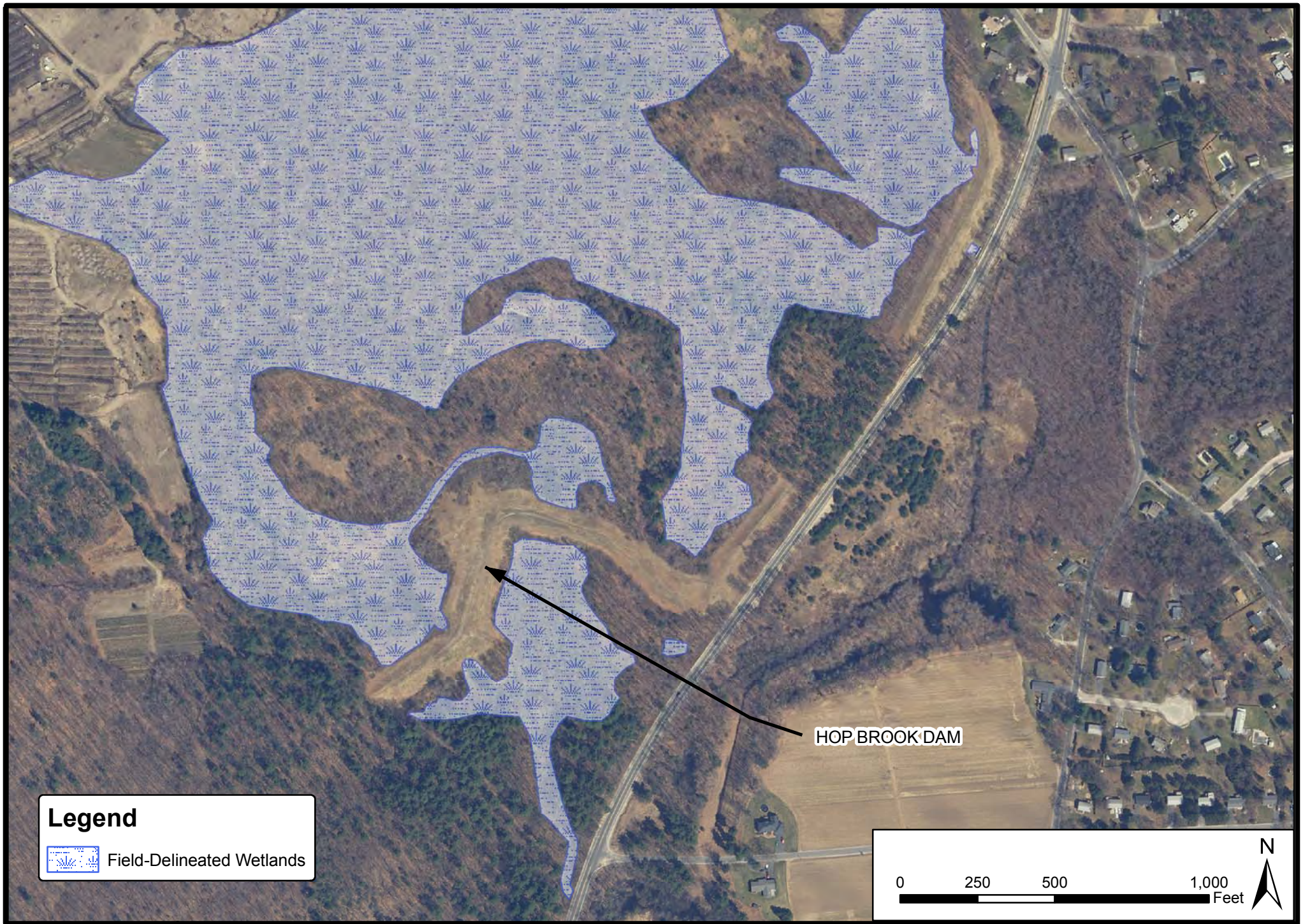
DESIGNED BY:	DATE:	DRAWN BY:	DATE:	CHECKED BY:	DATE:
		TGP	AUG 2008	JMB	AUG 2008

