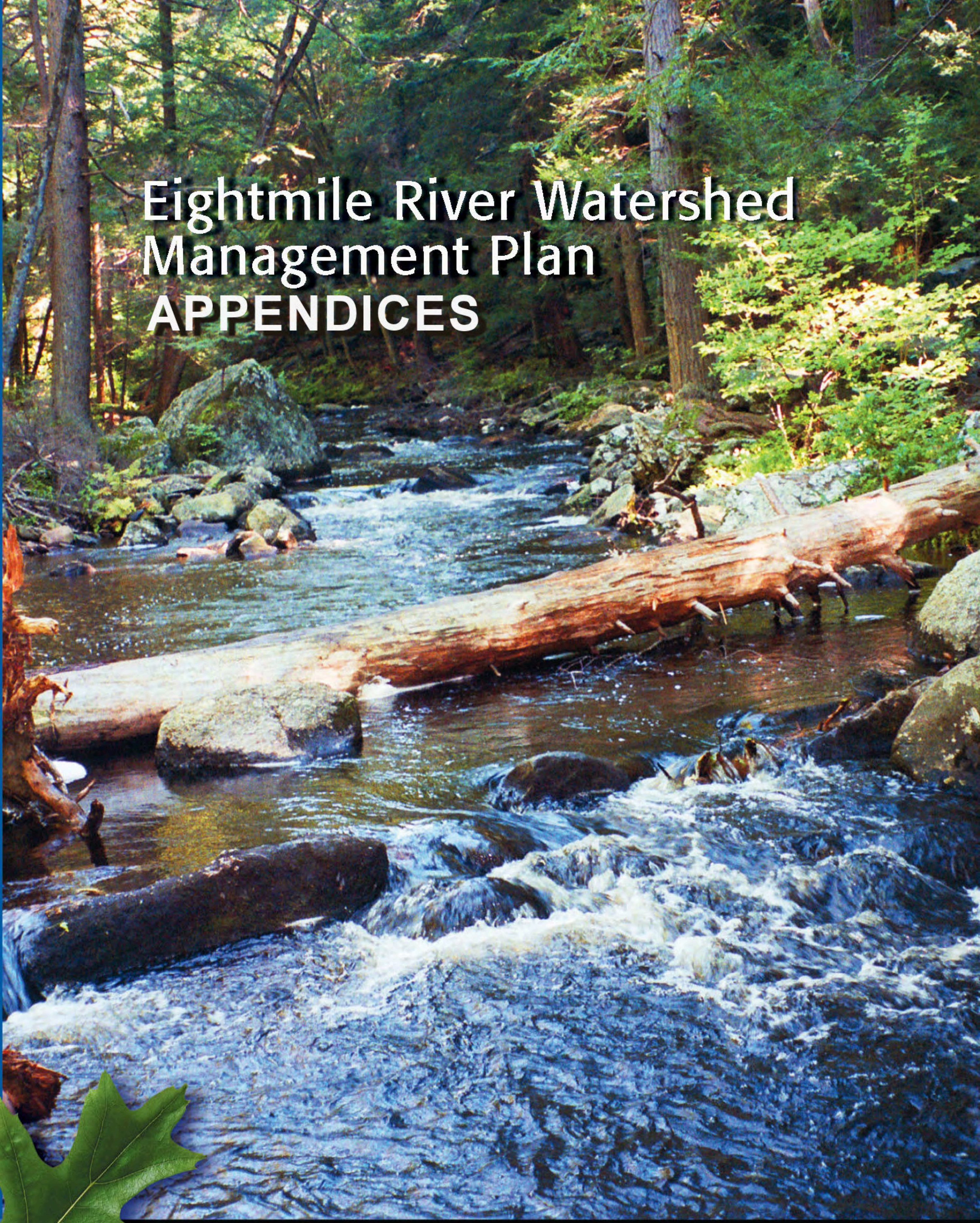
Eightmile River Watershed Management Plan
APPENDICES



Tools & strategies to protect and enhance the Eightmile River Watershed

Eightmile River Wild & Scenic Study Committee
National Park Service, Northeast Region

APPENDICES

Eightmile River Watershed Management Plan

Eightmile River Wild & Scenic
Study Committee
12/2005

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Appendix 1

Outstanding Resource Value Report: Water Quality

Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Value:
Water Quality
May 25, 2005

The Importance of High Water Quality

The myriad of sustainable resources that a healthy river system provides are only as good as the water quality flowing through the system. Whether the river is supporting unique plants and animals, offering recreational opportunities such as swimming, boating or fishing or, providing drinking water supply, good water quality is a must for sustaining these resource values.

At the state and national level the importance of achieving and maintaining high water quality led to the federal Clean Water Act and in turn the State of Connecticut's Water Quality Standards, with the overall goal to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Major objectives of the state and federal efforts include the elimination of discharge of all pollutants into the navigable waters of the country, and achieving a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife, as well as providing for recreation.[1]

Surface and ground water quality can be impacted in many ways. Land use near a river has a significant impact on water quality. Forest land, farm land, residential land and industrialized land, all have the potential to impact local water quality in different ways. The physical attributes of the stream and whether it is dammed, diverted, or piped underground, can play a key role in long-term water quality. And, pollutants such as mercury or nitrogen can be carried through the air, over the land, or through the soil ultimately being deposited in local water ways. Healthy rivers and streams not only offer a myriad of resources but also face a myriad of pressures affecting long-term water quality. It is only through continued diligence and care that high water quality can be sustained.

Indicators of Water Quality Conditions in the Eightmile River Watershed

Connecticut Water Quality Classifications

The State of Connecticut Water Quality Classifications provides the state with a policy for managing its rivers, streams, lakes, groundwater and coastal waters. The Classifications include: standards that identify desired uses and provide guidance on avoiding degradation of water quality; criteria that describe specific goals and the allowable levels of a variety of variables that affect goal attainment; and classifications for all surface and groundwater in Connecticut. While not a direct measurement of water quality, the classifications do clearly indicate the State policy towards managing individual water bodies. The primary differences between Class AA, A, and B waters are that AA waters are for active or proposed drinking water supply, A waters are considered potential drinking water supply and B waters cannot be used for drinking water supply. Also, only waters classified as B or lower, are allowed to accept industrial or municipal sewage treatment plant discharges. See Appendix A for details on the state water quality classifications and their designated uses.

[1] Federal Water Pollution Control Act, Title 1, Sec. 101 (a)(1-2)

The criteria used in the Connecticut Water Quality Classifications to assess overall water quality include: physical attributes such as water temperature, sediment load, flow, and color; chemical attributes including dissolved oxygen, pH, nutrients, and phosphorus; and biological data representing aquatic life such as insects.

Currently 92% of the perennial river and streams in the Eightmile River Watershed are considered Class A. Another 8% of perennial waters are considered Class B with a goal of A. These Class B waters are primarily classified as such due to past leachate issues with the Salem Landfill along the East Branch of the Eightmile River. The leachate issues have been contained and are being monitored. Water quality downstream of this old landfill (which has been closed) continues to rank at levels consistent with Class A, however because of the existence of the landfill State standards require that these waters be considered Class B. Monitoring results have shown slight impacts to the water from iron, ammonia, nitrate, and manganese, however these are considered minor and have not caused the river stretch to be classified as impaired.

Hamburg Cove is entirely classified as either a Class B or Class SB resource, along with 2 small ponds at the end of Falls Brook before they enter the Cove. Water classifications beginning with "S" are tidal waters, including 116 acres of lower Hamburg Cove.

Virtually all of the groundwater in the Eightmile Watershed, 99.84%, is considered Class GA or better. See Table 1 for summary of water classifications within the watershed.

The 2004 Water Quality Report to Congress published by CT DEP reports that both the East Branch and the mainstem of the Eightmile River fully support all designated use goals including aquatic life, cold water trout fishery, and primary contact recreation such as swimming. Statewide only 76% of assessed river miles were fully supporting for aquatic life use and only 69% fully supported recreation use.[2]

See Map 17 (Management Plan Volume 1) and map A in this section - Eightmile River Watershed, State of Connecticut, Water Quality Classifications.

[2] CT DEP 2004 Water Quality Report to Congress Prepared Pursuant to Clean Water Act Section 305 (b), April 2004

Table 1. Water Quality Classifications – Eightmile River Watershed

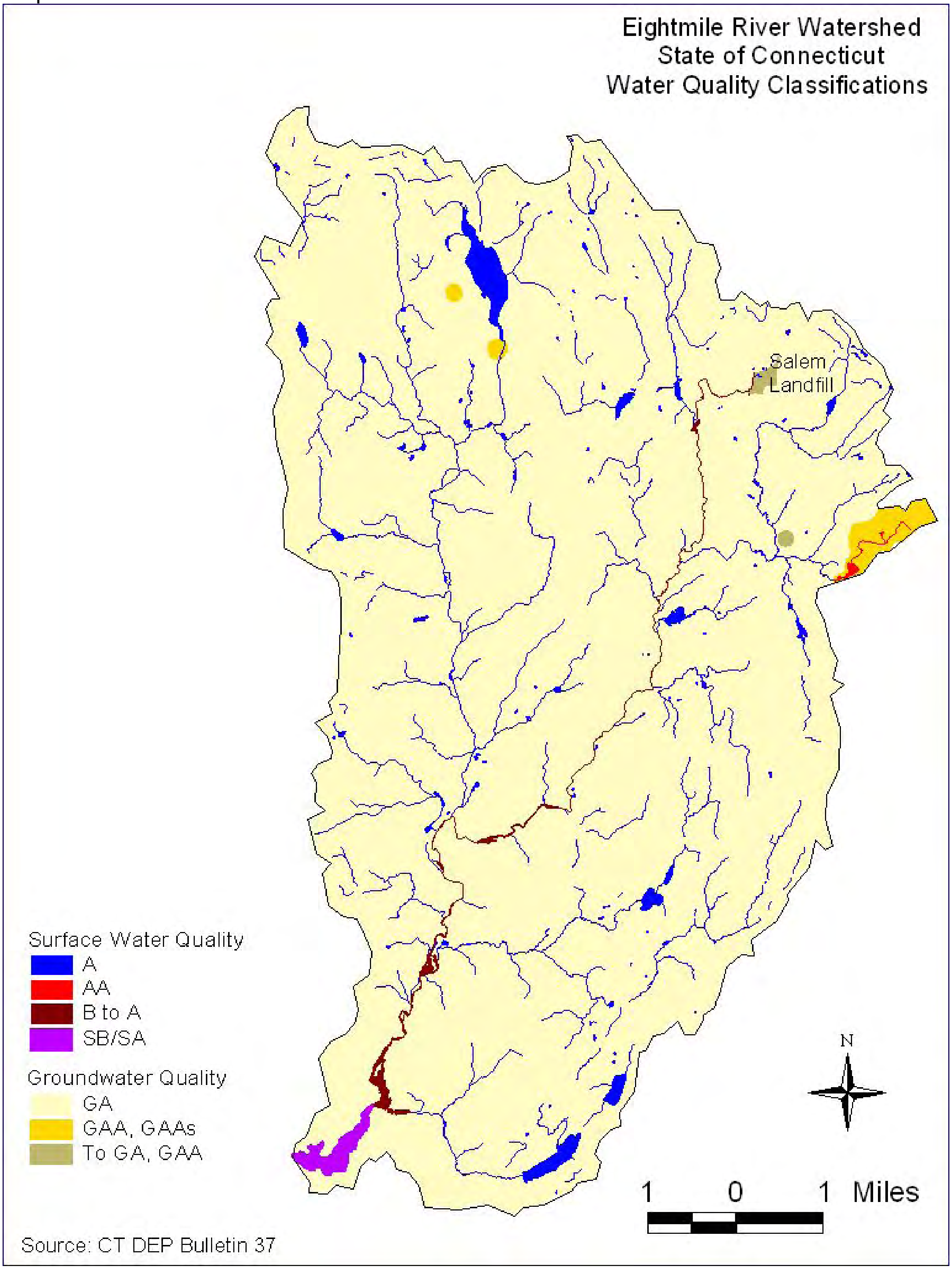
Rivers/Streams/Surface Water Perennial	Miles	% Total Miles
Class AA	0.61	0.56%
Class A	100.84	91.39%
Class B to A	8.88	8.05%
Total	110.34	100%
Rivers/Streams/Surface Water Intermittent	Miles	% Total Miles
Class AA	0.61	2.46%
Class A	24.18	97.54%
Class B to A	0.00	0.00%
Total	24.79	100%
Ground Water	Acres	% Total Acres
Class GA	38,875	99.02%
Class GAA, GAAs	319	0.81%
To GA (GA Impaired)	64	0.16%
Total	39,258	100%
Lakes/Ponds Surface Water	Acres	% Total Acres
Class AA	10	1.79%
Class A	461	82.32%
Class B to A	89	15.89%
Total	560	100%
Coastal Surface Waters - Hamburg Cove	Acres	% Total Acres
Class SB to SA	116	100%

Source: CT DEP Water Quality Classifications Data, DEP Bulletin 37

CT Unified Watershed Assessment

In 1998 the Department of Environmental Protection and the USDA Natural Resources Conservation Service conducted a *Unified Watershed Assessment* to determine how our water resources measured up to state water quality goals. The Eightmile was one of only two major basins in the lower Connecticut River watershed to receive the “in need of protection” designation. This is significant considering that 70% of the state’s major basins are designated “in need of restoration.” This analysis included consideration of whether a water body was meeting its water quality use attainment goals and whether any water quality impairment existed. By fully achieving its water quality goals and having no impairments the Eightmile River Watershed’s “in need of protection” designation signifies unique watershed conditions, including high water quality.

Map A


Eightmile River Watershed
State of Connecticut
Water Quality Classifications
Salem Landfill
Surface Water Quality
A
AA
B to A
SB/SA
Groundwater Quality
GA
GAA, GAAs
To GA, GAA
N
1 0 1 Miles
Source: CT DEP Bulletin 37

Biological Information
Of the biological criteria considered, aquatic insects, also known as benthic macroinvertebrates, are one of the most efficient indicators of biological integrity and overall water quality. The CT DEP reports they use the aquatic macroinvertebrate community as their primary indicator of biological integrity noting "The macroinvertebrate community in a stream or river is very sensitive to stress; and thus its characteristics serve as a useful tool for detecting environmental perturbation resulting from introduced point and non-point sources of pollution."[3] In addition, the U.S. Environmental Protection Agency recognizes the advantages of using aquatic macroinvertebrate sampling for assessing water quality for the following reasons:

- Macroinvertebrates are found in almost every type of aquatic habitat even those with very low water quality.
- Methods for sample collection, processing, and data analyses are widely accepted, established, and documented.
- Collectors can capture a representative sample of the macroinvertebrate community with relative ease, over a short period of time, and with relatively inexpensive equipment.
- Macroinvertebrate populations recover rapidly from repeated sampling.
- Knowledge of changes in the community structure and function of benthic macroinvertebrates helps to indicate water quality status and trends in the aquatic environment.[4]

Both the CT DEP and the Connecticut River Coastal Conservation District (CRCCD) have collected benthic macroinvertebrate data over the past 5 years that provide a clear picture of the high water quality found within the Eightmile River Watershed.

The CT DEP Bureau of Water Management reported that macroinvertebrate "monitoring data collected during 1998-1999 indicate exemplary ecological conditions for the Eightmile River and very good conditions for the East Branch Eightmile River. These conditions are representative of "best attainable" water quality and aquatic life situations for reference stations across the state." [5] (see Appendix B) Reference stations are specific sites that are exemplary by being minimally impaired and providing expected ecological conditions for a waterbody in a region. Being "best attainable" for reference stations across the state reflects conditions as good as any of these exemplary sights across Connecticut.

In addition to the DEP data, CRCCD has sponsored volunteer monitoring activities in the Eightmile River watershed beginning in 1999. Two stream walk surveys and three rapid bioassessments have been conducted over the last five years to collect baseline information about the condition of the Eightmile River and its tributaries, among other objectives. The bioassessments followed the CT DEP protocol *Rapid Bioassessment in Wadeable Streams and Rivers by Volunteer Monitors* (RBV), which is used to assess the health of benthic macroinvertebrate communities.

[3] Rapid Bioassessment in Wadeable Streams & Rivers, by Volunteer Monitors Part 1: Program Description, Michael Beauchene and Guy Hoffman, June 2000
[4] http://www.epa.gov/ceisweb1/ceishome/atlas/bioindicators/invertsasindicators.html
[5] Letter from Mike Beauchene, CT DEP, November 13, 2003

The RBV protocol is designed to help identify streams with pollution sensitive benthic macroinvertebrate communities. It is not a definitive assessment procedure; data are used primarily for screening purposes, to identify streams with either very high or very poor water quality. RBV organisms are categorized in one of three groups: *most wanted* (most sensitive to pollution, requiring a narrow range of environmental conditions); *moderately wanted* (less sensitive to pollution and found in a variety of water quality conditions); *least wanted* (least sensitive to pollution and tolerant of the widest range of conditions).

According to the RBV protocol, good representation (3 or more) of organisms in the *most wanted* category—the most sensitive to pollution—is an indicator of very good water quality. Sites with 5 or more organisms in the *most wanted* category are considered by DEP to be among the exceptional sites, with reference conditions and in full support of the water quality standards for aquatic life. Based on the RBV organisms found in the Eightmile River, East Branch Eightmile River and Beaver Brook, especially the abundance of *most wanted* organisms, one can infer that these streams are of reference quality.

A 2002 DEP statewide assessment of all volunteer monitored sites noted the Eightmile River Watershed had good to excellent representation of the “most wanted” aquatic organisms with a good to optimal diversity of organisms. As a result, water quality was inferred to be very good and supportive of the aquatic life water quality standard.[6]

Potential Threats to Water Quality

Water quality can be assessed not only by empirical data, but also by the presence or absence of stressors that cause known impacts to water conditions. Point source pollution and nonpoint source pollution are two of the primary ways that water quality is impacted.

Point Source Discharges

Point source pollution comes from known points where pipes from facilities such as sewage treatment or industrial plants discharge directly into a water body. Since the passage and implementation of the federal Clean Water Act, great progress has been made in the permitting and monitoring of these discharges to meet state water quality standards.

The Eightmile River Watershed has no point source discharges, eliminating a major potential threat to overall water quality.

Nonpoint Source Discharges

Nonpoint source discharges come from diffuse sources typically carried by stormwater runoff across and under the ground. Such runoff can carry with it sediment, pesticides, fertilizers, car drippings and whatever else may be on road ways, parking lots, residential lawns and agricultural fields, ultimately ending up in local streams or wetlands. The U.S. EPA’s most recent National Water Quality Inventory[7] noted non-point source pollution as the leading source of river impairment nationwide.

[6] CT DEP Rapid Bioassessment in Wadeable Streams and Rivers by Volunteer Monitors Year 2002 Summary Report

[7] US EPA - National Water Quality Inventory 2000

A key indicator of impacts from stormwater runoff is the level of impervious surfaces in a watershed. Impervious surfaces are things such as roads, parking lots and rooftops that block rainwater from infiltrating into the ground, causing it to run overland and into local water bodies and wetlands. Scientific research suggests that in watersheds of up to 10 square miles stream quality can degrade when impervious cover is just 10% of the total watershed area. For certain sensitive aquatic species, such as brook trout, impervious cover of as little as 4% can cause major population declines.[8]

One of the key resources affected by impervious surfaces is soil function. Of the many services soils provide, there are two that figure prominently to the maintenance of water quality. They are briefly described here: (1) Soils regulate the water regime in the watershed: Water flows over the land and through the soil, regulating base flow in streams and maintaining a constant and clean supply of water; and (2) Filtering capacity: The minerals and microbes in soils are responsible for filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials from industrial, commercial and residential pollutants and atmospheric deposition.

The ability of soils to provide these services is impacted by their natural spatial extent, the landscaper relationships between different soils, and the human influences and management that impact their ability to function. This can happen through modification of soil characteristics by site alteration or through the complete loss of soil function through the creation of impervious surfaces. Soil services cannot be replaced when they are covered over and water quality degradation results.

A summary of impervious cover for the 84 sub-watersheds within the Eightmile River Watershed is in Table 2.

Table 2. Impervious Cover Eightmile River Subwatersheds

Impervious Cover	# of Subwatersheds	Total Area Square Miles	% of Total Watershed Represented
0 – 1 %	0	0	0.0%
1.1 – 2%	12	6.7	10.7%
2.1 – 3%	35	29.7	47.7%
3.1 – 4%	19	14.6	23.4%
4.1 – 5%	7	5.8	9.2%
5.1 – 6%	4	4.1	6.6%
6.1 – 7%	3	1.3	2.1%
7.1 – 8%	1	0.1	0.1%
8.1 – 9%	1	0.1	0.2%
9.1 – 10%	1	> 0.01	0.0%
> 10%	1	> 0.01	0.0%
Total	84	62.4	100%

[8]Center for Watershed Protection Impacts of Impervious Cover on Aquatic Systems, Watershed Protection Research Monograph No. 1, March 2003

All of the subwatersheds in the Eightmile River Watershed are less than 4.6 square miles in size, with 94% under 2 square miles in size. Of these, 80 subwatersheds, representing 99.7% of the watershed area have imperviousness levels of less than 7%. Forty-seven of the subwatersheds representing over 58% of the total watershed area have impervious cover levels of less than 3%. When considering the entire 62 square mile watershed, current imperviousness totals 3%.

As can be seen none of the Eightmile River Watershed is being impacted by high levels of impervious cover, indicating stream quality to be potentially high.

Riparian Corridor/Land Cover
When impervious cover is less than 10% in a watershed, The Center for Watershed Protection reports its effect is "relatively weak compared to other potential watershed factors, such as percent forest cover, riparian continuity, historical land use, soils, agriculture, acid mine drainage or a host of other stressors." [9]

A healthy riparian corridor–or buffer– involves a natural setting of native trees, shrubs and tall grasses along local rivers and streams. Generally, a 100 foot buffer of native vegetation can act as a "living filter," trapping sediments, nutrients, and other soluble pollutants carried by rainfall or snow melt. Buffers also provide critical wildlife habitat and serve as migratory corridors for many species. The leaves, logs, and branches that fall into the water provide important cover habitat for fish and help support the aquatic food chain. And along the banks, shade trees help moderate water temperature keeping conditions healthier for fish and other aquatic life. Healthy trees and shrubs with strong root systems provide structural support to stream and river banks, holding soil in place. Without soil stability, sediment from eroding banks can cause significant turbidity and can bury critical aquatic habitat used by fish, insects, and other water dependent organisms.

When impervious surface data for the Eightmile River Watershed is coupled with forest cover and riparian corridor quality, the picture of high water quality conditions becomes even clearer. The Eightmile River Watershed is over 80% forest cover compared to the rest of Connecticut that is overall less than 60% forest cover. Only 7% of the watershed is considered developed, while statewide development stands at nearly 19%. When looking closer at the riparian corridor land area within 100 feet of the 160 miles of rivers and streams in the watershed, only 6% is considered developed, with 4% in grass or agriculture and 89% in essentially a natural undisturbed condition.[10] See Table 3 Eightmile River vs. State of CT Land Cover 2002.

[9] Ibid
[10] UCONN CLEAR Data 2002

Table 3. Eightmile River vs. State of CT Land Cover 2002.

Land Cover Type	% of Watershed	% of State of CT
Developed	6.74%	18.70%
Turf/Grass	0.74%	4.50%
Grass/Agriculture	8.57%	12.00%
Deciduous Forest	72.46%	46.80%
Coniferous Forest	4.01%	9.00%
Water	1.98%	3.00%
Wetlands	0.46%	0.50%
Forested Wetlands	4.02%	3.50%
Tidal Wetlands	0.00%	0.50%
Barren	0.65%	1.20%
Utility ROW	0.38%	0.30%
TOTAL	100.00%	100.00%

Source: UCONN Center for Land Use Education and Research

In addition, The CT River Coastal Conservation District in 1999 and 2000 led a volunteer stream corridor survey effort that visually surveyed approximately 69% of the Eightmile and East Branch Eightmile river sections. Their findings on both sections of river showed riparian buffers commonly to be greater than 100 feet in width, with stream bank cover primarily trees and shrubs, further confirming the undisturbed conditions of the riparian corridors of the Eightmile River Watershed.[11]

Other land uses such as agriculture and turf/grass (lawns) can be significant sources of non-point source pollution from the effects of excessive fertilizer, pesticide, and herbicide applications being washed off into rivers and streams. The low levels of these land use activities in the Eightmile Watershed compared to the statewide average is another good indicator stresses to water quality are minimal.