SCALE: 1" = 100'±
PROJ. NO. 08147.00
FIGURE NO. 3

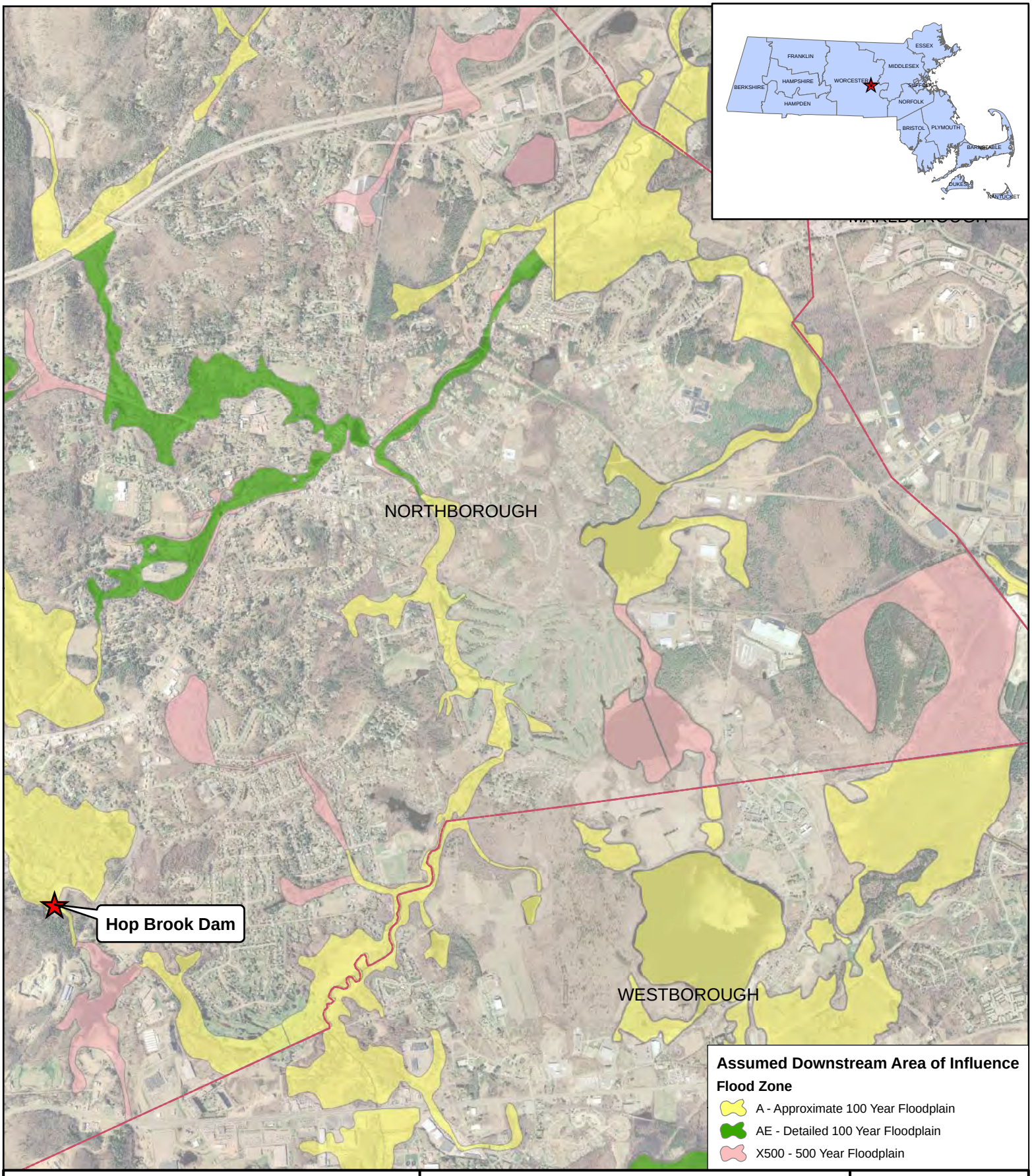
NRCS	WOOD TURTLE HABITAT HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 3 WOOD TURTLE HABITAT
		JE	MR	PT	JE	AS SHOWN	APRIL 2009	62028.23	



NRCS	DEP ESTIMATED WETLANDS HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 4 DEP ESTIMATED WETLANDS
		JE	MR	MR	JE	AS SHOWN	APRIL 2009	62028.23	



NRCS	FIELD-DELINEATED WETLANDS HOP BROOK DAM NORTHBOROUGH, MASSACHUSETTS	PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FIGURE 5 FIELD-DELINEATED WETLANDS
		JE	MR	MR	JE	AS SHOWN	APRIL 2009	62028.23	



BGI

ENSR INTERNATIONAL

0 1,375 2,750 5,500 Feet

1 inch equals 2,750 feet

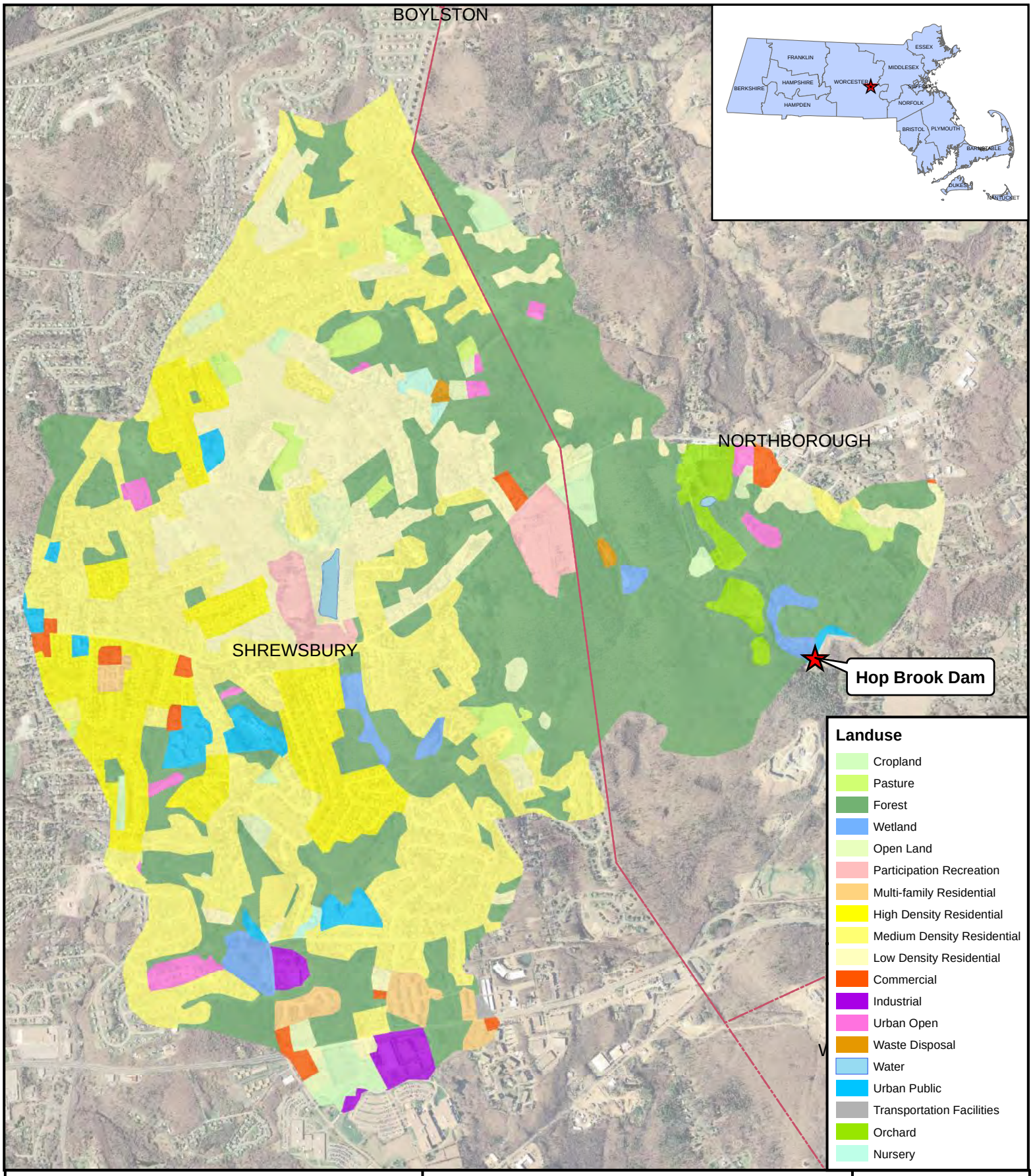
N W E S

Hop Brook Dam
Downstream Floodplain Area
Natural Resources Conservation Service
Northborough and Westborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Zones A, AE, X500 downstream of dam, from FEMA Q3 data layer