Overall, land uses that are the major cause of nonpoint source pollution, including impervious surfaces, agricultural activities, suburban lawns and degraded stream buffers are at comparatively very low levels in the Eightmile River Watershed. It is clear that any potential impacts from these leading causes of water pollution nationwide are minimal and circumstances that support high water quality conditions are strong.

Instream Flow

A natural flow regime in a river is important to sustaining high water quality. Natural instream flow conditions help regulate various water quality conditions such as water temperature, dissolved oxygen, and sedimentation.[12] In the Eightmile River Watershed

[11] CRCCD May 2000, December 2001 Eightmile and East Branch Eightmile Stream Walk Reports

[12] Table 1from Appendix A - Water Allocation Task Force Report 7/2/02 Draft, Ecological Needs Section ECOLOGICAL NEEDS - NEED FOR A CT INSTREAM FLOW STANDARD - DRAFT VERSION (excerpt of sections 1

there are no consumptive surface water diversions and only one groundwater diversion of 150,000 gallons per day that is likely not causing major alterations to natural flow conditions based on its location in bedrock, its distance from the river and strong permit conditions that cause reductions in withdrawal rates during low flow situations. Overall the existing natural flow regime within the Eightmile River Watershed is consistent with conditions that support high water quality.

Nitrogen Loading

As a part of the U.S. Geological Survey National Water-Quality Assessment Program an assessment of nitrogen yields and loads from basins draining to Long Island Sound was completed for the years 1988-1998. As an unmonitored basin, estimates were created for the Eightmile River Watershed through modeling to determine that the Watershed had the lowest nonpoint nitrogen yield as measured in pounds per square mile per year of any basin in the CT River watershed. This may be a reflection of the large undisturbed natural landscape.

Leachate and Wastewater Discharge

The State of Connecticut maintains a database on leachate and wastewater discharge sites (lwds) statewide that includes surface and groundwater discharges that (1) have received a wastewater discharge permit from the state or (2) are historic and now defunct waste sites or (3) are locations of accidental spills, leaks, or discharges of a variety of liquid or solid wastes.[13] The database includes over 3,100 distinct active or historic leachate and wastewater discharge sites. The Eightmile River Watershed has only 7 lwds sites all associated with historic spills or leaks (as discussed above there are no direct point source discharges in the Eightmile River Watershed). None of the lwds sites are actively impairing water quality in the Eightmile Watershed and active montioring and remediation are going on where necessary. See Appendix C for a summary.

<u>Summary</u>

In summarizing the water quality of the Eightmile River Watershed it can be said:

- 92% of the rivers and streams and 99% of the ground water is class A or better
- All waterbodies in the watershed evaluated by the state are fully attaining their water quality use goals.
- None of the water bodies in the watershed are impaired from meeting their water quality use goals
- Studies of the benthic macroinvertebrates within the watershed found conditions that represent the best attainable results when compared to any of the state's reference sites.
- There are no point source discharges in the watershed.
- Impervious cover in 58% of Eightmile River Watershed's subwatersheds is under 3%, with 99.7% having less than 7% impervious cover.
- Riparian corridors are essentially intact and continuous.
- A natural flow regime exists.
- 80% of the watershed is forested with less than 7% developed, in comparison to the state as a whole with less than 60% forested cover and 18% developed area.

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and 2) - Prepared by: James G. MacBroom, P.E., Milone & MacBroom, Inc. and Richard A. Jacobson, C.F.S., Department of Environmental Protection

[13] http://dep.state.ct.us/gis/dataguides/dep/layers/lwds.htm

- The Eightmile River Watershed is one of only two major basins in the lower Connecticut River watershed to receive the “in need of protection” designation in the *CT Unified Watershed Assessment*.
- There are no leachate sites impairing water quality.

This substantial amount of information represents data that provides direct indication of high water quality, as well as data that underscores the pristine condition in which this river system exists and remains relatively free from water quality threats. As such it is clear the water quality of the Eightmile River Watershed is exemplary in the State of Connecticut and an outstanding resource value for the watershed ecosystem.

Appendix A - Summary of State of Connecticut Water Quality Standards and Classifications – CT DEP Website September 2004.

The Water Quality Standards and Criteria are an important element in Connecticut's clean water program. The WQS set an overall policy for management of Connecticut's surface and groundwaters in accordance with the directives provided by Section 22a-426 of the General Statutes and Section 303 of the Federal Clean Water Act.

The WQS have several purposes; they are to:

- provide guidance about existing water quality in the state as well as DEP's goals for maintaining or improving that quality;
- indicate the general types of discharges allowed;
- ensure the segregation of drinking water supplies from waters used for waste assimilation;
- show areas of conflict between usages, and areas where ground and surface waters are degraded;
- provide the standards for toxicity consideration to protect aquatic life;
- provide a framework for the establishment of priorities for pollution abatement, dispensation of State funding, remediation goals; and finally;
- provide clear guidance for location decisions for business and industry as well as other economic developments.

The WQS do not stand alone as a regulatory means of protecting public health and the environment. These standards are integrally related to, and applied by DEP simultaneously with, other statutory and regulatory requirements governing water and waste management. As an example of how these pieces fit together, the following may be of assistance.

- Section 22a-430 of the General Statutes allows and sets procedures for the permitting of discharges of treated wastewaters to the waters of the State.
- The WQS set forth the types of wastewater that can be discharged in various classifications in order to meet statutory goals. In addition, the WQS provide the guiding principles concerning waste assimilation, aquatic toxicity and the goals for receiving waters.
- If the type of discharge is allowed, then the details of application procedures and requirements for treatment, monitoring and reporting of the specific discharge are provided by Sections 22a-430-1 through 4 of the Regulations of Connecticut State Agencies.

THREE FUNDAMENTAL ELEMENTS

Element One. First, the *water quality standards* describe DEP's general policies and goals for maintaining or restoring specified levels of quality for each classification. The Standards describe discharges to ground and surface water consistent with DEP's goals for each classification. The Standards also define the concept of a *zone of influence* for such discharges; this concept is covered in more detail below. Other key provisions of the standards include policies for protecting ground and surface water whose actual quality exceeds that quality associated with its classification. These policies are known as the *anti-degradation principles*. There are also policies and procedures that define the methods by which DEP may alter an assigned classification. The Standards also include important appendices which provide guidance on anti-degradation, definitions, lake trophic classifications, bathing water standards and numerical criteria for aquatic toxicity.

Element Two. The second element is the *water quality criteria* which: (i), describes the uses DEP has designated as appropriate for each water quality classification, and, (ii), establishes narrative and numerical factors used by DEP to determine whether goals established in the standards are being met.

Criteria are divided into groups with surface fresh waters having the designations AA, A, B, C, and D. Saline waters are assigned classes SA, SB, SC and SD. It should be noted that C, D, SC, and SD are **never** acceptable goals; these classifications reflect certain problems, usually a distinct and difficult situation.

Element Three. *Classifications* and the *classification maps* are the third element. Classifications are assigned to surface and groundwater in all areas of the state. These assignments are based on both the use or potential use of such waters as well as on their known or presumed quality. The individual water quality classifications are described in more detail below.

WATER QUALITY CLASSIFICATIONS

Classifications are shown on water quality classification maps. In cases where the actual quality of groundwater does not meet the assigned classifications criteria, the water quality classification maps reflect that fact by means of color coding or a split designation on older maps, such as GA/GB, indicating that the existing groundwater quality in the subject area may be GB quality but the goal is the higher GA criteria.

Significantly, over 90% of the State is classified at the highest levels of protection, as suitable for drinking without treatment. A little more than 6% of the land area is classified as GB, indicating historically urbanized areas. A very small area of the State is classified as GC, having demonstrated hydrogeologic characteristics suited for waste disposal.

Inland surface water classifications.

Class AA

Designated uses: existing or proposed drinking water supply, fish and wildlife habitat, recreational use (may be restricted,) agricultural and industrial supply.

Discharge restricted to: discharges from public or private drinking water treatment systems, dredging and dewatering, emergency and clean water discharges.

Class A

Designated uses: potential drinking water supply; fish and wildlife habitat; recreational use; agricultural and industrial supply and other legitimate uses including navigation.

Discharge restricted to: same as allowed in AA.

Class B

Designated uses: recreational use: fish and wildlife habitat; agricultural and industrial supply and other legitimate uses including navigation.

Discharge restricted to: same as allowed in A and cooling waters, discharges from industrial and municipal wastewater treatment facilities (providing Best Available Treatment and Best

Management Practices are applied), and other discharges subject to the provisions of section 22a-430 CGS.

Class C

Indicates unacceptable quality, the goal is Class B or Class A. Designated uses: same as for B. One or more of the class B uses is not fully supported due to problems that can and will be corrected by normal DEP programs. A good example is the intermittent water quality problems caused by combined sewer overflows.

Discharges restricted to: same as for Classes B or A .

Class D

Indicates unacceptable quality, the goal is Class B or Class A. Designated uses: same as for B. One or more of the designated uses for class B is not fully supported due to an intractable or very difficult pollution problem. An example is the PCB contaminated bottom sediments in the Housatonic River.

Discharges restricted to: same as for Classes B or A.

Coastal and Marine Surface Waters.

Class SA

Designated uses: marine fish, shellfish and wildlife habitat, shell fish harvesting for direct human consumption, recreation and all other legitimate uses including navigation.

Discharge restricted to: same as for AA or A surface waters.

Class SB

Designated uses: marine fish, shellfish and wildlife habitat, shellfish harvesting for transfer to approved areas for purification prior to human consumption, recreation, industrial and other legitimate uses including navigation.

Discharge restricted to: same as for B surface waters.

Classes SC or SD

Indicates unacceptable quality, the goal is Class SB or Class SA. Designated uses: same as for Classes C or D surface waters.

Discharge restricted to: same as for Classes C or D surface waters

Groundwater Classifications.

Class GAA

Designated uses: existing or potential public supply of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies.

Discharges limited to: treated domestic sewage, certain agricultural wastes, certain water treatment wastewaters.

Class GA

Designated uses: existing private and potential public or private supplies of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies.

Discharge restricted to: as for GAA and discharge from septage treatment facilities subject to stringent treatment and discharge requirements, and other wastes of natural origin that easily biodegrade and present no threat to groundwater.

Class GB

Designated uses: industrial process water and cooling waters; baseflow for hydraulically connected surface water bodies; presumed not suitable for human consumption without treatment.

Discharge restricted to: same as for A (Note; same treatment standards apply), certain other biodegradable wastewaters subject to soil attenuation.

Class GC

Designated uses: assimilation of discharge authorized by the Commissioner pursuant to Section 22a-430 of the General Statutes. As an example a lined landfill for disposal of ash residue from a resource recovery facility. The GC hydrogeology and setting provides the safest back up in case of technological failure.

Discharge restricted to: potential discharges from certain waste facilities subject to extraordinary permitting requirements.

Appendix B - Letter From CT DEP Re: State Water Quality Data and Interpretation for Eightmile Watershed

Kevin M. Case
National Park Service
P.O. Box 395
100 East River Road
Pleasant Valley, CT 06063

November 13, 2003

Mr. Case,

This letter is in response to your request for interpretation of water quality data collected from the Eightmile regional basin in Lyme, Connecticut. The Connecticut Department of Environmental Protection (CT DEP), Bureau of Water Management (BWM) is responsible for the collection, analysis and reporting of water quality of rivers and streams within the state as required by section 106 of the Federal Clean Water Act. To meet this obligation, BWM collects a variety of water quality data including quarterly water chemistry and macroinvertebrate community structure. The analysis and interpretation of these data are presented in the 305b Report to Congress as the degree of support for each designated use. This process is described in the consolidated assessment listing methodology (CALM) and is available on the CT DEP web page at: http://www.dep.state.ct.us/wtr/wq/calm/2002_calm.htm.

Monitoring Stations:
There are 3 monitoring stations in the Eightmile River regional basin. Two stations were established as part of the Rotating Basin Strategy (http://www.dep.state.ct.us/wtr/wq/rotbasinplan.pdf). The Eightmile River station (#203) is located immediately upstream of the confluence with the East Branch Eightmile River. The East Branch Eightmile River (# 204) station is immediately upstream of the mouth. Available data for these 2 stations include quarterly chemistry, quarterly indicator bacteria, and macroinvertebrate community structure for 1998-1999.

Commencing in 2002 a station was established as part of a statewide probabilistic monitoring project. Sixty-one stations were randomly selected statewide. One of the selections is on the Eightmile River, 150 meters below the confluence with the East Branch Eightmile River. Data are currently being collected at this station and will include quarterly chemistry, as well as, macroinvertebrate, fish and periphyton community structure.

Data interpretation:
Data for the rotating basin stations have been assessed according to designated uses and are available in the 2002 Report to Congress (http://www.dep.state.ct.us/wtr/wq/305b/2002_305b.htm). The assessment for both of the rotating basin stations fully supports aquatic life use and primary contact. The criteria for each level of use support are presented in the CALM document.

AQUATIC LIFE USE ASSESSMENT DATA SOURCES:
Macroinvertebrate Bioassessment: Macroinvertebrate community structure methods follow EPA Rapid Bioassessment Protocol III (http://www.epa.gov/owow/monitoring/rbp/). This method compares the benthic community to that of a reference community. A reference community is a community with diverse representation of sensitive taxa. It is selected based on best professional judgment and is used to represent the best attainable water quality condition for a major basin. The difference between the 2 communities infers a level of water quality impairment. At the 2 rotating basin stations both communities are considered to be high quality with a diverse assemblage of taxa sensitive to water quality perturbation. The Eightmile River macroinvertebrate community is 95% (non-impaired) and the East Branch Eightmile 71% (slightly impaired) of the reference community at the Salmon River in Colchester. Both conditions exceed water quality standards for aquatic life.

Individual macroinvertebrate metrics: Statewide 191 fall macroinvertebrate samples were collected as part of the RBS. Three common metrics EPT index, Taxa Richness, and HBI are included in the RBPIII assessments and are generally considered reliable indicators of water quality when looked at independently. EPT index is the total number of taxa that belong to 1 of 3 insect orders, ephemeroptera, plecoptera, and trichoptera. In general representatives of these 3 orders are very sensitive to impairments. Taxa Richness is the total number of unique taxa identified in the sample. HBI is the Hilsenhoff Biotic Index. Each taxon is assigned a tolerance value indicating its sensitivity to organic pollution. Values range from 0, most sensitive, to 10, most tolerant. Taxa considered to be most sensitive are assigned 0 and those most tolerant 10. The HBI is a weighted mean calculated by multiplying the tolerance value of a taxa by the number of that taxa. This product is then divided by the total number of organisms. HBI values close to 0 indicate a community dominated by sensitive organisms. The HBI value for the Eightmile River is 2.52 and is in the upper quartile for sites statewide and approximately at the median for reference sites. The East Branch value (3.48) ranks in the upper half of sites statewide. Both sites have HBI values below 3.50 that Hilsenhoff uses as a cutoff for indicating organic enrichment. The Eightmile River has an exemplary community with the maximum EPT index in the data set and is fourth highest in total Taxa Richness. While not as high, the East Branch Eightmile is well above the 75 percentile for both EPT index and taxa richness.

Although the RBS was designed to increase monitoring coverage, sites included those historically monitored because of known water quality issues and permitted discharges. Therefore there may be some bias in the data set toward selection of impaired and waste receiving streams. However, as part of the RBP III protocol, each sampling season, a series of reference streams are sampled in order to compare communities. Comparison of the Eightmile and East Branch Eightmile to these reference values shows that both streams are close to or exceed mean values for reference stations.

Values for 3 community structure metrics for the Eightmile River and East Branch Eightmile River monitoring stations for samples collected in the fall of 1998.

Station	Taxa richness	EPT index	HBI
Eightmile River #203	49	31	2.52
East Branch Eightmile River #204	41	24	3.48

Distribution of data for 3 community structure metrics collected as part of the RBS data set and the reference station data set.

Metric name: Data set /Number samples	Maximum	75%	Median	25%	Minimum
Taxa Richness:					
Statewide N=191	52	34	26	19	7
Reference N=34	44	40	33	29	20
EPT index:					
Statewide N=191	31	19	13	8	2
Reference N=34	30	25	19	17	13
HBI:					
Statewide N=191	7.64	4.75	3.93	3.30	1.50
Reference N=34	3.79	3.18	2.56	2.41	1.75

Other community structure parameters also indicate that the Eightmile River supports a reference quality benthic community. These include high values for % intolerant individuals, % intolerant taxa and low values for % tolerant individuals and taxa. The Eightmile River also supports an array of rare taxa (found at <10%

of the rotating basin sites) and includes mayflies *Rhithrogen*a spp. and *Leucrocuta* spp., and caddisflies *Diplectrona modesta*, *Brachycentrus numerosus*, *Helicopsyche borealis*, and *Lype* spp.

Quarterly Grab Chemistry and field measurements: There were no exceedances of CT WQS for any of the samples collected at either the Eightmile or East Branch Eightmile River stations. All chemistry data was consistent with reference station chemistry values.

PRIMARY CONTACT USE ASSESSMENT DATA SOURCE:
Indicator Bacteria:
Evaluation of primary contact use support is based on comparison of indicator bacteria counts to CT Water Quality Standards (WQS) http://www.dep.state.ct.us/wtr/wq/wqs.pdf. Appendix B, of the WQS, lists the numeric criteria for standard exceedances. The use support is determined based on Table 6 in the CALM document. For the 1999-2000 cycle, no indicator bacteria exceedances were documented at either the Eightmile River or East Branch Eightmile River stations.

In summary, BWM monitoring data collected during 1998-1999 indicate exemplary ecological conditions for the Eightmile River and very good conditions for the East Branch Eightmile River. These conditions are representative of "best attainable" water quality and aquatic life situations for reference stations across the state.

Please feel free to contact me at your convenience if you have any questions regarding the material presented above.

Mike Beauchene
CT DEP, Bureau of Water Management
Planning and Standards Division
Phone 860-424-4185

Appendix C – Leachate and Wastewater Discharge Sites – Eightmile River Watershed

Leachate and Wastewater Discharge (LWDS)
Sites in the Eightmile River Watershed
Source: CT DEP Bulletin No. 37

LWDS #	Status	Flow Direction	Name	Type of LWDS	Description
4802001	ACTIVE	GROUND	Town of Salem	LANDFILL	active mixed waste landfill
4801001	ACTIVE	GROUND	Town of Salem	SALT STORAGE -COVERD	covered salt storage and covered sand/salt on baregroud
4801002	ACTIVE	GROUND	Town of Salem	SALT STORAGE -COVERD	covered salt storage on bareground and covered sand/salt on bare ground
4801003	INACTIVE	GROUND	Salem General Store	OIL/CHEMICAL SPILLS	petroleum spill
4801004	INACTIVE	GROUND	Hendel's Gas Station	OIL/CHEMICAL SPILLS	petroleum spill
4801005	ACTIVE	GROUND	Sid's Auto Salvage/Used Parts Inc.	AUTO JUNKYARD	auto junkyard
4803001	ACTIVE	GROUND		SEPTAGE LAGOON	Septage disposal

Appendix 2

Outstanding Resource Value Report: Watershed Hydrology

Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Values:
Watershed Hydrology
June 2, 2005

Why Watershed Hydrology Is Important

Watershed hydrology describes the journey of water through a watershed system. The processes that move water through the system such as precipitation, evapotranspiration, groundwater infiltration and surface water flow all have significant affects on overall ecosystem health.

Instream flow, the amount of surface water flowing in a river or stream at any given time, has been called the "master variable"[1] in a river system. Instream flow affects a multitude of river ecosystem functions including aquatic life and its related habitat, nutrient cycling, sediment transport, water temperature, river bank stability, groundwater recharge, and a host of other features. Water from river and groundwater sources also plays an important role in sustaining human health by providing drinking water, agricultural irrigation, fire protection, recreational opportunities and wastewater assimilation of discharges from sewage treatment plants and other sources. Table 1 below lists the physical and biological resource features that are affected by instream flow. The ability to balance instream needs with out-of-stream uses is a difficult challenge endemic to the whole country, and certainly Southern New England and Connecticut.

Table 1. Water Resource Features Affected By Instream Flow[2]

Physical	Biological
water temperature	migratory fish passage
dissolved oxygen	macroinvertebrate production
effluent dilution	juvenile fish development
effluent assimilation	endangered species
groundwater recharge	amphibians
sediment transport	reproduction
salinity intrusion	vegetation encroachment
aesthetics	riparian wetlands
channel morphology	fish egg incubation
bank stability	
substrate composition	

[1] *Ecological Applications,* 13(1), 2003, pp. 206–224, q 2003 by the Ecological Society of America

[2] Table 1from Appendix A - Water Allocation Task Force Report 7/2/02 Draft, Ecological Needs Section ECOLOGICAL NEEDS - NEED FOR A CT INSTREAM FLOW STANDARD - DRAFT VERSION (excerpt of sections 1 and 2) - Prepared by: James G. MacBroom, P.E., Milone & MacBroom, Inc. and Richard A. Jacobson, C.F.S., Department of Environmental Protection

Impacts to River Flow in the Eightmile Rive Watershed

The flow of a river can be described using five variables: magnitude – the volume of water going down the river at any one time; duration – the length of time a certain magnitude is sustained; frequency – how often different flow levels are achieved; timing- what time of year various flow conditions occur; and rate of change – how quickly flow conditions change.[3] All of these components play a role in supporting the aquatic habitat and life found today in the Eightmile River.

The five variables that describe river flow can be influenced by human activity in a number of ways, including: (1) diversions of water out of the river by either direct withdrawals or groundwater wells; (2) alteration of flow from dams; (3) discharges of effluent into the river from treatment plants, industrial sources and stormwater pipes; and (4) influence of impervious cover, such as roadways, parking lots and roof tops, that both generates stormwater runoff and interrupts the important connection between surface water and groundwater including the important recharge function of vegetation, wetlands and soils to maintain a stable flow regime.

Such human influences and corresponding alterations to natural surface and groundwater flows are to a large extent absent in the Eightmile Watershed, suggesting this watershed is a naturally functioning hydrologic system. Following is a summary of the status of such influences.

Water Diversions

In Connecticut water diversions are either categorized as being permitted or registered. Permitted water diversions are those diversions greater than 50,000 gallons per day that have received a review and permit by the CT DEP in accordance with CGS §22a-373 The CT Water Diversion Policy Act. As of 2000 there were 354 permitted diversions in Connecticut. Registered diversions are those diversions that existed at the time the Diversion Act came into effect in 1982 and were allowed to be grandfathered without an environmental impact review. There are1,842 registered diversions in Connecticut.

Diversions can be categorized further as consumptive or non-consumptive. Consumptive diversions are those that take water, use it and do not put it directly back into the river system, such as drinking water or irrigation withdrawals. Non-consumptive diversions are those that take water, use it and put it back into the river system such as cooling water for a power plant or a hydroelectric facility.

A summary of the diversions within the Eightmile River Watershed is in Table 2.