FIGURE

6



BGI

ENSR INTERNATIONAL

0 2,125 4,250 Feet

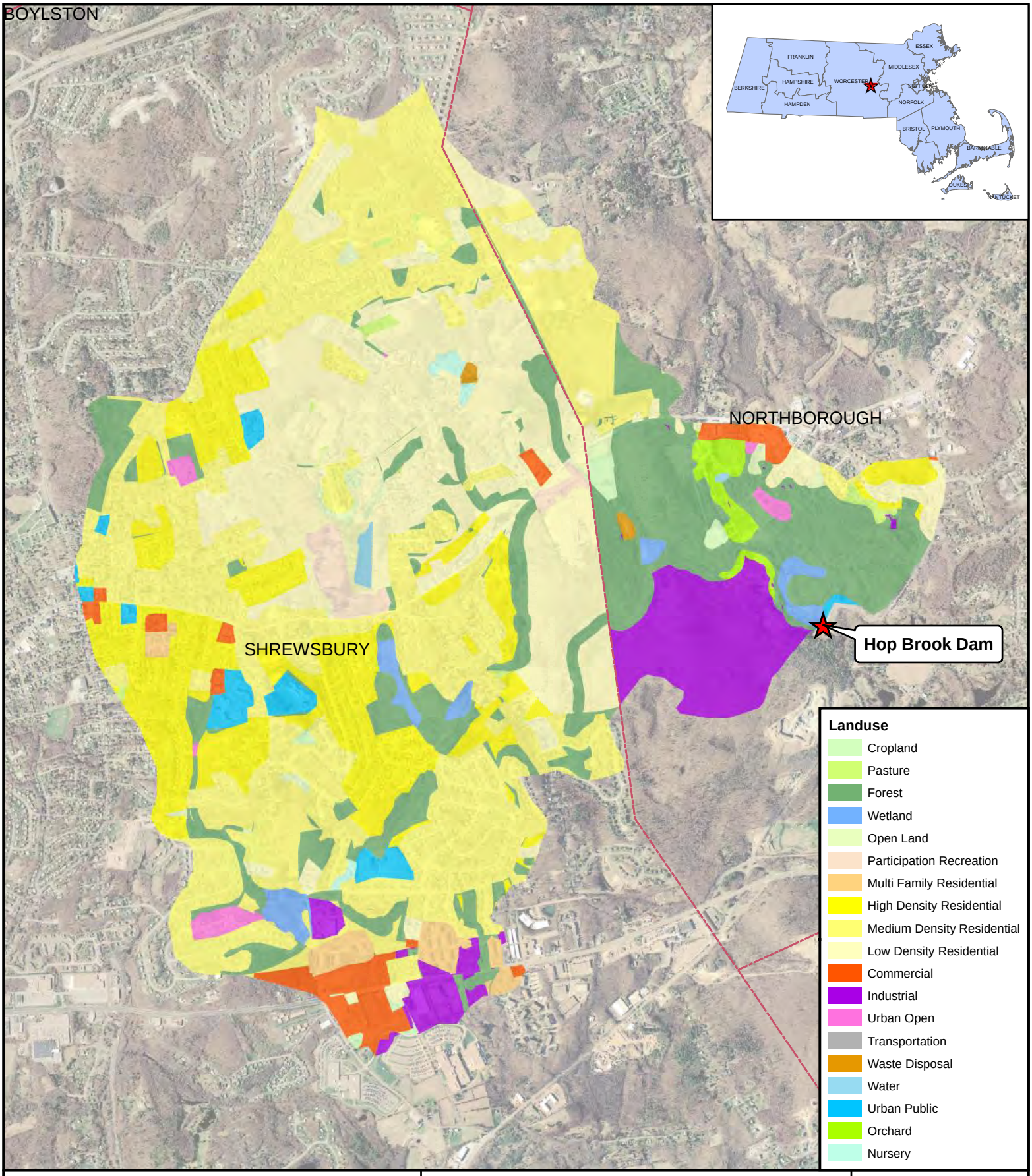
N W E S

1 inch equals 2,125 feet

Hop Brook Dam
Current Conditions Landuse
Natural Resources Convservation Service
Northborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Watershed Landuse taken from MassGIS landuse data layer

FIGURE
7



BGI

ENSR INTERNATIONAL

0 1,125 2,250 4,500 Feet

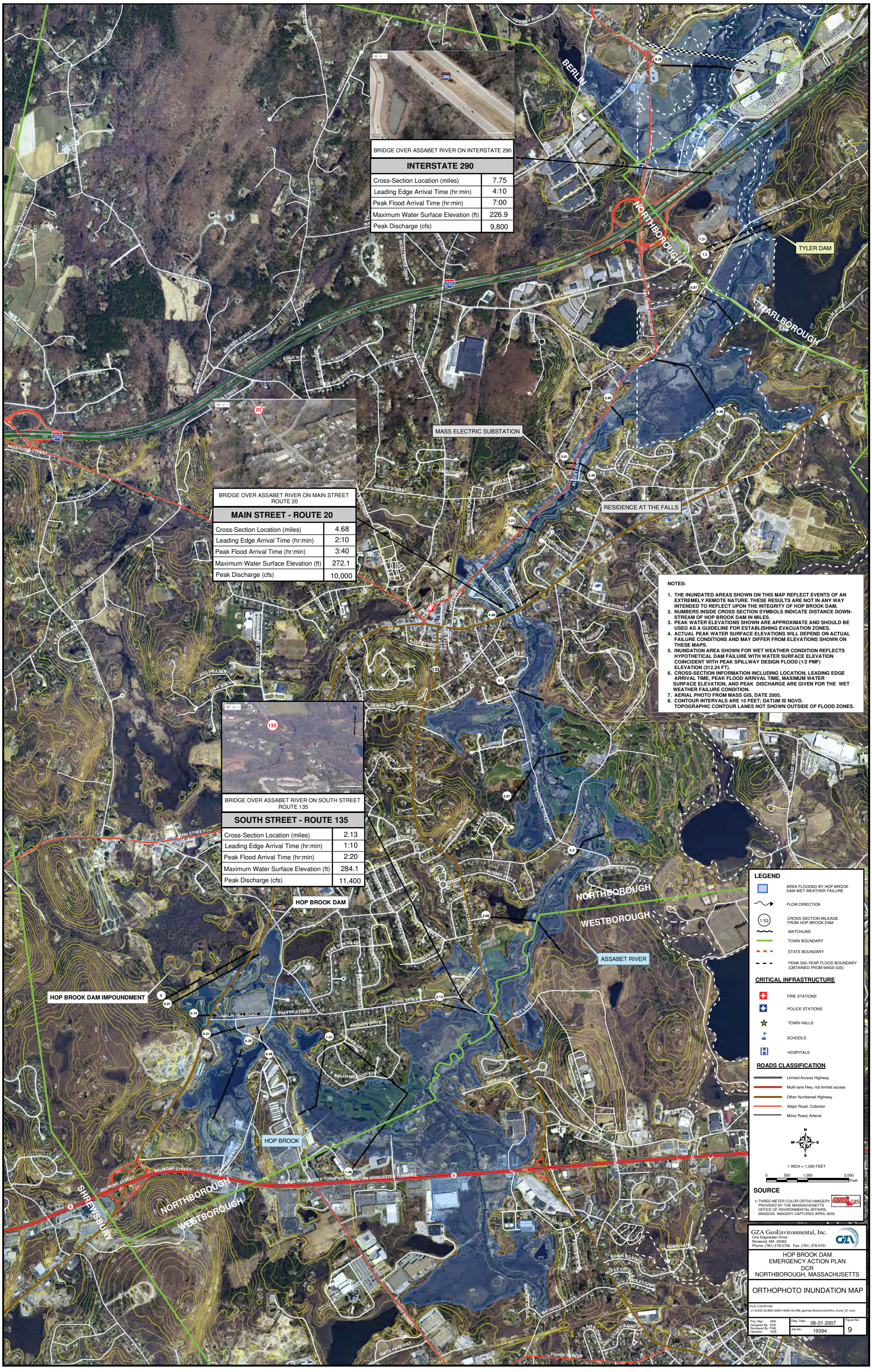
1 inch equals 2,250 feet

N W E S

Hop Brook Dam
Ultimate Buildout Conditions Landuse
Natural Resources Conservation Service
Northborough, Massachusetts

SOURCES:
Basemap MassGIS 1:5000 Color Ortho Imagery, April 2001
Watershed Landuse modified from MassGIS landuse data layer and EOEA landuse data layer