[3] The Case For Natural Flow Variability In River Basin Management – The Nature Conservancy

Table 2 Diversions in the Eightmile River Watershed[4]

Diverter	Description	Type	Consumptive?	Withdrawal Size
East Haddam Fish & Game Club	6 Recreation Ponds	Registered	No	None – impoundments
New London Water Dept.	Emergency Public Water Supply	Registered	Yes	None – needs permit for actual withdrawal
Lyme Hydroelectric Project	Run of River Hydroelectric Generator	Registered	No	Run of river operation – not a withdrawal - 59 million gallons per day maximum through turbine
Fox Hopyard Golf Course	2 Groundwater Wells for Irrigation	Permit	Yes	150,000 gallons/day maximum

As can be seen there are almost no impacts in the Eightmile River Watershed from the small amount of diversion activity that exists (see Map A for locations). The only active consumptive diversion in the watershed is for two golf course irrigation wells that are limited to withdrawing a combined 150,000 gallons per day. Analysis from the diversion permit application for the wells suggests this may contribute to a nearly 2% reduction in average stream flow in the Eightmile River upstream of the confluence with the East Branch during the low flow months of July, August and September.[5]

The other diversions on record for the Eightmile are not consumptive in nature and consist primarily of small historic recreational ponds used by the East Haddam Fish & Game Club to augment fishing opportunities. It does not appear any of the ponds regulate flow. The registered diversion of the New London Water Department is for Bond Reservoir in Salem. The reservoir is an inactive emergency public water supply. Any actual withdrawals from the reservoir would require a diversion permit from CT DEP.[6]

The Lyme Hydroelectric generator, a run of river operation associated with Moulson Pond and the Rathbun Dam, is not consumptive and is not currently in

[4] Source: CT DEP
[5] "An Evaluation of the Potential Effects of Groundwater Pumping for the Proposed Fox Hopyard Golf Course on the Fisheries of Cranberry Meadow Brook and Eightmile River" Philip C. Downey, Ph.D., CFS, Aquatec Biological Sciences, South Burlington, VT, March 1999.
[6] CT DEP Registered Diversion Database

operation. There are plans to operate the 20 kilowatt facility in the near future after the completion of some repairs. The electricity generated would be used for home use, with excess being sold back to the electric utility. To ensure adequate instream flow downstream of the dam an arrangement exists between the operator of the flume and the CT Department of Environmental Protection to pass the first 20 cubic feet per second downstream over the dam.[7] This understanding ensures the 1,400 foot stretch of river, between the dam and where the tailrace sluiceway re-enters the river, always has sufficient water.

Dams

There are thirty-eight dams listed by CT DEP in the Eightmile River Watershed.[8] Almost all of the dams are either off stream, small with very low head, or no longer in existence.[9] Because the dams are small and none currently regulate flow the overall impact to natural flow is minimal. The two dams of significance, Moulson Pond Dam on the mainstem in Lyme and Ed Bill's Pond Dam on the East Branch in Salem both have fish ladders and no active efforts to regulate flow through store and release operations. Two additional dams of some significance, one in East Haddam and the Zemko Dam in Salem, have active efforts underway to achieve their removal.

An assessment of the biological and physical attributes of the Eightmile River Watershed conducted in the summer of 2004 by the University of Massachusetts' Northeast Instream Habitat Program found elevated water temperatures as a result of shallow impoundments and limited canopy cover on the East Branch. While not impairing overall river quality, it appears the elevated temperatures coupled with a deficiency of woody debris along the river corridor has resulted in a paucity of cold water fish species in certain areas of the watershed.[10]

Table 4 is a list of dams provided by CT DEP. Map A provides detail as to the location of the dams and diversions. Some on the list and on the map are no longer in existence.

Discharges

Any person or municipality in CT that discharges water or substances into any surface waters, ground waters, sanitary sewers or stormwater systems of certain sizes are required to be permitted by the state as a part of the Clean Water Act's National Pollution Discharge Elimination System (NPDES).

Such discharges, whether from municipal sewage treatment plants, industrial processes, or storm water systems can have significant impacts on the variables

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[7] The Gazette, Vol. 8, No. 26, Dec. 2, 1981, "Lyme Hydro Power Plan Gets DEP Approval"
[8] CT DEP Bulletin 37
[9] Steve Gephard, CT DEP Personal Communication, 9/12/03
[10] Northeast Instream Habitat Program, Dept. of Natural Resources Conservation, University of Massachusetts, Diana L. Walden and Dr. Piotr Parasiewicz, "Integrative Assessment of Biological and Physical Attributes of the Eightmile River", Draft, February 2005,

that define natural flow. The Eightmile River Watershed does not have any permitted discharges that have an effect on watershed hydrology.

Land Use - Impervious Cover

Impervious surfaces such as roads, rooftops, and parking lots can have profound impacts on the flow regime of a river. Impervious surfaces break the connection between surface water and groundwater and interrupt the natural water cycle, causing a host of impacts, including: increased volume and velocity of runoff; increased frequency and severity of flooding; peak storm flows many times greater than in natural basins; loss of natural runoff storage capacity in vegetation, wetlands and soil; reduced groundwater recharge; and a decrease in the groundwater contribution to stream flow, causing streams to become intermittent or dry, and in turn affecting water temperature.[11]

Numerous studies have shown a relationship between the level of imperviousness in a watershed and degradation of that watershed's stream quality. Scientific research suggests that in watersheds of up to 10 square miles stream quality can degrade when impervious cover is just 10% of the total watershed area. For certain sensitive aquatic species, such as brook trout, impervious cover of as little as 4% can cause major population declines.
Of the 84 subwatersheds in the Eightmile River Watershed all are less than 4.6 square miles in size, with 94% under 2 square miles in size. Of these, 80 subwatersheds, representing 99.7% of the watershed area, have imperviousness levels of less than 7%. Forty-seven of the subwatersheds representing over 58% of the total watershed area have very low impervious cover levels of less than 3%. When considering the entire 62 square mile watershed, current imperviousness totals 3.3%. Table 3 provides a summary of impervious cover by sub-watershed.

[11] UCONN Cooperative Extension NEMO Program Fact Sheet #3, Impacts of Development on Waterways. 1993

Table 3. Impervious Cover Eightmile River Subwatersheds

Impervious Cover	# of Subwatersheds	Total Area Square Miles	% of Total Watershed Represented
0 – 1 %	0	0	0.0%
1.1 – 2%	12	6.7	10.7%
2.1 – 3%	35	29.7	47.7%
3.1 – 4%	19	14.6	23.4%
4.1 – 5%	7	5.8	9.2%
5.1 – 6%	4	4.1	6.6%
6.1 – 7%	3	1.3	2.1%
7.1 – 8%	1	0.1	0.1%
8.1 – 9%	1	0.1	0.2%
9.1 – 10%	1	> 0.01	0.0%
> 10%	1	> 0.01	0.0%
Total	84	62.4	100%

With relatively low levels of impervious cover throughout the Eightmile River Watershed, conditions are very favorable for supporting a naturally functioning hydrologic system.

Land Use – Forest Cover and Wetland Recovery

When impervious cover is less than 10% in a watershed, The Center for Watershed Protection reports its effect is “relatively weak compared to other potential watershed factors, such as percent forest cover, riparian continuity, historical land use, soils, agriculture, acid mine drainage or a host of other stressors.” [12]

The Eightmile River Watershed is over 80% forest cover where as the whole state of Connecticut is less than 60% forest cover. In addition, only 7% of the watershed is considered developed, while statewide development stands at nearly 19%. When looking closer at the riparian corridor land area within 100 feet of the 160 miles of rivers and streams in the watershed, only 6% is considered developed, with 4% in grass or agriculture and 89% in essentially a natural undisturbed condition.[13]

An assessment of the biological and physical attributes of the Eightmile River system done by the University of Massachusetts Northeast Instream Habitat Program has shown significant stabilization in low flow patterns within the East Branch of the Eightmile River over the last 67 years. Data from the U.S. Geological Survey gauge on this stretch of river indicates that extreme low water conditions aren’t happening as often, and the duration of overall low flow

[12] Center for Watershed Protection Impacts of Impervious Cover on Aquatic Systems, Watershed Protection research Monograph No. 1, March 2003
[13] UCONN CLEAR Data 2002

conditions are shorter than in the past. One of the major factors identified by UMASS for this phenomenon is the recovery of wetland systems in the watershed, a strong indicator of an ecosystem recovering from an intensive agricultural past.[14]

Overall, the landscape conditions in the Eightmile River Watershed are at present compatible with sustaining a naturally functioning hydrologic system.

Summary

Overall, the Eightmile River Watershed has:

- One small consumptive groundwater diversion
- No direct point source discharges impacting hydrology
- Very low levels of impervious cover
- High levels of forest cover coupled with low levels of developed area
- No dams that are currently regulating flow.

Combining all these factors it is apparent the Eightmile River Watershed hydrologic regime is operating without major impediments and as such is a naturally functioning system. It is extremely rare in Connecticut, especially along the coast, to have a watershed system of this size with a natural intact flow regime in place. As such the Eightmile River Watershed can be considered a unique example of how a natural hydrologic system in Connecticut functions and is considered an outstanding resource value based on such exemplary characteristics.

[14] UMASS Northeast Instream Habitat Program, Diana L. Walden, Dr. Piotr Parasiewicz, "Integrative Assessment of Biological and Physical Attributes of the Eightmile River", March 2005.

Map A – Dams and Diversions of the Eightmile River Watershed

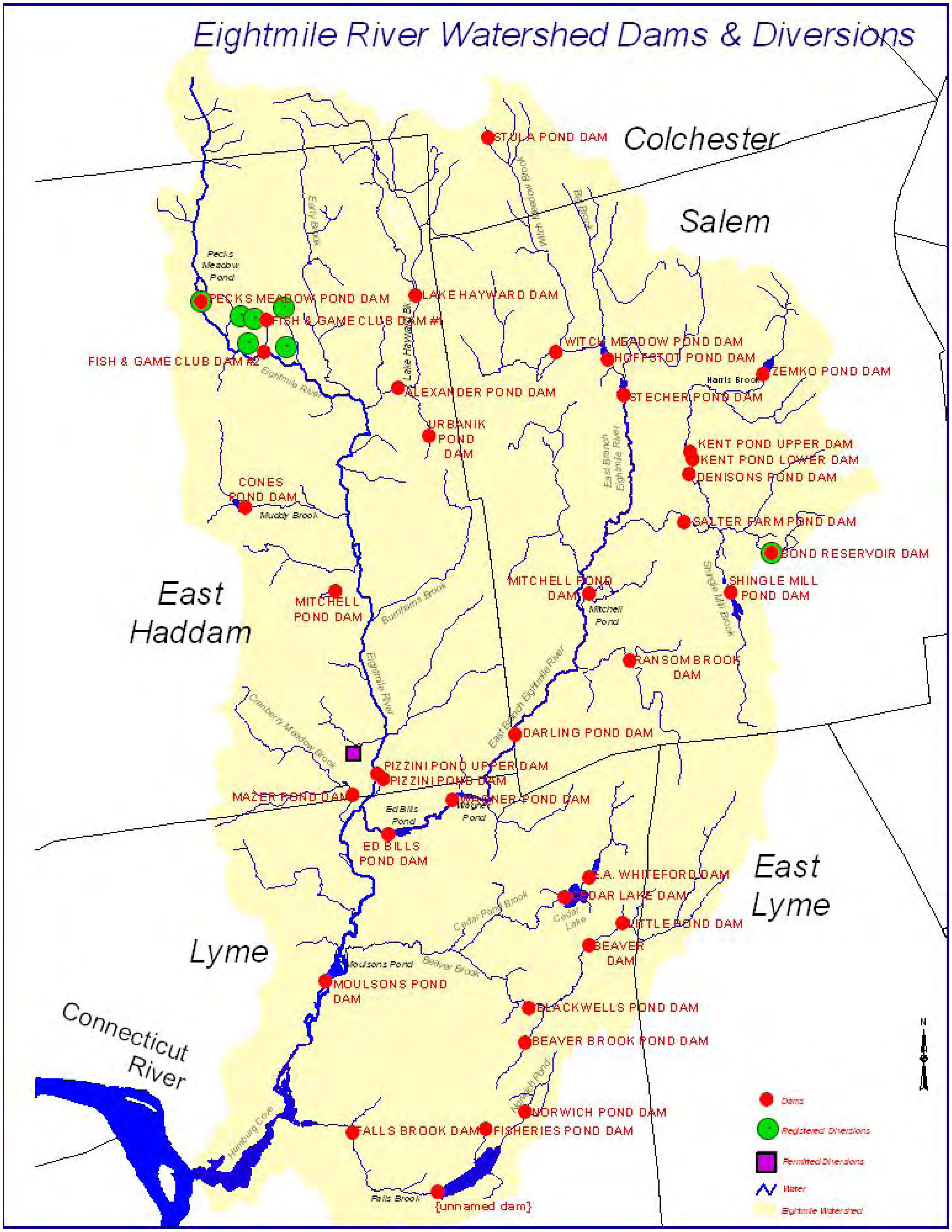

Table 4
Dams in the Eightmile River Watershed

Dam Name	Location
Stula Pond Dam	Colchester
Lake Hayward Dam	East Haddam
Pecks Meadow Pond Dam	East Haddam
Fish & Game Club Dam #1	East Haddam
Fish & Game Club Dam #2	East Haddam
Witch Meadow Pond Dam	Salem
Hoffstot Pond Dam	Salem
Zemko Pond Dam	Salem
Alexander Pond Dam	East Haddam
Stecher Pond Dam	Salem
Urbanik Pond Dam	East Haddam
Kent Pond Upper Dam	Salem
Kent Pond Lower Dam	Salem
Denisons Pond Dam	Salem
Cones Pond Dam	East Haddam
Salter Farm Pond Dam	Salem
Bond Reservoir Dam	Salem
Mitchell Pond Dam	East Haddam
Shingle Mill Pond Dam	Salem
Mitchell Pond Dam	Salem
Ransom Brook Dam	Salem
Darling Pond Dam	Salem
Pizzini Pond Upper Dam	East Haddam
Pizzini Pond Dam	East Haddam
Mazer Pond Dam	East Haddam
Wagner Pond Dam	Lyme
Bills Pond Dam	Lyme
E.A. Whiteford Dam	Lyme
Cedar Lake Dam	Lyme
Little Pond Dam	Lyme
Beaver Dam	Lyme
Moulsons Pond Dam	Lyme
Blackwells Pond Dam	Lyme
Beaver Brook Pond Dam	Lyme
Norwich Pond Dam	Lyme
Fisheries Pond Dam	Lyme
Falls Brook Dam	Lyme
{unnamed dam}	Lyme

Appendix 3

Outstanding Resource Value Report: Geology

Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Value:
Geology
06/17/05 (authored by former state geologist Ralph Lewis)

Introduction

The landscapes and drainage patterns that typify most of New England, including Connecticut, developed over the last 500 million years of our earth's history. The crushing and folding of warm pliable bedrock as mountain ranges formed and New England was assembled, the fracturing of cooler rock as the Atlantic Ocean formed, hundreds of millions of years of stream erosion and the effects of at least two glaciations created a north-south "grain" to the land.

This "grain" is evident to anyone who has driven around Connecticut. Throughout most of the state, driving east-west is difficult (resembling driving across the ridges of a corrugated roof) but driving North-south usually entails going up valleys and is much easier (e.g. Plainfield to Danbury vs. New Haven to Hartford). Owing to the shape of the land, early commerce was east-west on Long Island Sound and north-south up the river valleys. The influence of Connecticut's geology can still be seen in development patterns throughout the state. There are still very few east-west highways that cross the entire state.

The shape of the land also determines how water flows. It is no accident that a drop of water landing in CT will almost always end up in Long Island Sound. Streams generally follow the pattern of the north-south bedrock fabric and tend to flow from north to south across the state.

In the southeast corner of CT, a slight variation in the history of the bedrock produced east-west trending bedrock ridges which are cut by north–south fractures. While the Eightmile River follows the general pattern of southward flow, it does so in a distinctive way, across a landscape and geology that is unique to southeastern CT

Plate Tectonics (Building Mountains and Creating Oceans)

The earth is composed of bedrock segments called plates. There are two types, plates composed of continental type rocks and plates composed of oceanic type rocks. The theory of plate tectonics holds that these plates move over time (at about the rate that your fingernail grows). When plates move they interact with neighboring plates in three ways. They come together (collide), they move apart (rift), or they "sideswipe" each other as is happening along the San Andreas fault in California.

Continental plates can grow larger (accrete) over time as masses of continental rock that share a common geologic history (terranes) collided and stay joined (sutured) together. New England was assembled from west to east in a series of three such collisions.
The two types of plate interactions that are most important to the geology of Connecticut involve collisions and rifting. During plate collisions, the edges of the "colliding" plates get rumpled up and mountains form (e.g. India example, continent to continent collision, California ocean to continent collision). The rocks involved are heated by the compression of the collision and their depth in the earth. They become pliable and tend to fold.

The heat also commonly modifies their character and they are changed (metamorphosed) from what they were to some type of metamorphic rock (typically gneisses and schists in Connecticut). The character of rock that they become is in part determined by what type they were before they were heated. In southeastern Connecticut, the schists and gneisses were formed from heated and crushed sediments that once lay deep in the Iapetos Ocean and small continents and island arcs (similar to today's Japan) that collided with North America as the Iapetos Ocean closed (see cartoons for discussion below). The resistance of these rocks to weathering can vary depending on their origin and history.

When plates move apart, tension is involved. There is generally less heat so the rocks are more brittle and they tend to break or fracture under tension. Fractured rock is commonly more susceptible to erosion than solid rock so valleys often form along fracture zones. Rifting is termed "successful" when a new ocean forms between the plates that are moving apart.

Geologic History: Building and Shaping Connecticut

The Collision Phase: 480-250 Million Years Ago

Connecticut (and New England) was built from west to east over the course of three mountain-building events each of which involved a "collision" and the addition of new rock to the eastern margin of North America. These successive collisions were part of the sequence of events associated with the closing of the Iapetos Ocean (The Ocean that predated the Atlantic) and the assembly of the Super Continent of Pangaea.

- **480-440 Million Years Ago**-The Taconic Island Arc collides with the North American Plate. Western third of Connecticut is assembled and Taconic Mountains form. A portion of the ocean bottom sediment from the Iapetos Ocean is incorporated in this process, turned to rock and made part of western Connecticut.
- **440**-**350 Million Years Ago-**The Taconic Mountains are eroded away,

and the Nashoba Island Arc and a small continent called Avalonia collide with the North American Plate. The Acadian mountains form and the rocks of eastern Connecticut (including more of the metamorphosed ocean bottom sediments of the Iapetos Ocean) are joined to the North American Plate.

- **350-200 Million Years Ago-**The Acadian Mountains erode away and Africa and South America collide with the North American Plate. The Appalachian Mountains form. The assembled rocks of New England are heated and compressed in an east-west direction so they fold along north-south alignments. By now all the rocks that represent the terranes of Connecticut have been heated and changed from what they were to a variety of schists and gneisses.
- In Southeastern Connecticut a small wrinkle in the regional pattern develops and east-west rock alignments result. The rocks of Avalonia (The Avalonian Terrane) have been pushed under the rocks of the Iapetos Ocean (Iapetos Terrane) along the east west trending Honey Hill Fault.

The Rifting Phase: 200 Million Years Ago to Present

The super continent of Pangaea covered much of the earth [Map] as the Appalachian Mountains were forming. The internal heat of the earth built up under this continental “heat blanket” and upwelling of hot magma (like thick pea soup or oatmeal boiling on the stove) began to tear the Super Continent apart. The compression of mountain building was replaced by the tension of rifting. Places where plates had come together in the collision phase (suture zones) were weakness zones that tended to fail first under tension. In Connecticut, a rift started to tear the state in half between New Haven and Hartford (today’s central valley) but this rift “failed” because no oceanic rocks developed in it. Farther to the east, another rift succeeded. The rocks of the Avalonian terrane were torn apart and the Atlantic Ocean began to form.

It has taken 200 million years for the Atlantic Ocean to grow as wide as it is now. During this process part of Avalonia remained in southeastern Connecticut and part ended up in Morocco. The Atlantic Ocean is still getting larger but the earth is a fixed size so something has to “give”. As the Atlantic Ocean grows the Pacific Ocean is getting smaller. The earthquake and volcanic activity around the Pacific Rim (ring of fire) are a result of the plate interactions associated with this process.

Locally we see the result of the rifting phase in the north south fractures that are common in southeastern Connecticut. These fractures occurred when the rocks of the region were relatively cool and brittle. They break across the east–west trend of the bedrock units and provided weakness zones for streams to exploit as the Appalachian Mountains were eroded down to their present configuration.

The Erosion Phase: 250 Million Years Ago to Present

The development of the modern landscape of Connecticut began as the Appalachian Mountains were still forming. As the mountains were rising, the forces of erosion (streams, ice, gravity, vegetation, etc.) were working to wear them down. Less resistant rock types and fracture/fault zones were most susceptible to these forces and stream valleys tended to form where the rock was most vulnerable. Nearly 200 million years of stream erosion preceded the glaciations that added a punctuation mark to the landscape over the past 150,000 years.

Some geologists believe that up to 30 km of rock was removed from Connecticut as the Appalachian Mountains were eroded and the pre-glacial drainage system developed. The configuration of the drainage that developed was influenced by the trend of bedrock folds, faults and fractures and by the orientation of belts of less erosion resistant rock units. Throughout most of Connecticut, the tectonic history of the rocks dictated that these influences would favor south-flowing drainage.

A very well developed south-flowing drainage system had developed in Connecticut prior to the arrival of the first known glacier about 150,000 years ago. This glacier is thought to have stripped away most of the soil and "rotten" rock that had accumulated on the bedrock over 200 million years but not much is known about it. The second of the two known glaciers began to spread over Connecticut about 26,000 years ago. It was thick enough to completely cover Mt. Washington (6,028 ft high), it covered all of CT and advanced as far south as Long Island (by about 19,000 years ago), and it persisted in northern Connecticut until about 15,500 years ago.

Glaciers flow "down hill" under the influence of gravity. In Connecticut, the last glacier flowed over around and through existing hills and valleys and its flow was influenced by the topographic features that it encountered. Hills were rounded and valleys were widened and deepened as the glacier flowed from north to south across the state. The overall effect on the bedrock surface was a slight streamlining and modification of what already existed. Bedrock "grain" preserved and in many cases enhanced.

As the last glacier melted out of Connecticut a streamlined version of the pre-glacial bedrock drainage system was uncovered and streams began to reoccupy old drainages. Southeastern Connecticut was ice free first.

Two types of glacial deposits were left behind as the ice melted. One type, till, came directly from the ice and is a combination of unsorted, boulders and fines and everything in between all mixed together. Till is unfavorable for farming, water supply, and similar endeavors. The other type, stratified drift, was deposited in or by glacial melt water and includes well sorted sand and gravel. These are compatible with development and good for water supply among other things. Till on the hills and stratified drift in the valleys influenced development of infrastructure and population distributions in Connecticut.

The Eightmile River Drainage Basin

Several aspects of the geology of the Eightmile River watershed stand out as being regionally and locally significant. On the bedrock side, these include a rare (for New England) combination of tectonic setting, rock assemblages and fractures that controlled the development of a topography that is unique to a small part of southeastern Connecticut. The advance and retreat of the two glaciers that are known to have overridden Connecticut also left their mark on the watershed in the form of a nice sampling of most of the glacial features that would typically be found in Connecticut.
<u>Bedrock</u>:

Lundgren (1966) describes the assemblage of bedrock units that underlie the watershed of the Eightmile River as "an exceptionally varied suite of rocks that includes representatives of nearly all of the major stratigraphic and granitic units known in eastern Connecticut". This exceptional variety in rock units has its origin in the plate tectonic history of New England, which involved the closing of the Iapetos Ocean as the African and North American plates converged and ultimately collided between 480 and 250 million years ago. Eleven rock units representing the remnants of the Iapetos Ocean and rock units that were once part of western Morocco were crushed together, heated and metamorphosed to form what is now the bedrock foundation of the Eightmile watershed.

Throughout most of New England, the closing of the Iapetos Ocean resulted in a general north-south alignment of terrane boundaries and their attendant rock units. This is not the case in a small area of southeastern Connecticut, which includes the Eightmile. A small crinkle in the regional bedrock fabric produced an anomalous east-west alignment of rock units in this area. As a result, rocks from two of the major players in the New England-wide plate tectonic scenario are represented in the watershed. The east-west trending Honey Hill fault is a terrane boundary that delineates the contact of oceanic affinity Iapetos Terrane bedrock units to the north, and Avalonian Terrane (African affinity) rock units to the south.

Most of the metamorphic bedrock of Connecticut is acidic and weathers to an acidic soil. Five of the eleven metamorphic rock units underlying the Eightmile River watershed have basic (calc-silicate or marble) members that would be expected to weather to basic or "sweet" soils. The occurrence of these soils is ecologically significant in a regionally acidic setting. Calc-silicate and/or marble rock members are mapped in the vicinity of Cedar Lake and at the south end of Moulsons Pond.

Topography and Glacial Modification:

Stream erosion over the past 250 million years, and the erosive power of the two known Pleistocene glaciations have combined to sculpt the bedrock surface that forms the rolling topography so typical of most of Connecticut (and New England). Weathering of less resistant bedrock units and of similarly aligned north-south fault/fracture zones, which developed across the region as rifting formed the Atlantic Ocean, created an overall north-south grain to the landscape. The pattern of north-south ridge systems drained by south-flowing streams holds true for most of southern New England, save for the small section in and around the Eightmile watershed. The anomalous alignment of rock units in this area creates a series of east-west trending strike ridges which are cut by valleys that mirror the regional pattern of north-south fractures. The result is a rectangular or "blocky" local topography that is atypical for Connecticut and the region as a whole. The drainage pattern of the Eightmile River, and its tributaries, locally reflects the east-west bias produced by the bedrock alignments (strike ridges) and the north-south bias of the crosscutting fractures.

The pattern of glacial deposition in the watershed is typical for areas of southern New England that are underlain by metamorphic rock. Upland areas are blanketed by thin till which is punctuated by the occurrence of patches of thicker till, drumlins (at least two nice examples) and bedrock outcrops. Striations, polished surfaces, rouche moutonnee and evidence of relict glacial spillways are most often found in association with the exposed bedrock of the uplands (glacial map here?). Valleys are filled with the stratified drift deposits (sands, gravels and lake/pond deposits) that issued from the last glacier as it retreated northward. Five former ice positions are marked by ice-contact stratified drift deposits that lie in the valley between Hamburg Cove and Rte. 82. Eskers and Kettles occur in several locations but exemplary examples of these passive ice features are found in the Pleasant Valley Preserve. Open fields adjacent to Rte.156 (just north of Hamburg Cove and in the pleasant valley area) and Rte. 82 (in the North Plain area) afford a very nice example of the "eggs in basket" topography that the game of golf was invented on in Scotland. Just down the street an exaggerated man-made form of this glacial topography has been recreated for the Fox Hopyard course.

Appendix 4

Outstanding Resource Value Report: Unique Species & Natural Communities

Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Value:
Unique Species and Natural Communities
1/4/03 (authored by William H. Moorhead III)

Summary Report of Eightmile River Watershed Rare Plant and Community Survey - 19 Jun – 27 Oct 2003

William H. Moorhead III
Submitted 4 Jan 2004

Introduction.

The report presents a condensed summary and interpretation of a survey of the Eightmile River watershed for rare plant and significant natural community occurrences, conducted by me from 19 June – 27 October 2003. A more detailed summary has been prepared, in the from of a digital Microsoft EXCEL spreadsheet entitled “Site Survey Summary – 8mile River Watershed 2003.xls”, which includes a summary of individual site survey results is broken down into 17 parameters. These cover different classes of significant species and natural communities looked for and not found as well as those found at the site, an invasive species control urgency rank subjectively assigned to the site, together with explanatory comments, and comments on other site management concerns and issues. An explanation of the invasive control urgency ranks is appended to the Site Survey Summary EXCEL spreadsheet.

Results of the rare plant survey.

The total of new[1] locations/occurrences of State-listed rare plants documented by the survey was 27 occurrences (29, including occurrences of species to be delisted in 2004), which approximately doubles the number of extant occurrences known in the Eightmile watershed. These new occurrences include 5 State-Endangered, 1 State-Threatened, and 12 State-Special Concern plant species (using proposed new species listing statuses to go into effect in 2004). A breakdown by species is presented below in Table 1. Eleven of these species are also New England regional rare species[2], and several of these occurrences are of regional significance (see Comments column of table 1). The Eightmile River watershed can now be said to host:

- most of the plants still known to exist in New England of *Scutellaria integrifolia*;
- the most robust occurrences of *Aristolochia serpentaria*, perhaps also the majority of plants known in New England;
- the majority of the known CT occurrences of *Xyris smalliana*.

[1] i.e., new to the CT-DEP-Natural Diversity Data Base (CT-DEP-NDDB)
[2] Brumback W. E., L. J. Mehrhoff, R. W. Enser, S. C. Gawler, R. G. Popp, P. Somers, D. D. Sperduto, W. D. Countryman, and C. B. Hellquist. 1996. *Flora Conservanda*: New England. The New England Plant Conservation Program (NEPCoP) list of plants in need of conservation. *Rhodora* 98: 233-361.

In other words, the Eightmile River watershed is a New England regional stronghold for these three plants of regional conservation concern.

There are no known previous records from the study area towns for 7 of the State-listed plants documented by this survey: *Acalypha virginica, Arsitida longespica, Carex hirsutella*, *Desmodium glabellum*, *Lespedeza repens*, *Salix petiolaris*, and *Vitis novae-angliae*. Four species documented in the study area were known only historically from the 5-town area: *Asclepias purpurascens* (last documented 1917), *Scleria triglomerata* (1907), and *Carex bushii* (1926), and *Silene stellata* (1895).

As of June 2003, the Connecticut Natural Diversity Data Base (CT-DEP-NDDB) had 26 extant State-listed plant occurrences mapped in the Eightmile watershed. This survey has added to that at least 27 new locations/occurrences. **This brings the total of known extant State-listed plant occurrences in the watershed to about 54 occurrences** (including one historic occurrence of State-Special Concern *Oxalis violacea* rediscovered earlier this year by NEPCoP staff and volunteers; there may be additional discoveries by other botanists in the watershed this past year of which I am unaware). I suspect that this ratio of extant rare plant occurrences to unit area ranks the Eightmile River watershed among the highest in Connecticut[3].

This survey also revisited/updated 7 of the 26 previously documented rare plant occurrences in the watershed. Seven occurrences of 7 State-listed plants, including **2 occurrences of 2 globally rare plant species**, were confirmed to still be extant in 2003. Thus this survey documented the existence of 34 out of the 54 total rare plant occurrences currently believed to be extant in the Eightmile watershed.

In my best professional judgment, it is reasonable to estimate that based on this survey's ratio of effort (a relatively modest 21 field days) to the number of new discoveries (27 rare plant occurrences), the real number of State-listed and regionally rare plant occurrences in the study area is probably at least 50% higher than the current total now known for the watershed. In considering the implications of this, it is important to realize that the majority of the occurrences discovered by this survey will likely not persist without some form of habitat management/disturbance/manipulation by man. Several of these occurrences (e.g., those of *Scleria triglomerata*, *Asclepias pupurascens*, *Lespedeza repens*, *Liparis liliifolia*, *Xyris smalliana*) may be viewed as having been discovered just in the nick to time to prevent their imminent loss. Likewise, several priority natural communities were identified which are still intact and of high quality but threatened by one or more of the following: invasives, beaver activity, deer over-browse, lack of management or less-than-optimal management, and in some cases lack of protection. The timely recognition of these community occurrences' management and protection needs makes their continued existence more likely.

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[3] a precise ranking of the watershed with respect to htis parameter may be available from the CT-DEP-NDDB

Table 1. Summary of State-listed plant occurrences documented by this survey in the Eightmile River watershed (19 Jun – 27 Oct 2003).

Taxon	Common Name	Number of new occurences (i.e., previously unknown to CT-DEP-NDDB)	Current CT State-listing Status (per 1998 list revision)	Proposed new CT State-listing status (to go into effect in 2004)	Comments/significance of occurrences[4]
Acalypha virginica	Virginia Copperleaf	1	Special Concern (historic)	Special Concern	Four other extant occurrences known in CT.
Aristida longespica	Needlegrass	1	Special Concern	Special Concern	
Aristolochia serpentaria	Virginia Snakeroot	1[3]	Threatened	Special Concern	New England regional rarity: at est. several hundred plants, this Lyme occurrence is largest known in N.E. Most other known occurrences have only a handfull of individuals.
Asclepias purpurascens	Purple Milkweed	2	Special Concern (historic)	Special Concern	New England regional rarity. These 2 occurrences bring total known extant New England occurrences to ~8.
Asplenium montanum	Mountain Spleenwort	2	Threatened	Threatened	New England regional rarity. The addition of these new discoveries to the previously documented one creates a meta-occurrence associated with the "escarpment" ecological landscape unit, and there are likely additional suboccurrences, perhaps throughout the "escarpment" unit. This is therefore arguably a New England stronghold for this species.

Table 1. Summary of State-listed plant occurrences documented by this survey in the Eightmile River watershed (19 Jun – 27 Oct 2003).

Taxon	Common Name	Number of new occurences (i.e., previously unknown to CT-DEP-NDDB)	Current CT State-listing Status (per 1998 list revision)	Proposed new CT State-listing status (to go into effect in 2004)	Comments/significance of occurrences[4]
Carex bushii	Bush's sedge	4[2]	Special Concern	Special Concern	New England regional rarity and tracked as a rare species in most of the eastern U.S.[5]; at several hundred plants each, two of the new Salem populations are apparently the largest known in CT. Most other known occurrences have no more than a few several tens of individuals.
Carex hirsutella	a sedge	2	Special Concern	Proposed to be delisted	
Desmodium glabellum	Dillen's Tick-trefoil	2	Special Concern (historic)	Special Concern	New England regional rarity. One of these new occurrences is large/exemplary.
Hydrocotyle umbellata		1	Endangered	Endangered	Robust population
Lespedeza repens	Creeping Bush-clover	1	Special Concern	Special Concern	New England regional rarity; only one other population known extant in CT and New England. This species is probably the rarest plant on this list, in terms of numbers of known occurrences in New England.
Liparis liliifolia	Lily-leaved Twayblade	1	Endangered	Endangered	New England regional rarity. This find brings total known extant CT occurrences to ~4.

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Taxon	Common Name	Number of new occurences (i.e., previously unknown to CT-DEP-NDDB)	Current CT State-listing Status (per 1998 list revision)	Proposed new CT State-listing status (to go into effect in 2004)	Comments/significance of occurrences[4]
Lycopus amplectens	Clasping-leaved Water-horehound	2	Special Concern	Special Concern	Both are robust populations
Mimulus alatus	Winged Monkey-flower	1	Special Concern	Special Concern	New England regional rarity
Podostemum ceratophyllum	Threadfoot	1	Special Concern	Special Concern	
Salix petiolaris	Slender Willow	1	Special Concern (historic)	Special Concern (historic)[1]	
Scleria triglomerata	Nutrush	1	Endangered	Endangered	One of ~3 known extant occurrences in CT
Scutellaria integrifolia	Hyssop Skullcap	1	Endangered	Endangered	New England regional rarity: this find makes total for New England ~3 known extant occurrences. Two of these occurrences are in the Eightmile River watershed.

Table 1. Summary of State-listed plant occurrences documented by this survey in the Eightmile River watershed (19 Jun – 27 Oct 2003).

Taxon	**Common Name**	**Number of new occurences** (i.e., previously unknown to CT-DEP-NDDB)	**Current CT State-listing Status (per 1998 list revision)**	**Proposed new CT State-listing status (to go into effect in 2004)**	**Comments/significance of occurrences**[4]
Silene stellata	Starry campion	1	Special Concern	Special Concern	New England regional rarity. Ca. 4 other extant occurrences known in CT and New England.
Vitis novae-angliae	New England Grape	1	Special Concern	Special Concern	
Xyris smallianana	Small's Yellow-eyed Grass	1	Endangered	Endangered	New England regional rarity; Eightmile watershed hosts 3 of the ~5 known occurrences in CT
TOTAL NEW STATE-LISTED PLANT OCCURRENCES		**29** (**27**, minus occurrences of a species proposed for delisting)			

Table 1. Summary of State-listed plant occurrences documented by this survey in the Eightmile River watershed (19 Jun – 27 Oct 2003).

Taxon	Common Name	Number of new occurences (i.e., previously unknown to CT-DEP-NDDB)	Current CT State-listing Status (per 1998 list revision)	Proposed new CT State-listing status (to go into effect in 2004)	Comments/significance of occurrences[4]

[1] this/these tentatively identified *Salix petiolaris* discoveries in the Eightmile watershed do not represent the first recent CT records for this species, as the proposed continued "historic" status for this species implies; several other CT occurrences were reported in 2002 and 2003; it is unclear why the species is still listed as "historic".

[2] one of these occurrences was discovered and reported to me by Casper Ultee, Connecticut Botanical Society

[3] site originally found by Lepidopterists

[4] information presented here on species' total numbers of occurrences in CT, New England, and U.S. is for the most part not more current than the beginning of 2003; *before using/quoting these statements in other documents state heritage programs and NatureServe should be consulted for the most up-to-date information*

[5] NatureServe. 2003. NatureServe Explorer: An online encyclopedia of life [web application]. Version 1.8 Natureserve, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: Jan. 3, 2004)

Significant natural community occurrences.

Approximately 100 occurrences of natural communities in the watershed were identified as "significant" and documented by this survey (summarized in Table 2). Communities were deemed significant on the basis of rarity, uncommonness or restricted occurrence (factoring in threats, and rate and magnitude of decline over last century), high native-species-richness (often including multiple rare and uncommon plant species), and/or exemplary character and/or condition (especially with respect to relative prominence of exotic and/or invasive species). Each natural community occurrence was assigned a biodiversity significance rank on a scale of 1 (Very High) to 4 (Moderate) or 5 (Exemplary) or 6 (Arguable). The following is a breakdown of the 100 natural communities by biodiversity rank:

1.	Very High	7 occurrences
2.	High	11 occurrences
3.	Moderate-High	10 occurrences
4.	Moderate	34 occurrences
5.	Exemplary	18 occurrences
6.	Arguable	20 occurrences

All significant natural community occurrences were classified using Metzler and Barrett's "Vegetation classification of Connecticut"[4].

Among what I believe must be considered the potentially most important biodiversity features of Eightmile River watershed is the extensive meta-occurrence of so-called "warm-season" grasslands, which include, more frequently, little bluestem (*Schizachyrium scoparium*)- and/or *Carex pensylvanica*-dominated grasslands, and, less frequently, big bluestem (*Andropogon gerardii*)-dominated "prairies". These dry to seasonally wet/dry grasslands, which require periodic anthropogenic disturbance (fire or mowing) to persist as open-canopy communities, represent among other things an important reservoir of native genotypes of grass species whose seeds of non-local origin are purchased and planted at considerable expense by land managers in efforts to create warm-season grassland habitat by around New England. There appears to be a strong correlation between the occurrence and prominence of the tall-grass prairie species (i.e., *Andropogon gerardii*, *Sorgastrum nutans*, *Tridens flavus*, etc.) and the occurrence of rare and uncommon herbaceous species, and a similar, but somewhat weaker, correlation between little bluestem (*Schizachyrium scoparium*)-dominated grasslands and the occurrence of rare and uncommon herbaceous species.

[4] Metzler, K. J., and J. P. Barrett. 2003. Vegetation classification for Connecticut. Draft 07/11/03. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection. Hartford, CT. 135 pp.

Table 2. Summary of significant natural communities documented by this survey in the Eightmile River watershed (19 June – 27 October 2003).

Natural Community/Natural Community group/other designation	**No. Occur-rences**	**Biodiversity Significance Rank[s] (1=highest, 6 lowest)**	**Rationale for Assigning Significance**	**Rare Plant Habitat (Actual/Potential/Negligible)**
Freshwater Intertidal Flats	2	1-2	Recognized globally rare (G2) vegetation alliance	Actual (including 2 globally rare species [G2, G3]) and potential
Freshwater Tidal Marsh	3	1-4	Uncommon/restricted to rare community (one or more may be globally rare)	Actual (including 1 globally rare species [G2]) and potential
Dry rich cedar-dogwood forb/Carex pensylvanica savannas	1 meta-occurrence	1	Rare or uncommon community; host concentrations of rare and uncommon plants with robust populations	Actual and potential
Floating seasonally flooded peat flat community	1 meta-occurrence	1	Rare (possibly globally rare) community; hosts multiple rare plants with robust populations	Actual and potential
Fresh-spring-tidal wet meadow/acidic, sandy seasonally saturated meadow	1	1	Rare (possibly globally rare) community; hosts two regionally rare plants and several uncommon species	Actual
Big bluestem prairies	3	2	Uncommon or rare community	Actual and Potential
Sandy, acidic, seasonally saturated and/or inundated meadowmeadows	7	2-4	Rare or uncommon community, threatened without management	Potential

Table 2. Summary of significant natural communities documented by this survey in the Eightmile River watershed (19 June – 27 October 2003).

Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Wet meadows and scrubby seasonally wet meadows of Thick Till landscape in Salem	2	2	High native plant diversity including multiple rare and uncommon species; rarity?	Actual
Sand Barrens, dry grasslands, dry acid cedar savannas, and acid oak woodlands	34	2-6 (ave: 4)	Uncommon community, at least as large meta-occurrence, threatened without management	Actual and potential (global rarities among potentials)
Medium and Poor Fens	6	3-6	Rare or uncommon community	Actual and potential
Ice talus forest	1	3	Rare or uncommon community	Potential
Acidic cliffs	1 large meta-occurrence	3	Exemplary meta-occurrence	Actual and potential
Open and semi-open Acidic Rocky Summit/Outcrop communities	2	3-4	Rare or uncommon community	Potential
Acidic Atlantic White Cedar Basin Swamp	1	4	Uncommon/restricted community	Actual and potential

Table 2. Summary of significant natural communities documented by this survey in the Eightmile River watershed (19 June – 27 October 2003).

Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Acidic Spring Fen	3	4	Uncommon/restricted community	Potential
Subacidic Rocky Summit/Outcrop communities	1	4	Rare or uncommon community	Potential (global rarities among potentials)
Dry Subacidic Forests	4	3-4	Rare or uncommon community	Actual and potential (global rarities among potentials)
Old-age ravine hemlock forest	1	5	Exemplary	Probably negligible
Mature swamp white oak forest swamp	1	5	Arguably exemplary (large, with many large oaks)	Potential
Vernal pool communities and related draw-down swamp forests and woodlands	9	5	Exemplary	Potential for some, negligible in others
Basin Marsh	2	5	Exemplary	Potential
Riverside Seep/Riverbank Beach/Shore Community	1 meta-occurrence	5	Exemplary	Potential
Acidic Seepage Forests and Swamps	3	5-6	Exemplary	Potential

Table 2. Summary of significant natural communities documented by this survey in the Eightmile River watershed (19 June – 27 October 2003).

Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Assorted other common types of wet/seasonally wet meadows, fens, marshes and shrub swamps	7	5-6	Exemplary	Actual and potential
Acer-Fraxinus-Hepatica forests	2	2-4	Host rare and uncommon plants; may be uncommon or rare community	Actual and potential

Acknowledgements.

I am indebted to the following people for their assistance in the execution of this survey and the interpretation of the watershed's botany and ecology: Kevin Case, Ken Geissler, David Bingham, Rich Chyinski, Tony Irving, Chris Mangels, Mark Carabetta, Nathan Froeling, Karen Zyko, Ken Metzler, Nancy Murray, Nels Barrett, Juliana Barrett, Casper Ultee, Eleanor Saulys, Emery Gluck, Paul Rothbart, Ann Kilpatrick, Bill Brumback, Elizabeth Farnsworth, Chris Mattrick, Glen Dreyer, Andrew Doran, Mike Thomas, Dave Wagner, Jim Ventres, Sue Merrow, George Corbiel, Joan "Ning" Rich, and Arron Reneson. Organizations represented by the above-mentioned people, and owed thanks, include: Eightmile River Wild & Scenic Study Committee, U.S. National Park Service, Salem Land Trust, Lyme Land Trust, The Nature Conservancy, Connecticut Department of Environmental Protection, U.S. Natural Resources Conservation Service, Connecticut Botanical Society, New England Wildflower Society, University of Connecticut's Evolution and Environmental Biology Department and the George Safford Torrey Herbarium, Connecticut College, the town governments of East Haddam, Lyme, and Salem, and the East Haddam Fish and Game Club. Critical taxonomic assistance was provided gratis by Arthur Haines of Maine. Several of the above-listed people put in considerable time and effort to secure permissions to access private parcels for survey from landowners with whom I did not interact personally and whose names I did not learn, in many cases - I am grateful to both groups of people. Finally, I offer my sincere thanks and appreciation to all the landowners with whom I interacted personally and who graciously allowed me to survey their property.

Appendix 5

Outstanding Resource Value Report: The Cultural Landscape

Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Value:
Cultural Landscape
November 2004

Authored by Lauren Todd, UMASS Amherst

The following report is also available in its original color format from www.eightmileriver.org.

The Eightmile River Watershed

A Cultural Landscape Study

The Eightmile River Watershed

A Cultural Landscape Study

University of Massachusetts Amherst
National Park Service
November 2004

Cover: Eightmile River Watershed, October 2004. Courtesy: National Park Service.

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PREFACE

The National Park Service (NPS) is currently conducting a Wild and Scenic River designation study for the Eightmile River watershed in southern Connecticut, which includes parts of the three towns of Salem, East Haddam, and Lyme. The University of Massachusetts, Department of Landscape Architecture and Regional Planning, has produced this cultural landscape study in order to document, analyze, and assess the significance of the watershed as a cultural landscape. The assessment of the cultural values and resources in the region will complement and enhance the natural resource studies and reports that are currently in progress. This cultural landscape study has employed a synthesized methodology, based on NPS guidelines for documenting and analyzing cultural landscape features and characteristics.

The NPS is currently reviewing natural resource values of the Eightmile River watershed in terms of their statewide significance as unique, rare, or exemplary. This report assesses the significance of the cultural landscape of the Eightmile River watershed in a statewide context. The documentation and analysis presented here is also intended to be a source of information and analysis for residents and town officials making future land management decisions.

This project was made possible by the National Park Service, the Eightmile River Wild and Scenic Study Committee, and many concerned citizens of the Eightmile River watershed, who contributed their time and advice.

Special thanks to Carolyn Bacdayan of Lyme and David Bingham of Salem, both of whom generously shared their knowledge and history of the watershed.

Assistance and advice was also provided by: Anita Ballek, Ballek Garden Center; Mary Donohue, Architectural Historian, State Historic Preservation Office, Connecticut; Charles Farrow, Rose Farm Gallery; Elizabeth Farrow, Florence Griswold Museum; and David Wordell, First President of Salem Historical Society; the East Haddam Historical Society; the Lyme Historical Society; the Salem Historical Society; the Salem Library; and the Rathbun Library.

This report was researched and written by Lauren Todd, a Master of Landscape Architecture student at the University of Massachusetts Amherst, who also drew many of the maps and diagrams. Her work was supervised by Professor Ethan Carr, Department of Landscape Architecture and Regional Planning, University of Massachusetts Amherst, and Kevin Case, National Park Service.

INTRODUCTION

FIG 1. A Landscape Mosaic
The cultural landscape of the Eightmile River watershed is a mosaic of buildings, roads, agricultural fields, water features, and forest, all shaped and influenced by human history and interaction with the land and natural processes.

The landscape of the Eightmile River watershed is far from an untouched wilderness. The scenery that we see today, which is overwhelmingly a mosaic of successional forest and human settlement, is a product of thousands of years of human interaction with the land. The watershed is full of diverse ecological patterns and is rich in cultural history. This document offers an overview of the human relationship with the Eightmile River landscape and the patterns that have evolved as a result of the enduring connection between people and the land. For the purpose of this project, a "cultural landscape" is defined as a geographic area, including both cultural and natural resources, associated with a historical event, activity, or person or exhibiting other cultural and aesthetic values.[1]

PART ONE

CONTEXTUAL HISTORY

FIG 2. Aerial View of Forest Succession, Eightmile River Watershed, 2004

The Eightmile River watershed has gone through dramatic landscape transitions over the past 400 years. The forested landscape familiar to Native Americans was transformed into agricultural fields, pastureland, and woodlots with the arrival of the European settlers. By the end of the 19th century, a second major transition was caused by the widespread abandonment of agriculture, resulting in the successional hardwood forest seen today.

The name of the Eightmile River refers to the location of the river's mouth, which flows into the Connecticut River eight miles above Long Island Sound. The watershed is located approximately 30 miles south of Hartford, Connecticut and occupies 62 square miles (approximately 40,000 acres) in the eastern coastal slope and eastern upland regions of southern Connecticut. The watershed encompasses large portions of the towns of East Haddam, Lyme, and Salem.