FIGURE
8


BRIDGE OVER ASSABET RIVER ON INTERSTATE 290
INTERSTATE 290
Cross-Section Location (miles) 7.75
Leading Edge Arrival Time (hr:min) 4:10
Peak Flood Arrival Time (hr:min) 7:00
Maximum Water Surface Elevation (ft) 226.9
Peak Discharge (cfs) 9,800
BRIDGE OVER ASSABET RIVER ON MAIN STREET ROUTE 20
MAIN STREET - ROUTE 20
Cross-Section Location (miles) 4.68
Leading Edge Arrival Time (hr:min) 2:10
Peak Flood Arrival Time (hr:min) 3:40
Maximum Water Surface Elevation (ft) 272.1
Peak Discharge (cfs) 10,000
BRIDGE OVER ASSABET RIVER ON SOUTH STREET ROUTE 135
SOUTH STREET - ROUTE 135
Cross-Section Location (miles) 2.13
Leading Edge Arrival Time (hr:min) 1:10
Peak Flood Arrival Time (hr:min) 2:20
Maximum Water Surface Elevation (ft) 284.1
Peak Discharge (cfs) 11,400
NOTES:
1. THE INUNDATED AREAS SHOWN ON THIS MAP REFLECT EVENTS OF AN EXTREMELY REMOTE NATURE. THESE RESULTS ARE NOT IN ANY WAY INTENDED TO REFLECT UPON THE INTEGRITY OF HOP BROOK DAM.
2. NUMBERS INSIDE CROSS SECTION SYMBOLS INDICATE DISTANCE DOWN-STREAM OF HOP BROOK DAM IN MILES.
3. PEAK WATER ELEVATIONS SHOWN ARE APPROXIMATE AND SHOULD BE USED AS A GUIDELINE FOR ESTABLISHING EVACUATION ZONES.
4. ACTUAL PEAK WATER SURFACE ELEVATIONS WILL DEPEND ON ACTUAL FAILURE CONDITIONS AND MAY DIFFER FROM ELEVATIONS SHOWN ON THESE MAPS.
5. INUNDATION AREA SHOWN FOR WET WEATHER CONDITION REFLECTS HYPOTHETICAL DAM FAILURE WITH WATER SURFACE ELEVATION COINCIDENT WITH PEAK SPILLWAY DESIGN FLOOD (1/2 PMF) ELEVATION (312.24 FT).
6. CROSS-SECTION INFORMATION INCLUDING LOCATION, LEADING EDGE ARRIVAL TIME, PEAK FLOOD ARRIVAL TIME, MAXIMUM WATER SURFACE ELEVATION, AND PEAK DISCHARGE ARE GIVEN FOR THE WET WEATHER FAILURE CONDITION.
7. AERIAL PHOTO FROM MASS GIS, DATE 2005.
8. CONTOUR INTERVALS ARE 10 FEET; DATUM IS NGVD. TOPOGRAPHIC CONTOUR LANES NOT SHOWN OUTSIDE OF FLOOD ZONES.
TYLER DAM
MASS ELECTRIC SUBSTATION
RESIDENCE AT THE FALLS
HOP BROOK DAM
HOP BROOK DAM IMPOUNDMENT
HOP BROOK
ASSABET RIVER
NORTHBOROUGH
WESTBOROUGH
MARLBOROUGH
BERLIN
SHREWSBURY
LEGEND
AREA FLOODED BY HOP BROOK DAM WET WEATHER FAILURE
FLOW DIRECTION
CROSS SECTION MILEAGE FROM HOP BROOK DAM
MATCHLINE
TOWN BOUNDARY
STATE BOUNDARY
FEMA 500-YEAR FLOOD BOUNDARY (OBTAINED FROM MASS GIS)
CRITICAL INFRASTRUCTURE
FIRE STATIONS
POLICE STATIONS
TOWN HALLS
SCHOOLS
HOSPITALS
ROADS CLASSIFICATION
Limited Access Highway
Multi-lane Hwy, not limited access
Other Numbered Highway
Major Road, Collector
Minor Road, Arterial
1 INCH = 1,000 FEET
0 500 1,000 2,000 Feet
SOURCE
1) THREE-METER COLOR ORTHO IMAGERY PROVIDED BY THE MASSACHUSETTS OFFICE OF ENVIRONMENTAL AFFAIRS, MASSGIS. IMAGERY CAPTURED APRIL 2005.
GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, MA 02062
Phone: (781) 278-3700 Fax: (781) 278-5701
HOP BROOK DAM
EMERGENCY ACTION PLAN
DCR
NORTHBOROUGH, MASSACHUSETTS
ORTHOPHOTO INUNDATION MAP
FILE LOCATION: J:\19,000-20,999\19394\19394-00.DML\gis\Hop Brook\mxd\Ortho_Inund_D1.mxd
Proj. Mgr.: DML
Designed By: KDE
Reviewed By: PHB
Operator: KDE
Dwg. Date: 06-01-2007
Job No.: 19394
Figure No.: 9