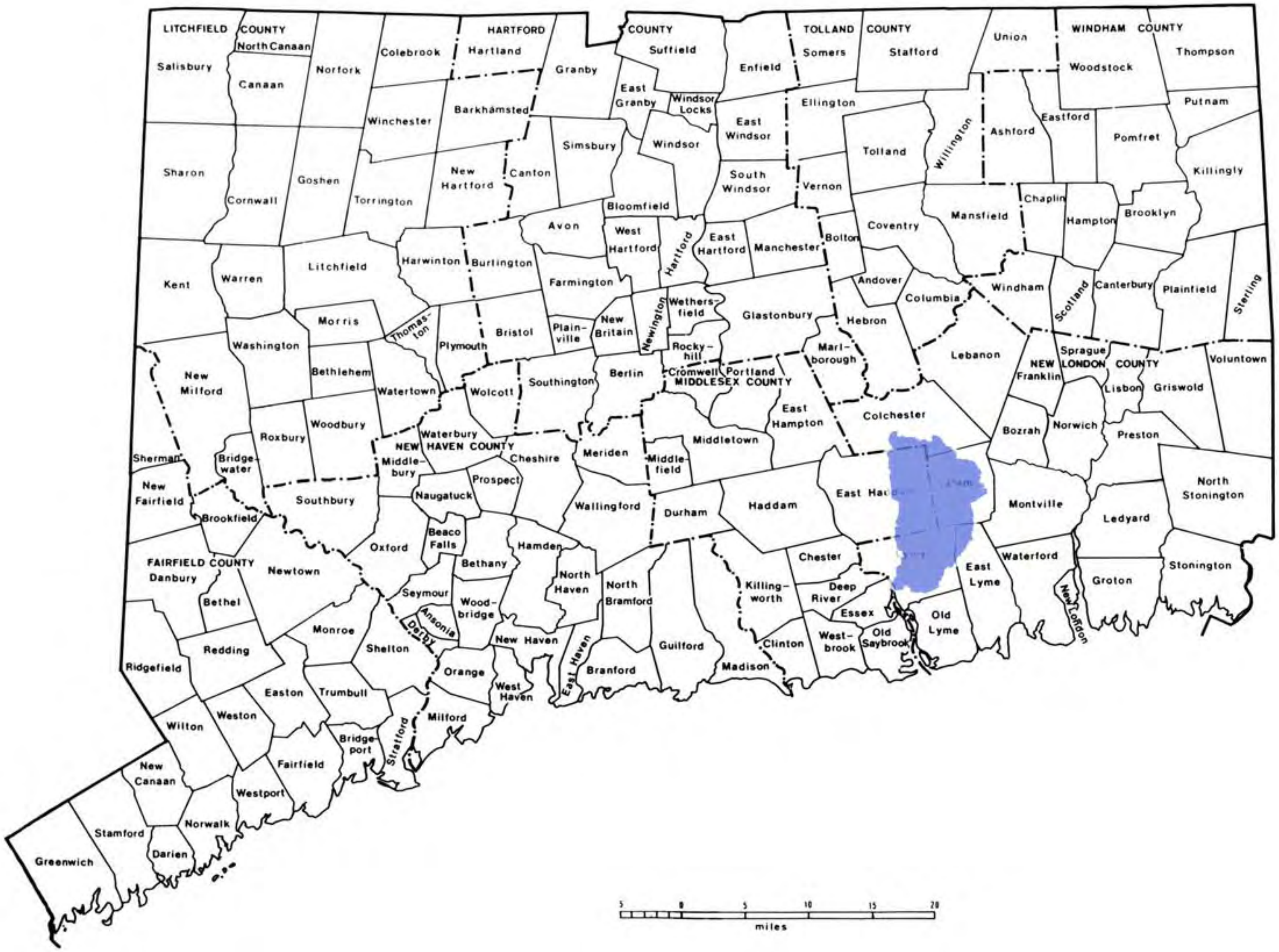

FIG 3. Statewide Context
The Eightmile River watershed is approximately 62 square miles and includes the towns of East Haddam, Lyme, Salem and a small portion of Colchester and East Lyme.

FIG 4. The Eightmile River Watershed
Ninety percent of the watershed is comprised of the towns of East Haddam, Lyme, and Salem.

Native American Settlement

This report addresses the impact of human settlement within the Eightmile River watershed that has affected the visual character of the physical features of the watershed landscape. Native American settlement within the watershed left minimal footprints on the present-day landscape, but began at least as early as the Middle Archaic Period (c. 6,000-4,000 BC).[2] Archaeological evidence of Native American settlement in the watershed is typically found close to fresh water, and on well-drained, sandy terraces and knolls. Native American settlements within the watershed are believed to have relied on geographic mobility, with settlement sites and movement dependent generally on the seasons. European land-use practices, such as clearing and lumbering, and new ownership boundaries inhibited Native American settlement patterns and disrupted tribal structure. European presence in the watershed caused Native Americans to become less nomadic and depleted many staple resources such as game and forest products.

Archaeological Integrity

This study does not include a survey of existing or potential archaeological resources. More information about the Eightmile River watershed's archaeological resources can be found in the 2004 report by Dr. Marc L. Banks and Dr. Lucianne S. Lavin, "Assessment of the Eight Mile River's Archaeological Resources." However, it is important to note that archaeologists have identified the mouth of the Connecticut River as an area with particular potential for intact archaeological sites. According to Banks and Lavin, "The land bordering the river has a high potential for intact archaeological resources, as the landscape has been less impacted by historic activities and development."[3] The topography, past land use, and delayed modern development contribute to a unique watershed landscape. The potential for intact archaeological sites within the watershed distinguishes the Eightmile River.

Early Settlement and Agriculture

Early settlement in the watershed was primarily influenced by English tradition, and the Puritan vision of communities in which individuals would settle close together, for protection and social control. Groups of settlers were granted permission from the General Court of the Connecticut Colony to settle and occupy certain parcels of land.[4] Configurations of the towns within the watershed varied, but often resulted in settlement patterns of colonial village-centered development, which soon evolved into dispersed farmsteads.

Town settlement in the watershed revolved primarily around agriculture. A village or town center was laid out around the town common, with an adjacent meetinghouse and house lots. Agricultural fields for cultivation, haying, and grazing were then organized, usually radiating around the town center. As the populations of the town centers grew, new holdings or farmsteads farther from the town centers were settled. The widespread, dispersed settlement pattern of farmsteads separated by agricultural lands made weekly attendance at religious services difficult for those living far away from the town centers. As a result, many farmsteads and settlements diverged from the original town centers or colonies, forming new towns with their own established meetinghouses. This is how the town center of Lyme, for example, was founded in 1665, as a new parish of the original Saybrook Colony. Similarly, the First Ecclesiastical Society was granted in East Haddam in 1700, and New Salem Parish was established in 1725. Transportation networks, mainly dirt roads or farm tracks, connected these dispersed farmsteads to one another, to town centers, and to coastal trading ports.

Along with agriculture, shipbuilding was established in the coastal area of Hamburg. Gristmills and sawmills were constructed in order to harness energy from local streams and rivers. Some hamlets grew around the industry of the mills, such as Millington in East Haddam, or Sterling

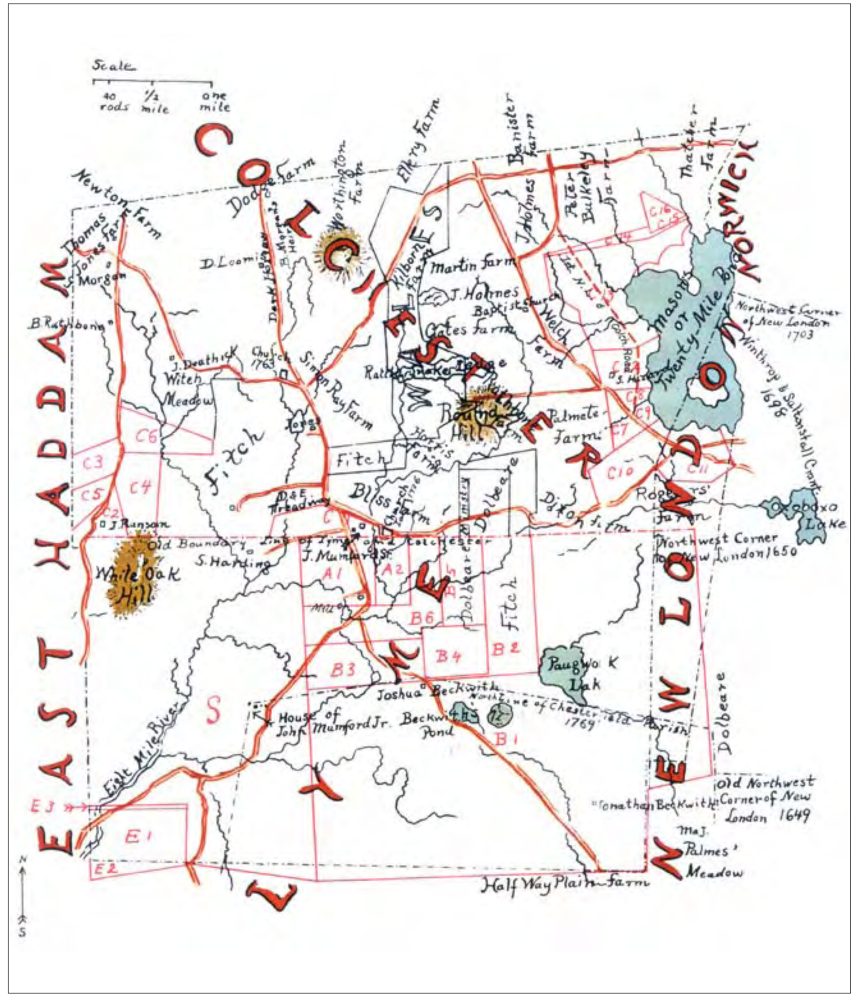

FIG 5. Early Map of Agricultural Land Salem, CT, 1769
This map, taken from *Chronicles of a Connecticut Farm 1769-1905*, demonstrates how patterns of early settlement were based on town-centered development, radiating agricultural land, and scattered farmsteads.

FIG 6. Huckleberry Hill From Candlewood Ledge Hillside, c. 1920s
During the 1920s, there was still open farmland above Hamburg Bridge.

City in Lyme, which developed around the Sterling Mill, established in 1709.[5]

During the colonial period, farmsteads were primarily self-sufficient, providing their own meat, produce, and fiber. However, there was a great amount of dependency between neighboring farms to share their tools and resources, creating a need for roads between farmsteads. Early colonists also readily adopted Native American agricultural practices. Eventually the colonists recognized that many of the Indian crops, such as corn, depleted the soil, and they began to adopt methods of crop rotation in order to replenish fields. Over time, grains such as wheat, rye, and oats were discovered to be better at maintaining the soil's fertility.

Agricultural land was cleared for three different purposes: as either cultivated land for growing crops, pasture land for grazing animals, or "mowings" to produce hay.[6] The early colonial land-use practices of farming, land clearing, and lumbering greatly affected the habitat of native animal and plant species. Colonists depended on trees, such as chestnut, hickory, oak, hemlock, cedar, and white pine for house frames, shingles, clapboards, fence posts, flooring and other uses. White pine was used extensively for the timbers and planking of ships, with the largest pines reserved for the masts of the Royal Navy. The colonists also shipped timber back to England.[7] These extensive lumbering and land clearing processes soon exhausted the native forests. Lumbering and agriculture, combined with fur trapping, had adverse effects on native animal species as well. By the beginning of the 19th century, the entire beaver population in southern New England had been eradicated. This in turn influenced the entire wetland ecosystem by inhibiting wetlands and associated species.

FIG 7. Historical Agriculture in East Haddam
Pasture land and hay field side by side, a typical agricultural landscape during the 19th and early 20th century.

FIG 8. The Beginning of Agricultural Succession
Typical red cedar growth on a former hay field in East Haddam, 1958.

Throughout the late 17th and 18th centuries, the average acreage available for a typical farmstead declined steadily. Farmers could no longer afford to clear new land for fields because land had become scarce due to soil infertility and growing human populations. Much of the rocky and hilly slopes of the Eightmile River watershed were more suitable for grazing, rather than cultivation, and there was an eventual shift to livestock and dairy production from grain crops during the mid 19th century.

Agricultural Abandonment and Forest Succession

By the mid 19th century, agricultural abandonment began throughout the watershed, triggering the processes of vegetative succession. Many farmers were moving to the west in search of more fertile land. Hill farms, which worked the thinnest and poorest soils of the watershed's ridges, were the first to be abandoned. With the rise of industry and manufacturing, agricultural practices were traded for machinery and factory work. Moreover, the machinery being developed at this time for plowing, cultivating, and harvesting was not suitable for the steep, rocky fields of southern Connecticut.

Mowings and hay fields were formerly harvested by hand with scythes, a practice that became less economical as new machinery was adopted. The need for mowings and pasture declined further as agricultural practices switched from animal power to engine power. Reforestation occurred at a steady rate as mowing and grazing declined. As agricultural land was abandoned, species that were growing along field edges and fence rows reseeded in the abandoned fields. By the early 1900s, vast areas of pine and successional forest growth on former agricultural land had established themselves throughout the watershed.

FIG 9. Agricultural Succession in Salem
View of the fields behind the Mumford House in Salem. Today, these fields are being managed to allow for a succession of native species.

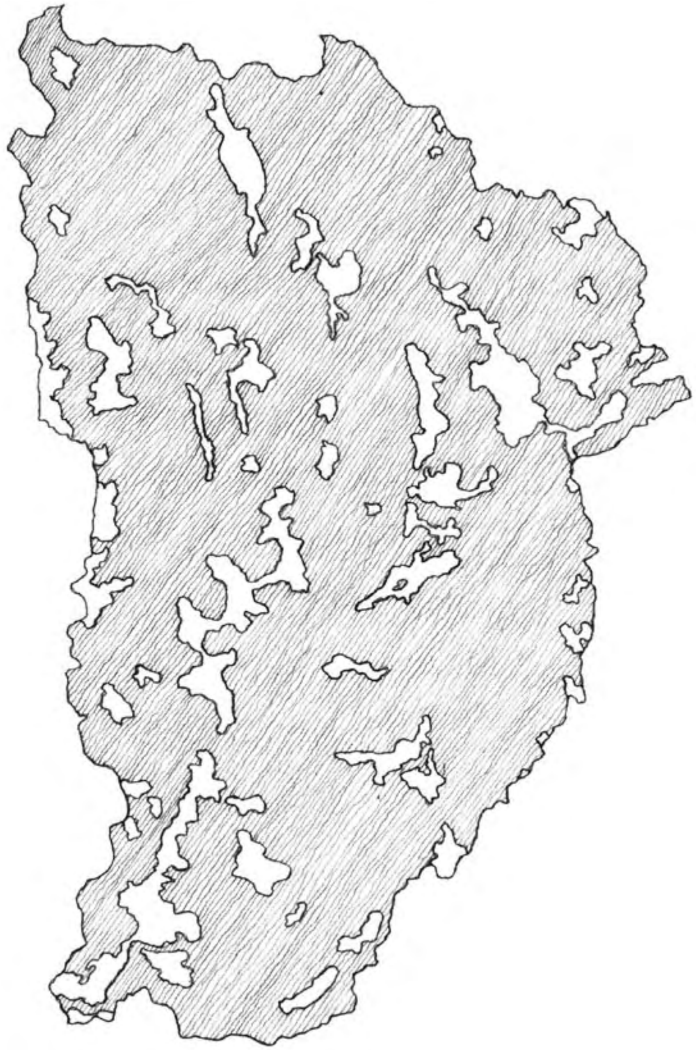

FIG 10. Diagram of Forest Cover by 1934
In the mid 19th century, it is estimated that 50% of the watershed landscape was covered by forest. This diagram of forest cover vs. non-forested land shows that approximately 75% of the watershed was forested by 1934.

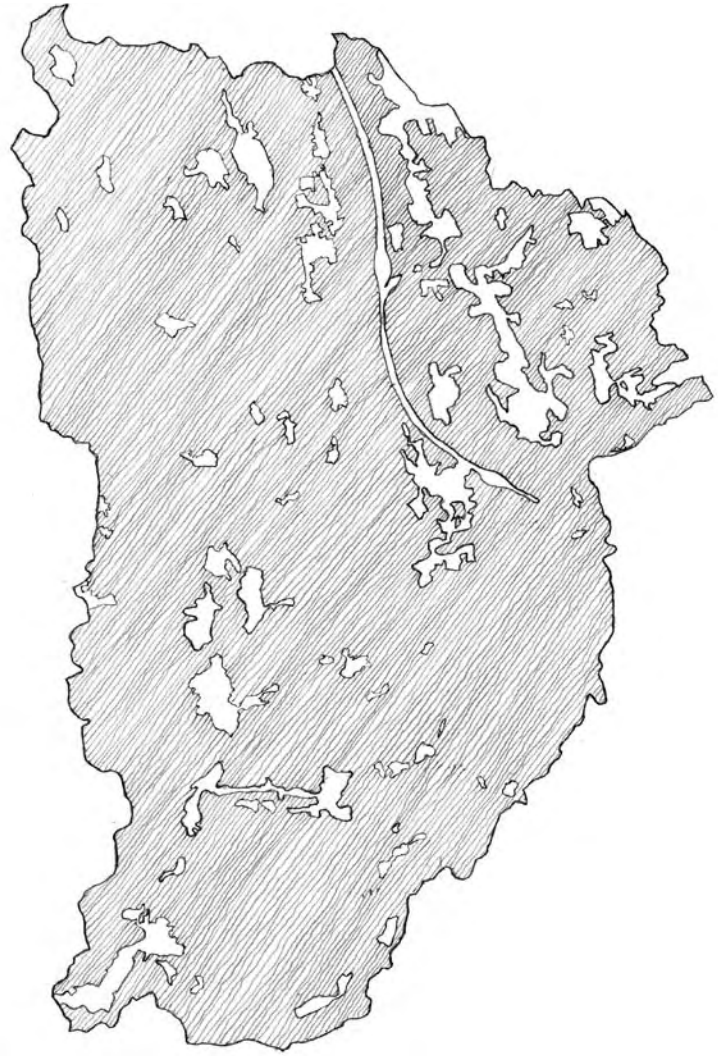

FIG 11. Diagram of Forest Cover by 1995
The patterns of forest cover vs. non-forested land by 1995 show that approximately 90% of the watershed is forested today.

Successional animal species are also linked to the abandonment of agriculture and forest succession. Deer and beaver populations increased in population as a result of the successional woodland habitat that soon covered the majority of the watershed landscape. The beaver was reintroduced to southern Vermont in 1921, and populations spread to all central New England states by 1940.[8] With the absence of trapping and large predators, beavers thrived in broad, flat valley ponds throughout the watershed. Beaver activity fostered biodiversity through the cyclic nature of wetland habitats and ecosystems that they created, and they became an important element of the Eightmile River watershed landscape.

FIG 13. Etching of Hamburg Cove
Note the young successional vegetation on the far hillside and in the foreground.

An Artistic Landscape

An increased aesthetic appreciation of the landscape was juxtaposed with the declining agricultural landscape of the Eightmile River watershed. By the early 20th century, artists came from New York, Hartford, and Chicago,

FIG 12. Music Vale Barn, 2004
A remnant of the 19th century agriculture that occurred at the Music Vale Seminary.

FIG 14. Sailing at Hamburg Cove
The picturesque and romantic qualities of the Cove are emphasized with the exaggerated slopes of the surrounding landscape and the reflections in the water.

and an artist's "colony" at Old Lyme was established. Over time, the artists at the Lyme Art Colony developed a relationship with the surrounding rural landscape as the subject of their paintings and drawings. By painting such scenes as Hamburg Cove, Tiffany Farm, and Czikowsky Barn, painters during this period created a sense of permanence in a rapidly changing landscape. Their work celebrated all aspects of New England rural life and helped preserve and create a sense of place out of the rock outcrops, grazing animals, agricultural fields, and scenic waterways within and around the Eightmile River watershed. Today, many of these paintings and artworks can be seen at the Florence Griswold Museum in Old Lyme, CT. Visitors to the Museum can explore where the artists lived and worked and experience the Connecticut landscape that inspired many of the works.

A precursor to the artistic influx of the early 20th century was the presence of a music school within the watershed. During the mid 19th century, the town of Salem became nationally recognized as a cultural center for music under Oramel Whittlesey, who founded the Music Vale Seminary and Normal Academy of Music in 1835. The Seminary was the first of its kind in the United States to confer degrees. The students of the Seminary provided their own sustenance through agricultural practices located on the property. The Whittlesey family manufactured pianofortes out of their factory in Salem, on the present-day site of the Salem Firehouse. This unique cultural arts center combined performance and craftsmanship with the agrarian lifestyle that is characteristic of the watershed's history.

Conclusion

Today, the Eightmile River watershed landscape contains features from many layers of cultural history. The most recent layers of history often contain the most visible features to residents today, since many historic footprints and features remain hidden behind trees or within dense successional forest. The process of agricultural succession is still occurring across the watershed landscape. However, there are many characteristic features and elements of the cultural landscape throughout the watershed, especially buildings, road corridors, and overall patterns of development that are remarkably intact and retain integrity to their 17th, 18th, and 19th century origins.

FIG 15. A Cultural Landscape
Hedgerows and field patterns are well-defined by successional forest growth.

The Eightmile River watershed has not developed in the same manner as areas near the mouths of great rivers such as the Hudson or the Delaware. The shifting mouth of Connecticut River, tidal currents, and sand accumulation prevented a major harbor from ever developing. Without a major harbor and associated industry, the towns upstream and around the river never had the population or industrial growth seen in areas such as New York City or Philadelphia. The steep slopes and rocky terrain limited access to the watershed towns, preventing railroad development, which in turn again limited industrial growth and population. Moreover, rocky terrain and unique geology also inhibited the extent of cultivation of farmland within the watershed, and heavy machinery could not be used on the saturated, low-lying fields adjacent to the Eightmile River and its branches. As a result, today the watershed has had a different land-use history than other areas similarly situated near the mouth of a great river. The area has also been less affected by 20th century suburban sprawl. The entire region around the mouth of the Connecticut River gives unique insight into a landscape that has had a very different history than most of southern New England, particularly on the coast and near the mouths of large rivers. The Eightmile River watershed constitutes an important and intact component of the regional landscape.

Landscape Features and Characteristics

The cultural landscape of the Eightmile River watershed can be described in terms of landscape features and characteristics, which give the watershed its historic character. This portion of the report will look more closely at the landscape characteristics of settlement patterns, circulation, vegetation, buildings, structures, sites, and spatial organization in order to ana-

FIG 16. Old Patterns of Circulation
Views of the abandoned farm road running between the Mumford House and Route 82.

FIG 17. Typical Road in Watershed
Smaller roads within the watershed are typically hilly, narrow, and windy, due to the rocky topography.

FIG 18. Open View of Field From Road
A typical view of a "gap" in the vegetation seen from the road. The watershed landscape is dominated by trees, but there are glimpses and sudden views of large expanses of open fields, as seen from the road.

lyze the historic integrity of the watershed landscape as a whole.

Settlement Patterns

There are many patterns of settlement that have occurred throughout the watershed. Most town or village centers were settled on the basis of either agriculture or an associated mill industry. The most characteristic patterns of settlement are those of farmsteads, hamlets, town-centered settlement, and marine-related settlement.

Farmsteads consist of a farmhouse, associated outbuildings, and are surrounded by vast acres of agricultural land. For example, Woodbridge Farm in Salem still manages approximately 150 acres of associated agricultural land and woodlots. These farmsteads are still spread out from one another, and a limited number are still engaged in some form of small-scale agriculture. Most farmsteads throughout the entire watershed however, are occupied as single-family residences.

Hamlets are typically small clusters of (now residential) development, such as Millington Green in East Haddam or Sterling City in Lyme. They operated as centers of commerce, and were settled around the timber and gristmill industry. Located adjacent to streams for water-power, many of the existing mill buildings still retain their 18th and 19th century architecture, yet function as single-family residences.

Salem is a good example of colonial settlement around a town common. The town was built around Salem Green, with the most important social buildings located along the Green. Houses and associated buildings were located around this town common, with agricultural land radiating around the town center. This pattern is still visible today and remains relatively unaltered by 20th century development. Modern use of the automobile has altered the landscape of the Green, requiring most public buildings to accommodate parking. On the whole, the town has made a concerted effort to maintain the historic character of the town center by placing most

FIG 19. Route 11 Overpass, Salem
This portion of the highway, although already built, is not in use.

FIG 20. Route 156, Lyme
Route 156 was recently repaved and widened.

public parking behind buildings.

Colonial settlement along the Eightmile River itself was a result of the maritime commercial activity of the 18^{th} and 19^{th} century. In the area of Hamburg Bridge and Cove, the pattern of settlement, and orientation towards the riverfront was a direct result of the dependence on commerce. In particular, land at the water's edge was not developed, and kept clear for business activity along the wharfs.

All 17^{th}, 18^{th}, and 19^{th} century settlement within the watershed was relatively small scale and clustered, with the exception of the dispersed farmsteads. All town and village-centered development remained close together and was built in similar architectural form. Many buildings, structures, and sites still exhibit these historic settlement patterns and contribute to the historic integrity of the watershed landscape.

Circulation

Winding roads, with patches of open fields interspersed, is the most characteristic description of a watershed road. Stonewalls often line the roads and houses, and 20^{th} century development is often set back from the roads and hidden behind a winding driveway, nestled deep into the woods. The winding roads of the watershed follow the footprints of the web of narrow 17^{th}, 18^{th}, and 19^{th} century roads that connected the dispersed farmsteads to one another, town centers, and coastal trading ports.

Some 20^{th} century circulation patterns, such as Route 11, a multilane highway, are uncharacteristic of the watershed. Route 11 cuts through the northern boundary of watershed, extends through the central region, and stops abruptly at Route 82 in Salem. Plans to finish the highway are still controversial, and the overpass already built above Route 82 remains unused. Main transportation routes, such as Route 156 and Route 82, have been widened since the 19^{th} century. The widening of roads can have many effects on the surrounding community. Route 156 was recently

FIG 21. Wolf Tree in Forest
A lone wolf tree towers over a young succesional forest in Millington.

FIG 22. Looking down to Hamburg Cove Towards Czikowsky Farm Barn
Open farmland along Hamburg Cove, c. 1920s.

FIG 23. Looking down to Hamburg Cove Towards Czikowsky Farm Barn, 2004
Successional growth has completely blocked the view towards the barn, which is in use as a garage for the new residence built beside it.

FIG 24. Reynolds General Store, Lyme

widened and repaved, and residents have observed faster driving, a lack of pedestrian access, and a more dangerous route for bicyclists.

Overall, the pattern of circulation and settlement can be traced to the 18th and 19th century. Although major transportation corridors exist within the watershed, most of the region's roads remain rural in nature. Dirt or unpaved roads, usually remnant farm roads, still exist in numerous places throughout the watershed. Many abandoned roads, such as old Wall Street in Millington, are used as trails for recreation.

Vegetation

There are many remnants of the agricultural past of the watershed that are indicated by the current vegetation. Wolf trees, or wide, low-branching trees, surrounded by a forest of younger trees, recall the agricultural past of the watershed. Wolf trees were left to stand alone as shade trees, when all other surrounding trees were cleared for agriculture. Juniper and red cedar indicate a recently abandoned agricultural field and early succession. Similarly, apple trees and other remnants of farmstead plantings can still be found throughout the woodlands of the watershed.

Because of the widespread abandonment of agriculture and the successional forest growth, much of the landscape that was recorded by artists in the 19th and early 20th century has changed. Today the watershed is approximately 90% successional forest cover. As a result, there has been a significant loss of characteristic views throughout the watershed and the landscape is more enclosed. The land above Hamburg Bridge and Cove was used for agricultural purposes and many views from Candlewood Ledge and Huckleberry Hill were painted by 19th and 20th century artists. A typical picturesque view was the one of Czikowsky Farm barn, looking down to Hamburg Cove. This vista was painted often, but because of forest growth and succession, this famous view has disappeared. The ways in which people today identify with the surrounding landscape has evolved with its progression into a largely forested landscape.

Buildings, Structures, and Sites

Many of the buildings, structures, and sites within the watershed exhibit 18th and 19th century settlement patterns. Many have been adapted to modern functions, but retain historical integrity.

Some buildings sit emphatically on the landscape, recalling the historical character of the place. For example, the First Congregational Church of

Lyme, (Hamburg Church, 1814) is the dominant architectural feature of Hamburg village, sitting on a hill overlooking Hamburg Cove. Similar Greek revival buildings sit on Salem Green, with clapboards painted bright white, located on the east side of the main road.

Stonewalls are a typical New England remnant of a post-agricultural landscape which are common throughout the watershed. Stonewalls are evidence of past agricultural use of the land and are indicators of patterns of past settlement and field layout. Barbed wire was first used during the early 1870s, and its presence throughout the watershed indicates more recent grazing pastures that were still in use into the 20th century.

Cemeteries are significant sites in the Eightmile River watershed. Carolyn Bacdayan, Lyme Public Hall archivist, observes that “cemeteries hold a special importance to the cultural landscape because of their obvious link to the community’s past and because of the uniqueness of the siting, layout, size and individual gravestones of each cemetery.”[9] There are numerous cemeteries throughout the watershed, the earliest dating to the 17th century. Many of the old cemeteries still have strong connections to the surrounding community. Ancestors of families that still reside in the watershed today are buried in the Woodbridge Cemetery in Salem and the North Lyme Cemetery, for example.

There is little commercial activity, and no major supermarket, within the watershed. The largest shopping complex is the strip mall development at Salem Four Corners. This type of suburban development has yet to become a common sight within the watershed. More common are the older businesses of Reynold’s General Store in Lyme, or Salem Valley Farms Ice Cream, which display the more historic, rural character of the area.

FIG 25. Salem Town Green, 2004
The white clapboard buildings are typical of town center buildings within the watershed.

FIG 26. Salem Historical Society, 2004

Spatial Organization

The experience of driving through the landscape of the watershed can be characterized by an overwhelming sense of enclosure, as most of the watershed is forested. Periodically the landscape opens up with views of pastoral, agricultural landscapes. The agricultural division of land is no longer apparent in the majority of areas because most stonewalls have been obscured by vegetation, with the exception of the stonewalls that line the winding roads.

Narrow, winding, rural roads that can be traced to 17th, 18th, and 19th century origins remain a primary means of experiencing the spatial organization of the watershed landscape. The web of roads that still connects colonial farmsteads, hamlets, and town centers remains the dominant form of circulation, as opposed to more major, wider roads such as Route 11. Numerous colonial farmsteads are dispersed throughout the watershed landscape, and are often visually disconnected from major transportation routes, because of successional growth. Many farmsteads still retain agricultural land which also separates the homesteads spatially and visually from other surrounding development.

In addition to dispersed farmsteads, clustered development in villages and hamlets also remains a distinctive spatial organizational feature of the watershed landscape. Millington Green, for example, exhibits tightly-settled residences radiating around common green space. Town commons at Salem and Lyme still have their social buildings located adjacent to the Green, with most buildings and structures dating to the same period. Most modern conveniences such as parking and automobile access have been accommodated to the rear of historic buildings in order to preserve their character.

Modern zoning regulations within the watershed are another contributing factor to contemporary spatial organization. Unlike earlier settlement patterns, most 20th century single-family development requires a larger lot size. Within the watershed, the average single-family lot size is two acres, as opposed to colonial footprints, which were usually clustered around a town common or along the water's edge. Modern development also requires a larger set back from the road, and is usually obscured by woodland, while more historic, 18th and 19th century houses are located closer to the road or riverfront.

Conclusion

As agricultural uses of the land declined and many farms moved west, agricultural practices within the watershed have had to adapt. In particular, a significant decline in dairy and other farms has made way for equestrian farms and riding centers. There has been a dramatic decline in dairy farms in the state of Connecticut since the 1940s, with less than 200 left in the state by 2003. Tiffany Farm, in Lyme, has been operated since 1841 and still operates as a dairy farm today, one of the few large agricultural

FIG 27. Tiffany Farm, 2004
One of the last dairy farms in operation in the Eightmile River watershed.

establishments left in the watershed. The farm consists of 140 acres and has to lease other agricultural fields in Lyme in order to raise enough silage for their cattle. Many farmsteads have become primarily residential, and similarly, many saw and gristmills have been converted into single-family houses.

There are a great number of buildings, structures, and sites within the watershed that have integrity to their 18th and 19th century origins. Nine properties within the Eightmile River watershed have already been recognized as having outstanding historical integrity and are listed in the National Register of Historic Places. Three of the properties (Millington Green Historic District, Hamburg Bridge Historic District, and Salem Historic District) are National Register Historic districts, and two (Woodbridge Farm and the Simon Tiffany House, Salem) are historic buildings. Three structures (bridges in Devil's Hopyard State Park, East Haddam) and one site (Hamburg Cove, Lyme) are listed in the *Lower Connecticut Valley Woodland Period Archaeological Thematic Resource.*

It is difficult to make generalizations about the historical integrity of the Eightmile River watershed as a whole without making it the subject of a much larger, in-depth study. Therefore, it is important to analyze characteristics of specific areas of the watershed in more detail. The next chapter focuses on three cultural landscape study areas that were selected for analysis and assessment. These cultural landscape study areas exhibit landscape features and characteristics that are illustrative and typical of the entire watershed, and will therefore give a better sense of the overall historical integrity of the Eightmile River watershed.

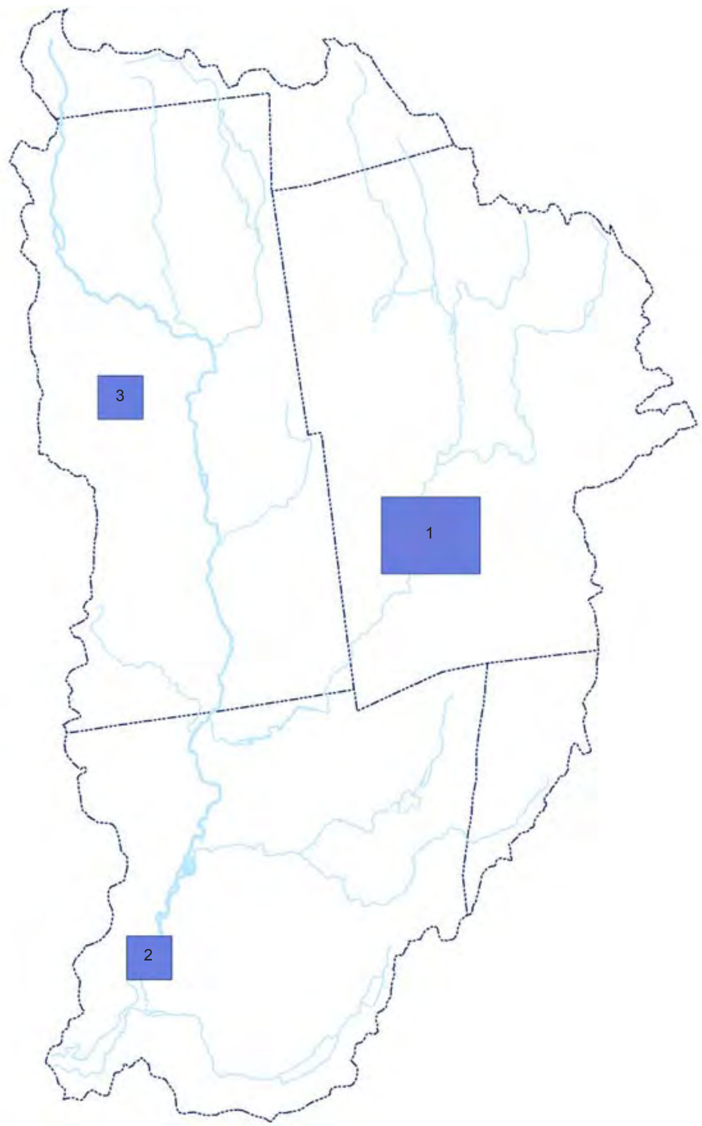

FIG 28. Cultural Landscape Study Areas

The Bingham family properties in Salem (1), Hamburg Bridge in Lyme (2) and Millington Green in East Haddam (3)

PART TWO

CULTURAL LANDSCAPE STUDY AREAS

In order to develop a better sense of the significance of the cultural landscape of the Eightmile River watershed, three study areas were selected for more detailed research. The Bingham family properties in Salem, Hamburg Bridge in Lyme, and Millington Green in East Haddam were chosen through consultation with local residents, historical societies, NPS staff, and State Historic Preservation Office staff. A range of landscape types were represented by the selections. The Bingham family properties are an excellent example of an agricultural landscape. The Hamburg Bridge area is an outstanding example of a historic waterfront settlement. Millington Green is a well-preserved example of an early center of commerce. These three cultural landscapes represent landscape types found throughout the watershed, and illustrate the general character and integrity of the regional landscape.

These three study areas were also chosen because National Register Districts and properties have already been designated within the boundaries of each study area. These three areas have already been recognized as having outstanding cultural resource value to the surrounding watershed.

A series of maps, diagrams and images document how human occupation within the watershed has affected each of the study areas. Patterns of settlement, circulation, and forest cover are analyzed in each study area to understand how these features and characteristics have changed over time. An assessment of the historical integrity of the existing conditions concludes the analysis for each study area.

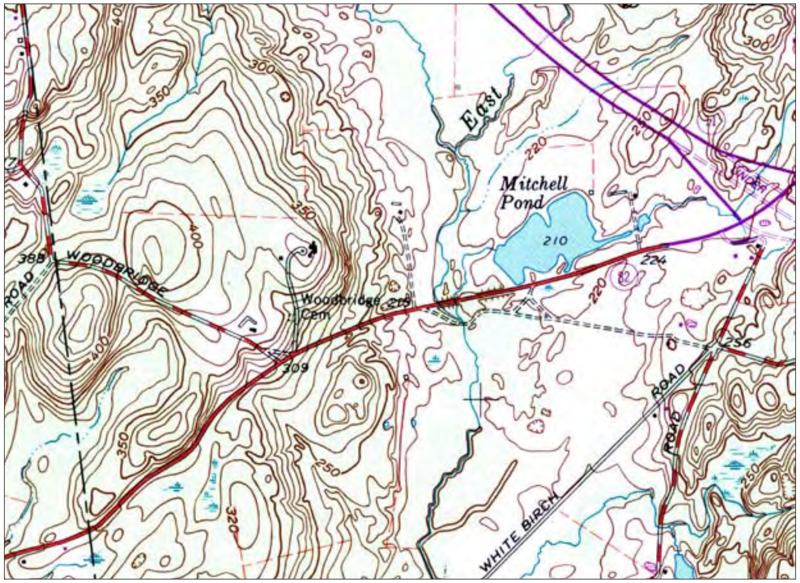

FIG 29. Bingham Family Properties Study Area

An Agricultural Landscape:
The Bingham Family Properties, Salem

The Mumford, Mitchell, Marvel and Woodbridge farms were brought under one ownership by Annie and Alfred Mitchell during the late 1800s. Today, there are six homesteads that include farmhouse and adjacent sites and structures. Mitchell Pond and the Brook Bridge are also part of the Bingham family properties. One property, the Woodbridge Farm, is listed in the National Register of Historic Places. The Bingham family occupies a portion of the buildings, including the Tiffany House and Woodbridge Farm, and leases some of the other properties, such as Marvel and Mitchell Farms. Tenants on these farms maintain the homesteads through agricultural practices such as horse and dairy farming.

Settlement

The Bingham family properties study area is a prime example of the dispersed farmstead pattern, separated by agricultural holdings, that is characteristic of 18th century agricultural settlement in New England. New Salem Parish was established in 1725, and by the mid 1700s the study area was already being used for agriculture. The first farmhouse was constructed by 1769, with an associated barn dating to the 1770s. Both of these buildings are in existence today.

The history of the Bingham farms and homesteads have been richly documented in the book *Chronicles of a Connecticut Farm 1769-1905,* by Mary E. Perkins, first privately printed in 1905. Descriptive maps were drawn to document the evolution of land ownership between the Woodbridge, Shaw, and Browne Estates, which were the former names of the Bingham family properties. These maps, when compared with property boundary maps today, depict changes in property tenure, from multi-family ownership to the present-day single family ownership.

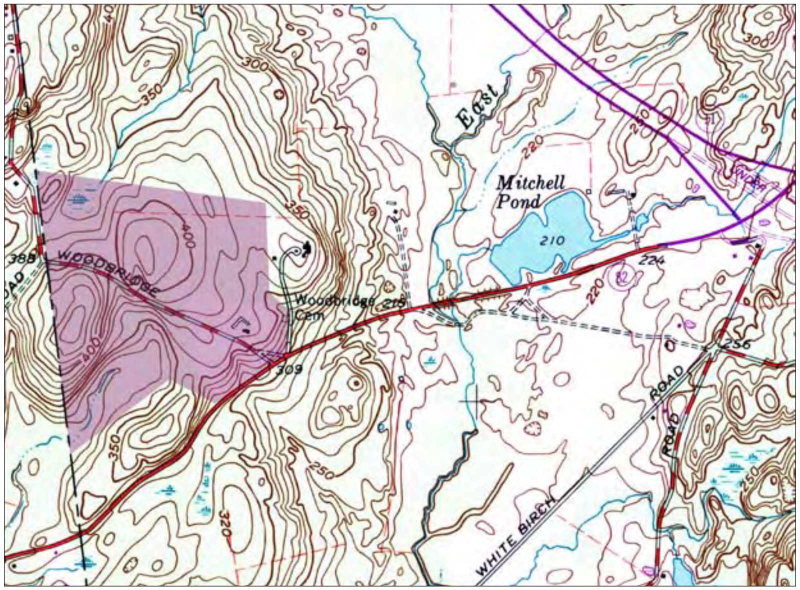

FIG 30. Woodbridge Farm Property, National Register of Historic Places
The Woodbridge Farm district, shown in pink, is currently listed in the National Register of Historic places.

Although property boundaries have changed from individual farmstead ownership to a single-family ownership, the pattern of development within the approximate 1,500 acres of the collective properties can be traced to the late 19th century. The pattern of settlement within this study area was initially dispersed farmsteads, surrounded by working agricultural fields, rather than a town center. The closest town center is Salem Green, approximately 2.5 miles north of the study area. Almost all buildings, including outbuildings such as barns and sheds, date to the 19th century, and some from the 18th century are still in existence.

Circulation

The 19th century pattern of circulation was established in response to the dispersed pattern of early farmsteads. This same road pattern, which still connects the farmsteads to each other, remains virtually unchanged in the 21st century landscape. This webbed pattern of circulation is characteristic of 18th and 19th century farmsteads throughout the watershed. The abandonment of the Mumford Farm road, the paving of roads, and the widening of Route 82 are the most significant circulation changes within the Bingham family properties study area. The basic pattern of circulation remains, although certain road widths and paving have been changed and modernized.

The construction of Route 11 remains the most prominent circulation change in the northern portion of the study area. The multilane highway is uncharacteristic as its footprint is larger than any other transportation corridor in the watershed. Unlike the colonial patterns of circulation, Route 11 does not connect farmsteads or town centers. Instead, it connects areas on a larger, regional scale. Successional growth has provided a visual buffer between the study area and the highway. If Route 11 is completed, it will become a new visual landmark that divides the study area from the center of town.

Vegetation

Vegetation and forest cover can be documented as early as the 1880s from a map of the Woodbridge estate drawn by Donald Mitchell. The most dramatic change in the study area's landscape was the succession to woodland as a result of the abandonment of agricultural activities during the early and mid 20th century. Because the East Branch of the Eightmile River runs through the study area, the land around the Mumford House has always had heavy, wet soil, which combined with the rocky terrain, could not be farmed with heavy machinery. Once agricultural practices became primarily machine operated in the early 20th century, much of the farming of the Mumford land ceased.

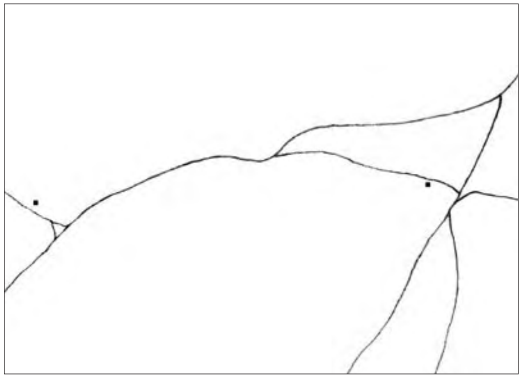

FIG 31. Diagram of Circulation c. 1880
Dirt roads appeared as a "web" of roads of roughly equal width and condition connecting various farmsteads.

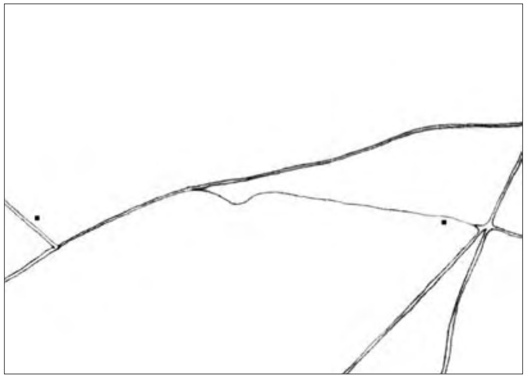

FIG 33. Diagram of Circulation c. 1934
By this time, Route 82 had been widened, but the road patterns of the 19th century remain intact.

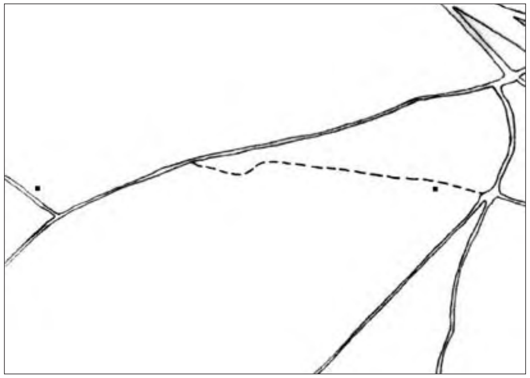

FIG 35. Diagram of Circulation c. 1995
This diagram shows circulation circa 1995. Note the addition of Route 11 in the upper right hand corner of the study area, and the abandonment of the Mumford Farm road, which was the Colonial era crossing of the East Branch of the Eightmile River.

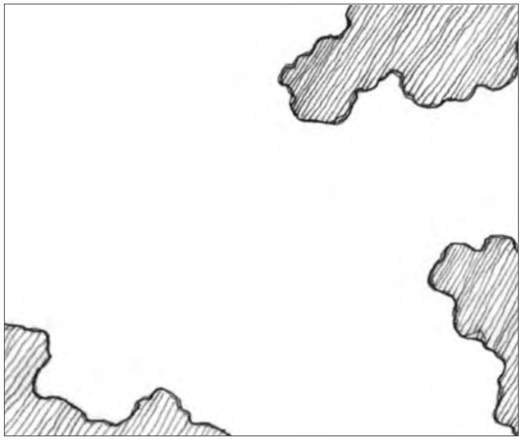

FIG 32. Diagram of Forest Cover c. 1880
Approximately 85% of the study area was non-forested and primarily used for agriculture.

FIG 34. Diagram of Forest Cover c. 1934
Agricultural abandonment lead to reforestation. Approximately 50% of the study area remained non-forested. Note that Mitchell Pond was made during the turn of the 20th century for agricultural purposes.

FIG 36. Diagram of Forest Cover c. 1995
Approximately 25% of the study area remains non-forested, with successional species increasing and maturing.

FIG 37. View of the Brook Bridge, 1919
The Brook Bridge was the colonial era crossing of the East Branch of the Eightmile River. The surrounding landscape was still used for agriculture during this period.

FIG 38. View of the Brook Bridge, 2004
Today, the road has been abandoned and the bridge is used mainly by the Bingham family. Note the loss in views beyond the bridge due to the successional growth.

FIG 39. View From the Camp, 1950
In the 1950s, there was still a significant visual connection from the Bingham family Camp looking across to Mitchell Pond, Marvel, Mitchell, and Mumford Farms.

FIG 40. View From the Camp, 2004
The present-day vista from the Bingham family Camp looking across to Mitchell Pond, Marvel, Mitchell, and Mumford Farms.

FIG 41. The Mumford House, 1945
View looking down the driveway of the Mumford house and farm, 1948.

FIG 42. The Mumford House, 2003
View of the Mumford house present-day. The house dates to 1769 and was built on the site of a former homestead.

FIG 43. View of the Red Hay Barn and Surrounding Fields
The land was originally used for various types of agriculture, but is now managed as a wetland and is rich in biodiversity and native species.

FIG 44. Stonewall and Stile
A finely crafted stonewall and stile found on the Bingham family properties. Stone-walls run extensively throughout the forested landscape of the watershed.

In the late 19th century, almost all of the study area was still an open, non-forested landscape, much of it cultivated for agriculture. Today, the majority of the study area is forested, with select areas around the Woodbridge, Mitchell, and Marvel farms still used for agriculture. Many of the signature views of the study area, such as the Brook Bridge view to the Mumford House, no longer exist. The meadows behind the house that ran adjacent to the agricultural road are managed to allow for the succession of native species. The area surrounding the Red Hay Barn is also being managed as a wetland, and has become an area rich in biodiversity and native species. Overall, the increase in woodland and forest cover has dramatically changed the landscape of the study area, even over the past 50 years. In 1950, the Mumford, Mitchell, and Marvel Farms could be seen clearly from the Camp to the north. Today the vista over the surrounding farmsteads has been completely obscured by successional vegetation growth and forest cover.

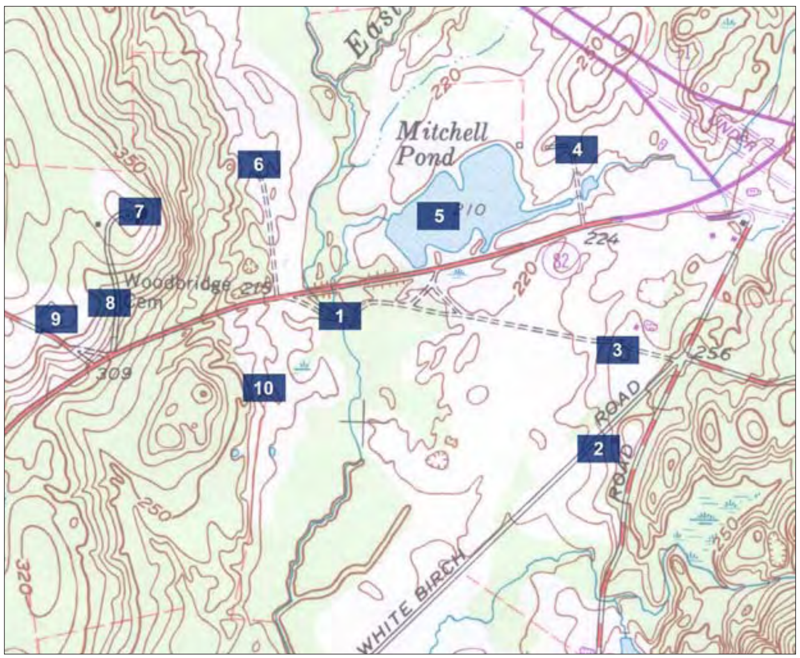

FIG 45. Bingham Family Properties: Buildings, Structures, and Sites

Buildings, Structures, and Sites

The following is a list and description of existing conditions of the contributing buildings, structures, and sites within the present day Bingham family properties. The list was compiled after visiting and touring the Bingham family properties, with supplemental descriptions from David Bingham.

1: The Brook Bridge, 1903
The bridge was the colonial era crossing of the East Branch of the Eightmile River on the Hadlyme Ferry Road. Alfred Mitchell rebuilt the bridge in 1903 as a roman arch stone bridge. The abandoned agricultural road is still used by the Bingham family, primarily to connect the Camp to the Mumford House during the summer months.

2: The Tiffany House, 1840
A wheelwright originally owned the house, and historic maps show the area being used as an orchard. Today, a portion of the property is still managed as an orchard.

3: The Mumford House, 1769
The house was built on the previous site of an earlier homestead. Today the house remains uninhabited permanently, and is shared by the family collectively.

4: The Mitchell Farm and Dairy Barn, c. 1800

5: Mitchell Pond, c. 1900
The present-day site of the pond was at one time a swamp. At the turn of the 20th century, the trees were cut to make an agricultural drainage pond as well as provide water for the farm animals.

6: Marvel Farm, 1790
The farm dates to 1790 and had an ice pond and ice storage during the 19th century that served the entire valley. Today the pond is overgrown and the property is leased to tenants who use the outbuildings and surrounding farmland as an equestrian farm and school.

7: The Camp, 1906
The Japanese-inspired pre-fabricated summerhouse was erected by Hiram Bingham.

FIG 46. View of the Tiffany House, 2004
The house dates to 1840 and historical records of the area depict the house site as an orchard. Some of the property is still in orchards.

FIG 47. Woodbridge Cemetery, 2004
The cemetery is on the Woodbridge Farm property and sits below the Woodbridge House. It dates to 1790 and is still used by the Bingham family.

FIG 48. The Bingham Family Camp
Built in 1906 by Hiram Bingham, the Camp sits on a hill overlooking the other farm properties. Note the rocky outcrops, typical of the watershed landscape.

FIG 49. View of Marvel Farm
The farm dates to 1790 and once had an ice pond that served the entire valley.

FIG 50. The Red Hay Barn, Mumford Farm, 1947

FIG 51. The Red Hay Barn, Mumford Farm, 2004

8: Woodbridge Cemetery, c. 1790s
The site is listed in the National Register of Historic Places. It is still in use today.

9: The Woodbridge House, 1790
The house is listed in the National Register and operates as a biodynamic free-range stock farm.

10: The Red Hay Barn, c. 1890s
The original barn dates to the 1770s, and was enlarged in the 1890s. The land around the barn has been used for various types of productive agriculture, as well as for farm drainage and ditches. Today, the adjacent land is managed as a wetland and is rich in biodiversity and native species.

One of the Bingham family properties, a house dating to the 1790s and approximately 150 acres off Darling Road, was sold during the 1930s.[10] The Darling Road house, barn, and land was subdivided in the 1970s and is now the site of the Hilltop Trail development which consists of seventeen single-family residential houses.

Spatial Organization

The spatial organization of homesteads within the study area represents a typical pattern of colonial farmstead settlement. The Woodbridge Farm, for example, is comprised of an 18th century farmhouse, surrounded by a group of interconnected barns, stables and sheds, which define an interior farmyard adjacent to the residence. Approximately 150 acres of agricultural fields and woodland surround the house and outbuildings. Stonewalls define the property boundary, and border Woodbridge Road, which bisects the agricultural fields and woodlots of the farm. Stonewalls were also used to define the different agricultural uses such as pasture land, crop fields, and woodlots. The Woodbridge Cemetery is located in a wooded area below the farmhouse, and is also bordered by a stonewall.

This layout, of farmhouse, surrounded by associated outbuildings which shape a courtyard or interior farmyard around the house, is representative of the Mumford, Marvel, Mitchell, and Tiffany farmhouses within the study

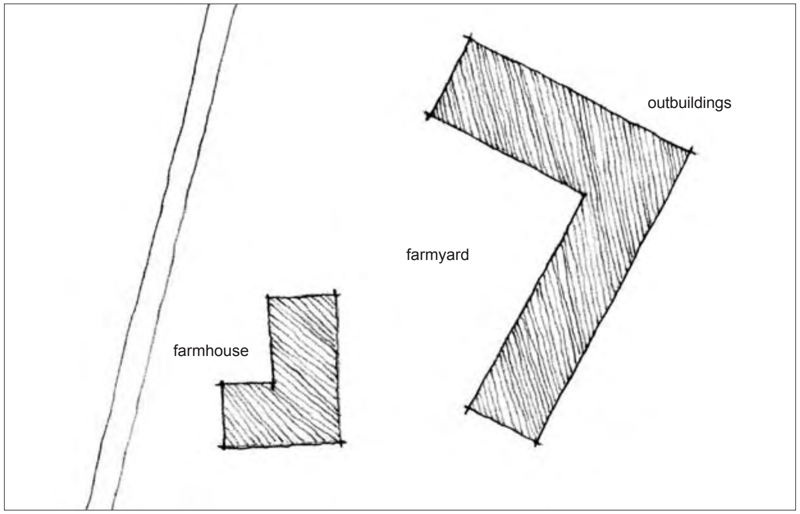

FIG 52. Typical Spatial Organization
Typical spatial organization of a farmstead in the study area. The farmhouse is set back from the road, and a farmyard or interior courtyard is defined by the farmhouse and associated outbuildings.

area. All of these farmsteads are located within a three-mile radius of one another, separated by agricultural land, and connected by a pattern of roads that can be traced to Colonial era circulation. The farmsteads were originally built according to the land division and field acreage that was worked by each farm. Stonewalls are found throughout the study area, many still defining the property ownership of each original farmstead. During the 19th century, most of the farmsteads had a visual connection to one another, but this relationship has disappeared with the reforestation of the watershed landscape.

Conclusion

Overall the use of the land within the study area has not changed dramatically over the last two centuries. The majority of the Bingham family properties are still used for agricultural-related practices. Although the farmsteads have been encroached upon by Route 11, the historic roads are still used to connect to the individual farmsteads, and the historical pattern of circulation still exists. The buildings, structures, circulation, and surrounding agricultural lands of the Bingham family properties exhibit a high degree of historical integrity. The dispersed pattern of farms and homesteads remains intact, with the major change in the surrounding landscape being the succession of woodland due to the abandonment of agriculture. Much of the abandoned farmland adjacent to buildings is being managed as either a wet meadow or to propagate native species for habitat. The family properties make up approximately 1,500 acres, and nearly 600 acres are already in conservation easement, as a result of efforts to protect this sensitive cultural and natural landscape.

There also exists extensive written and graphic documentation of this cultural landscape. The Bingham family properties in their entirety should be further considered for their potential to be listed as a district in the National Register of Historic Places. The study area has architectural integrity, as well as integrity of patterns of historic use, such as the dairy farming at Mitchell Farm or the use of the Woodbridge Cemetery.

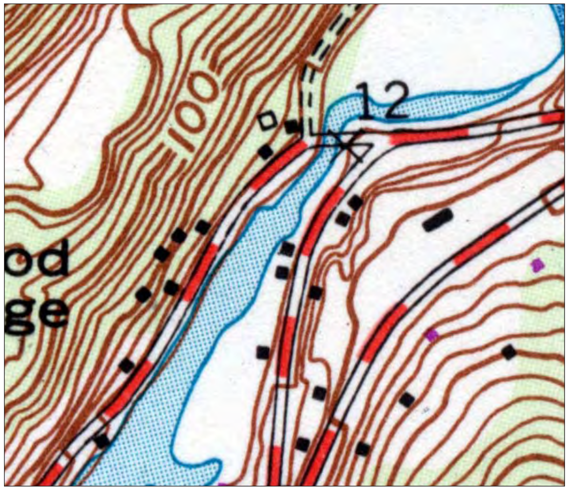

FIG 53. Hamburg Bridge Study Area

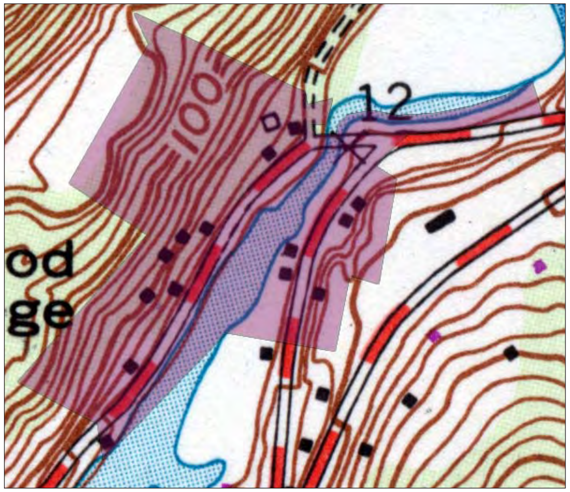

FIG 54. Hamburg Bridge Historic District
The area shown in pink is the district listed in the National Register of Historic Places.

By the Water's Edge: Hamburg Bridge, Lyme

This study area includes another National Register Historic District, the Hamburg Bridge Historic District, which was listed in 1983. The Historic District is a collection of eighteen land parcels on which there are ten houses and associated outbuildings and structures, all located near Hamburg Bridge, along the east and west sides of the Eightmile River on Old Hamburg and Joshuatown Roads. The District also consists of the bridge itself, as well as the banks of the Eightmile River below the bridge, once lined by wharfs.

Settlement

The pattern of life and community focus of the residents of the Hamburg Bridge area revolved around the wharfs and associated industries of fishing and commercial shipping. Although not the true town center of Lyme, the Hamburg Bridge area remained a busy port until the mid-19th century. The village of Hamburg had its center, with Congregational church and general store, approximately two-thirds of a mile downstream, below the bridge.

The parcels of land around Hamburg Bridge were always, and remain today, small in size, with homes close together, unlike the dispersed pattern of the neighboring agricultural communities. The pattern of settlement reflects the associated commercial activity. All the houses built in the study area deliberately face towards the water's edge, on both sides of the river. Land was left open by the river's edge, and houses were built on the far side of the roads in order to give priority to wharfs and marine commerce on the riverbanks. Today, land is still left open along the water's edge, appears as green space, and is used primarily for recreation.

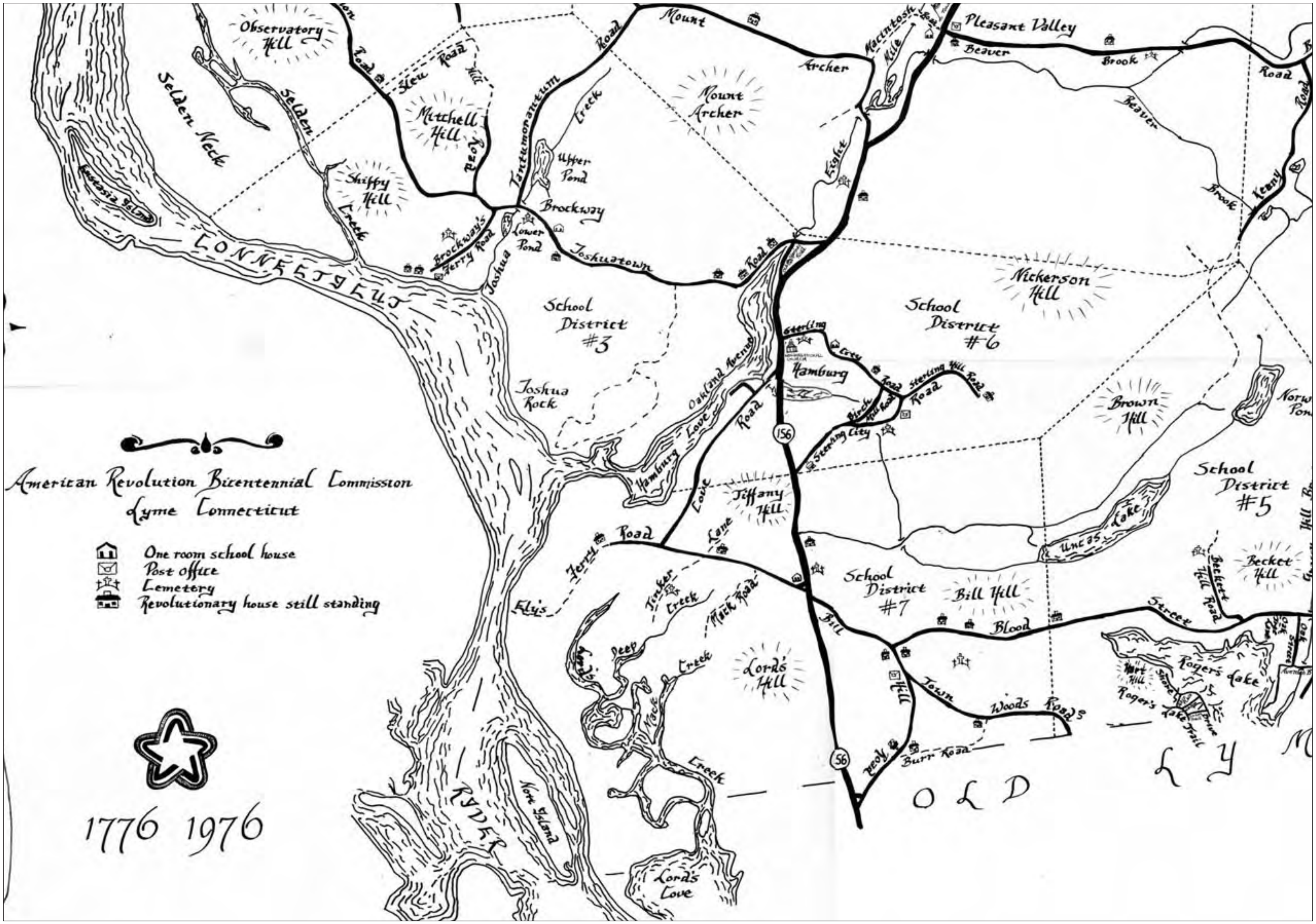

FIG 55. The Eightmile River at Hamburg Cove, 1776

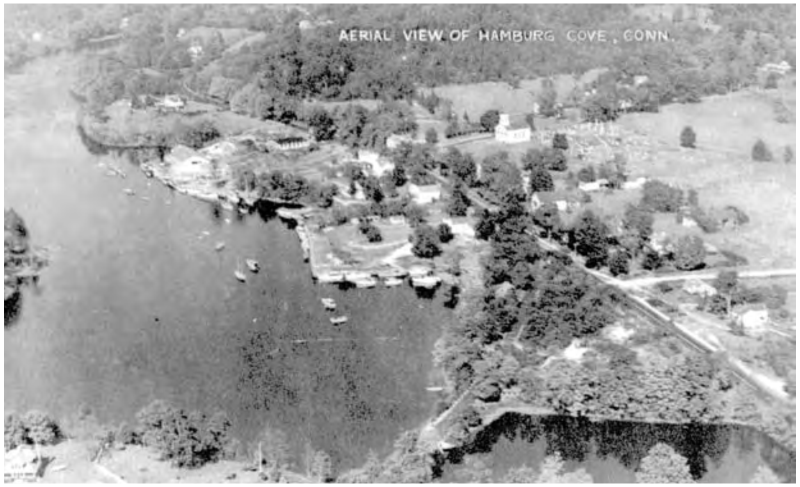

FIG 56. Aerial View of Hamburg Cove, Lord's Dock, c. 1936
Note the openness of the landscape beyond the town green.

FIG 57. Candlewood Ledge c. 1900
Note the openness of the agricultural landscape, juxtaposed with an abandoned field above Hamburg Cove.

Circulation

Hamburg Bridge crosses the Eightmile River approximately two miles above the point where it flows into the Connecticut River. The bridge joins Joshuatown Road and Old Hamburg Road together, and is sometimes locally referred to as the Joshuatown Road Bridge. The bridge carries Joshuatown Road traffic from Hamburg to Hadlyme. The location of the bridge was chosen in 1759 because of the narrow width of the river at this point. This particular site was also the northernmost point navigable by boat. After the bridge was built, wharfs were built, the junction of Joshuatown and Old Hamburg Roads emerged, and the Hamburg Bridge community evolved around the rising marine activity. A majority of the transportation between the Hamburg Bridge community and the larger Connecticut River community existed through ship and boat traffic.

Route 156, formerly known as the Salem Turnpike, connects Hamburg Center to the rest of the watershed, but bypasses Hamburg Bridge to

FIG 58. Hamburg Cove, Lord's Dock and Schooners c. 1906

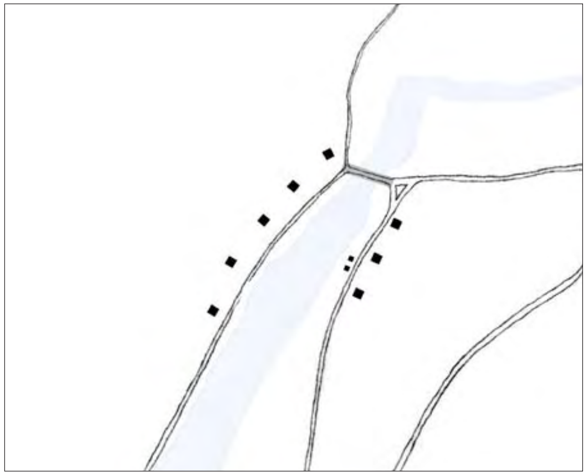

FIG 59. Diagram of Circulation c. 1934
Principal roads and selected buildings shown.

FIG 60. Diagram of Forest Cover c. 1934
Agricultural abandonment lead to reforestation. At this time, approximately 60% of the study area remained non-forested.

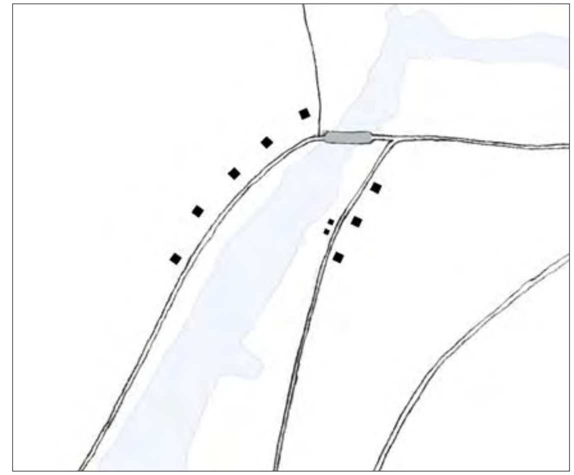

FIG 61. Diagram of Circulation c. 1995
The road pattern has remained virtually the same.

FIG 62. Diagram of Forest Cover c. 1995
Approximately 20% of the study area remains non-forested.

FIG 63. Grassy Riverbanks Along the Water's Edge
Grassy riverbanks belong to individual residents and provide visual continuity along each side of the river, and enhance the feeling of openness found along the water's edge.

the east. This route was always the main transportation corridor between Hamburg and inland towns. If Route 156 had followed Old Hamburg Road and connected directly to Hamburg Bridge, most certainly the character of the community would be different today. The lack of a major throughway has helped to preserve the quiet and picturesque character of the Hamburg Bridge community. The Eightmile River channel was also dredged in 1824 to the center of Hamburg, where commercial shipping continued well into the 20th century.[11] The dredging of the river to the docks at Hamburg center had a negative impact on the wharf activity at Hamburg Bridge, and the use of the wharfs declined thereafter. As a result, the community has experienced little development since 1824.

Vegetation

Historically, the area surrounding Hamburg Bridge has been valued for its scenic landscape, having often been the subject of etchings and paintings during the American Impressionist movement and earlier. One of the most famous renderings of Hamburg Bridge is a 19th century painting by G.F. Bottume, depicting the working wharfs of the bridge area as a picturesque landscape. At this time, Lombardy poplars lined Old Hamburg Road, demonstrating that the area had been beautified and improved by these ornamental plantings. At this time, Candlewood Ledge, above Joshuatown Road was an open agricultural landscape. The painting, when compared to a present-day photo of the same view, shows how little the buildings and structures of Hamburg Bridge have changed over the past century**.** The open landscape above Hamburg Bridge, however, began to revert to forest as soon as agriculture was abandoned. Today, Candlewood Ledge is completely forested, and most views down to Hamburg Bridge from the Ledge are obscured by vegetation.

Because of successional growth, it is impossible to achieve the same view as G.F. Bottume's painting. The Lombardy poplars of the 19th century have also long disappeared. Overall, the sense of an open landscape above Hamburg Bridge has been greatly altered by the growth of trees and increase in forest cover. Today, the landscape around the study area feels enclosed, especially around the buildings and structures. The marine activity within the community has become largely recreational, with only kayaks, canoes and rowboats navigating this part of the river.

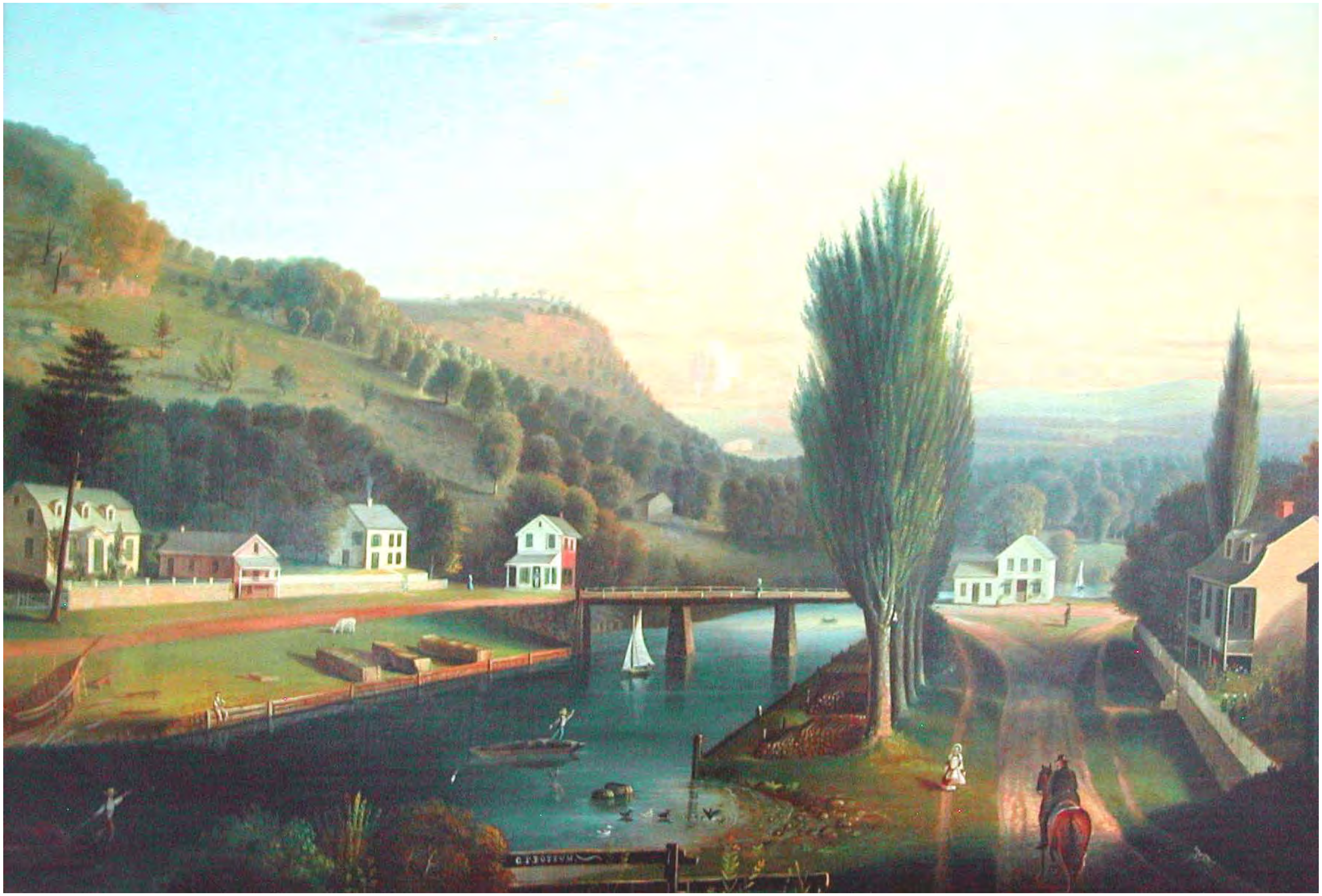

FIG 64. Old Hamburg Bridge and Reed's Landing
This mid-19th century painting was done by G.F. Bottume and originally titled "Canal Near Salem, Connecticut". The Lombardy poplars on the right side of the painting demonstrate that this landscape was "improved." The view shows the Old Joshuatown Road Bridge and the openness of the surrounding agricultural landscape.

FIG 65. Old Hamburg Bridge and Reed's Landing, 2004
The vegetation growth along the riverbank, as well as the growth on the hill overlooking the river, makes it impossible to replicate the same view of the bridge and surrounding buildings and structures.

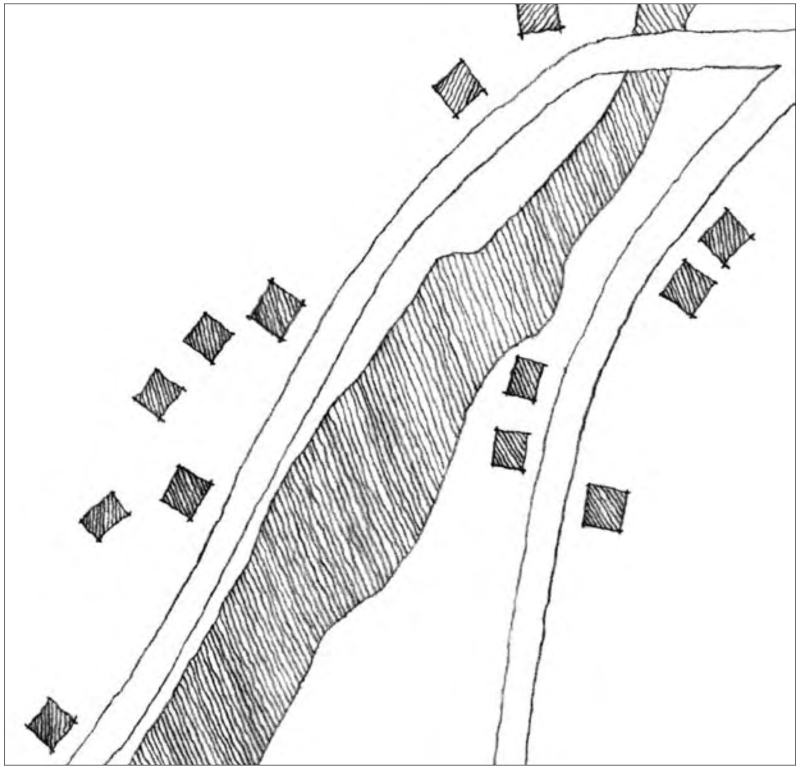

FIG 66. Figure Ground Diagram, Hamburg Bridge
This diagram shows the pattern of development that evolved along the Eightmile River at Hamburg Bridge. The majority of houses and buildings were built along the road, on the opposite side of the riverbank, allowing for the land adjacent to the water's edge to be used first and foremost for commercial activity.

Buildings, Structures, and Sites

The largest change in architectural development that the Hamburg Bridge study area has seen over the last two centuries is the concrete replacement of the old bridge after it was washed out in the 1936 flood. Joshuatown and Old Hamburg roads were also paved in the 20th century. The circulation pattern around Hamburg Bridge remains the same and can be traced to 1775. The houses and wharfs near the bridge, and the historic district generally, retain integrity to their 18th and 19th century forms. The houses and wharf sites have not been disturbed by development and continue to maintain their historic relationship to one another and to the river and the bridge.[12]

The following is a list of existing conditions of the contributing buildings, structures, and sites within the Hamburg Bridge Historic District. The list and descriptions follow the format of the National Register nomination form, which lists and describes each property according to a lot number.

Lot 9
Located on Joshuatown Road, this lot is currently vacant.

Lot 10
Located on Joshuatown Road, this lot is currently vacant.

Lot 11
Located on Joshuatown Road, this lot is comprised of one house dating to c. 1780.

Lot 12
Located on Joshuatown Road, this lot is comprised of one house, two sheds/cottages, one barn, one well, and a stone retaining wall.

Lot 13
Located on Joshuatown Road, this lot is vacant and has a remnant stone bulkhead.

Lot 14
Located on Joshuatown Road, this lot is vacant and has a remnant stone bulkhead.

Lot 15
Located on Joshuatown Road, this lot has one house, one well house, one studio, one garage/shed, all dating to c. 1800.

Lot 16
Located on Joshuatown Road, this lot is vacant and has a remnant stone bulkhead.

Lot 17
Located on Joshuatown Road, this lot has one house, one stone wall, one picket fence, and one garage, all dating to 1803.

Lot 18
Located on Joshuatown Road, this lot has one house dating to 1821.

Hamburg Bridge
This modern, three-arched concrete structure dates to 1936, and connects Joshuatown Road to Old Hamburg Road.

Eightmile River
The river is narrow and shallow in depth, typically used now for recreation, including kayaking and canoeing.

Lot 19
Located on Joshuatown Road, this lot is currently vacant.

Lot 96
Located on Joshuatown Road, this lot is vacant and has a remnant stone bulkhead.

Lot 23
Located on Old Hamburg Road, this lot has one house dating to c. 1803 and one garage dating to c. 1867.

Lot 24
Located on Old Hamburg Road, this lot has one house, one shed, one garage and one wharf area dating to c. 1867.

Lot 25
Located on Old Hamburg Road, this lot has one barn dating to the mid 20th century.

Lot 26
Located on Old Hamburg Road, this lot has one house and one barn dating to the turn of the 19th century.

Lot 27
Located on Old Hamburg Road, this lot has one cottage dating to the early 20th century.

Lot 28
Located on Old Hamburg Road, this lot is currently vacant.

Spatial Organization

Some of the open green areas along the riverbank still exist, yet even at the water's edge, the greatest sense of open space is on the Eightmile River. The majority of the woodland and forest succession that has occurred around Hamburg Bridge has happened during the 20th century and encroaches upon the backs of the houses. Surrounded by woodland and successional growth along the riverbanks, the river appears as an open corridor, separating the residents of Old Hamburg Road (east side) and Joshuatown Road (west side). There is also a sequence of woodland, house, road, green space, and river on each side of the Eightmile River. The relationship of the buildings, to the road, and to the water's edge is a function of the waterfront activity and commerce, and is a permanent indicator of the importance of access to the river.

For the residents of the Hamburg Bridge study area, there is still an orientation towards the river, despite the lack of wharfs and associated marine activity. The wharfs of the 18th and 19th century have disappeared over the past century with flooding, hurricanes, and weathering. Some of the residents have built modern, wooden docks for recreational use. The use of the green space around the water's edge for recreation and leisure has become a common past time for the community. Although the land along the river banks is divided by house lot and remains under private ownership, there is a unique notion of open green space that brings a sense of preservation of the community's relationship to the river.

Conclusion

The Hamburg Bridge Historic District has changed little since the mid-19th century. The bridge was rebuilt with modern materials after the 1936 hurricane, and one 18th century house was destroyed by a fire. Virtually no 20th century development, however, has occurred in the proximity of the bridge and surrounding parcels. Therefore, the pattern of buildings around Hamburg Bridge is a function of their relationship to the wharfs.

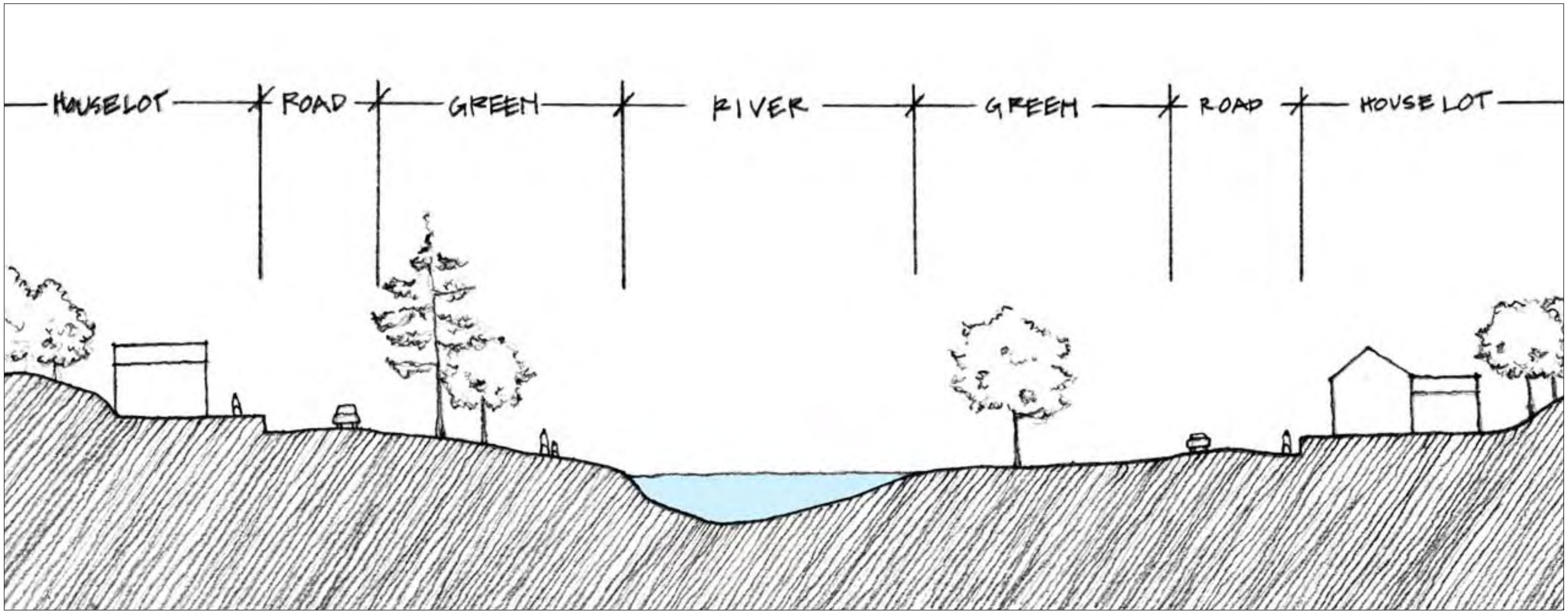

FIG 67. Typical Section, Hamburg Bridge
This section shows the relationship of b□
the riverbank. Most of the land along the water's edge is undeveloped.

The buildings and associated structures of the Hamburg Bridge study area still have great integrity to the mid 19th century.[13] The visual and physical appearance of the landscape has changed with successional vegetation, as has the marine use of the riverfront. But the cultural context still exists today, especially through the integrity of the architectural structures, the pattern of development, and the circulation of the study area.

The open parcels of land and vacant lots along the riverbank are fairly unique. Most waterfront properties in other parts of New England or Connecticut would have been further developed throughout the 20th century. The Hamburg Bridge Historic District has managed to preserve its historic riverfront. This connection between the houses, the narrow road, and the undeveloped, mostly grassy waterfront contributes to the quiet, charming character of Hamburg Bridge.

FIG 68. Hamburg Bridge Over Eightmile River, pre-1936
The former stone and wood structure of the old Hamburg bridge.

FIG 69. Hamburg Bridge Over Eightmile River, 2004
Replacement concrete bridge built by the Army Corps of Engineers in the late 1930s after the hurrricane of 1936.

FIG 70. Old Hamburg Road, Hamburg Bridge Historic District
The narrow road and building setbacks are characteristic of the pattern of development in the Hamburg Bridge Historic District.

FIG 71. Eightmile River, Hamburg Bridge Historic District
Today the Eightmile River is mostly used for recreation.

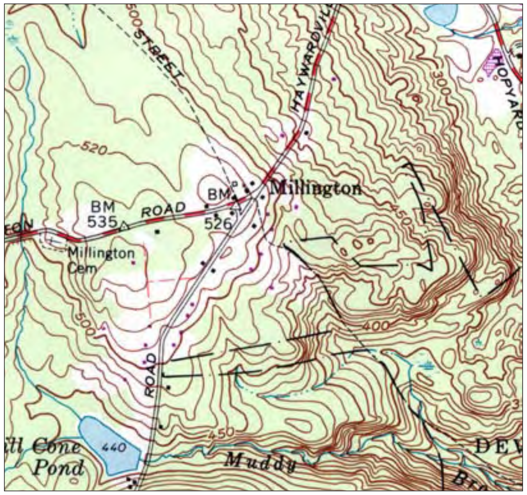

FIG 72. Millington Green Study Area

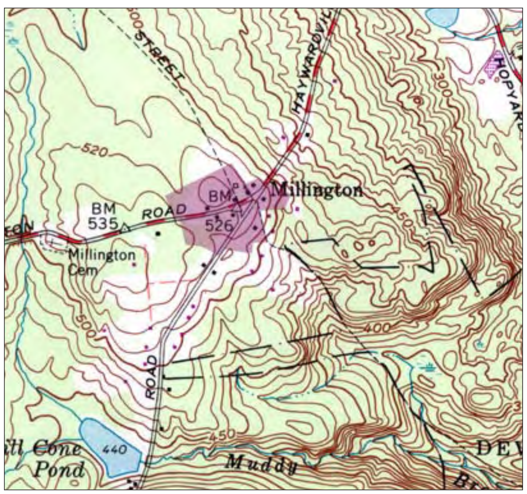

FIG 73. Millington Green Historic District
The area shown in pink is currently the historic district listed in the National Register of Historic Places.

A Village Center:
Millington Green, East Haddam

Millington Green has often been described as a quaint and picturesque New England hamlet. Driving through the winding, forested back roads of East Haddam, one might miss Millington Green, if it were not for the substantial, long triangular clearing, lined with six historic houses. Although the Green historically was the commercial center of the surrounding area, in recent decades, it has become one of the quietest parts of the town.

A portion of this study area has already been established as a National Register District, called the Millington Green Historic District. The study area is located along Millington Road, Haywardville Road, and Tater Hill Road in East Haddam, south of Lake Hayward. The National Register District, which encompasses a smaller area, is comprised of twelve buildings: six houses, a former parsonage for the Congregational meetinghouse, a former schoolhouse, and several small barns and outbuildings. The district also includes one site: the small triangular parcel called "Millington Green" at the center of the district. All of the district buildings, structures, and sites date to the 18th or 19th century.[14] The Historic District of Millington Green is an example of a religious, commercial, and social center for the surrounding agricultural areas, characteristic of early New England settlement.

Settlement

Millington Green was first settled in the early 18th century, with the arrival of Jonathan Beebe and his family in 1704.[15] By 1732, several families from neighboring communities moved to Millington and the settlement was granted the right to establish its own ecclesiastical society, separate from the nearby village of Moodus. Soon after, Millington began to develop around the Congregational meetinghouse, which was built in 1740 on the north side of the common land of what is now the Green. It was eventually

FIG 74. Settlement Along Wall Street
View of old foundations and stone walls from past settlement along Wall Street.

FIG 75. Remnants of Past Agricultural Use, Wall Street
An old pickup truck sits abandoned just off Wall Street.

rebuilt in 1832.[16] The first schoolhouse in Millington was built circa 1754, also located along the Green. During the late 18th century, several of the properties on Millington Green had small buildings that were general stores, one of which has become a single-family residence. The village green provided a social gathering place for the surrounding agricultural community, and the district schoolhouse also helped establish Millington as a social center.

According to records, the village was named Millington because of the many saw and gristmills located on the surrounding streams. By 1831, the Millington post office was established, and by the 1860s, commercial growth in Millington had reached its height, with numerous taverns, stores, and mills serving the local population. During this time, Millington had over one hundred buildings and was a thriving mill community, with a larger population than the town center of East Haddam.

Today, Millington Green is surrounded by only a handful of buildings, most of them residential. One house, located on the southern side of the Green, dates to 1952 and is considered non-contributing in the Historic District. Even this ranch-style house, however, incorporated an earlier barn into its 20th century architectural design. Overall, the pattern of settlement is centered around the Green. There are only four major buildings, however, that actually can be seen when standing on the Green. The majority of the residences within the study area are set back from the road, sometimes behind stonewalls within the wooded landscape, and often shielded by vegetation. The lack of imposing residential development and architecture emphasizes the feeling of being removed from the busy streets around the Goodspeed Opera House in downtown East Haddam.

Circulation

Although Millington today is a rural area, separated from the commercial centers of Moodus and East Haddam, during the 19th century Millington

FIG 76. Diagram of Circulation c. 1934

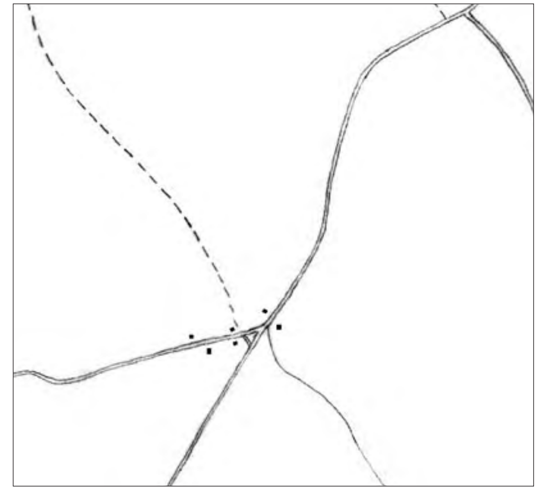

FIG 78. Diagram of Circulation c. 1995
The road pattern has remained virtually unchanged, with the exception of Wall Street becoming a trail with limited public access.

FIG 77. Diagram of Forest Cover c. 1934
At this time, approximately 40% of the study area remained non-forested.

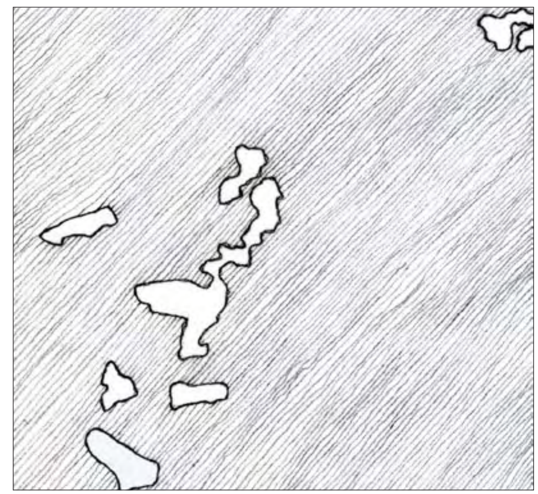

FIG 79. Diagram of Forest Cover c. 1995
Approximately 10% of the study area remains non-forested.

FIG 80. Wall Street, Millington, 2004
What was once the busiest commercial route in Millington has become an abandoned, overgrown trail in the woods. Access to the trail is through the driveway and backyard of the Daniel Bulkley House.

Road was part of the direct route from Goodspeed's Landing on the Connecticut River to Colchester and Lebanon, two large inland towns. This made Millington a busy commercial hub between the two larger commercial centers. In 1815 the establishment of the East Haddam and Colchester Turnpike provided an alternate route to Colchester and Lebanon, and historians speculate that Millington "continued to receive the advantage of through traffic as well as local business."[17] In 1868, however, the future of Millington's commercial growth was determined when plans for a railroad connecting Colchester and Old Lyme by way of Millington were abandoned due to the lack of capital.[18]

Today, the roads around the Green probably see less traffic than they did during the height of commerce at the end of the 19th century. Because there is no commercial activity, automobiles passing through Millington move fairly fast on the winding roads. Over the past century, the circulation pattern has remained mostly unchanged. Wall Street, leading to the Green, has become a trail in the woods, due to the abandonment of the adjacent farmland and the decline in population. It is used by the Millington Green residents for hiking and dog walking. The walk down old Wall Street is peculiar, with many stone foundations and dry cellars located just off the path. Surrounded by forest, it is difficult to imagine the overgrown trail as one of the busiest commercial corridors in East Haddam only a century ago. The remnants of occupation can still be seen, especially further down the road towards the old Eightmile River bridge crossing. Access to old Wall Street, which was once a main commercial route to Millington from the northern crossing of the Eightmile River has now been obscured by vegetation growth and a cast iron chain. Other trail systems to the east of the Green connect the community to Devil's Hopyard State Park.

Vegetation

The land surrounding Millington Green was primarily used for agriculture, with many saw and gristmills located on nearby fast-flowing streams. By the 19th century, most land was sparsely vegetated, with forests cleared for timber, and stonewalls and simple fencing separating agricultural fields. By the early 1930s, agriculture was still present immediately around the Green, but began to decline thereafter. By the 1990s, nearly all of the agriculture had been abandoned, with successional woodland taking over as the predominant view on the landscape.

Millington Green is approached by driving along winding roads, surrounded by woods. Millington is almost entirely a forested landscape, with the exception of the Green itself, which is literally a clearing in the woods, as well as an intersection of Millington Road, Haywardville Road, and Tater Hill Road. The forested land bordering Millington Green to the north is largely owned by East Haddam Fishing & Game Club, the largest land owner in East Haddam, owning over 2,000 acres of property.

FIG 81. Daniel Bulkley House, 1792
This clapboard house is an example of a historic home built on the north side of Millington Green. Note, Wall Street is located to the right of the house, and access to the trail is behind the house through the backyard.

Buildings, Structures, and Sites

The majority of the buildings in the study area date to the 19th century. However, the most important social building of the Millington Green community no longer exists. The Congregational meetinghouse that was located on the north side of the Green was destroyed by a fire in 1971 and was never rebuilt. The original parsonage, an 1854 schoolhouse, and many houses dating to the 18th and 19th century still exist, which help preserve the historic appearance of the village. Many of the houses exemplify the distinctive characteristics of New England Colonial and Greek Revival architecture. Well-preserved, with their small-pane windows, brick chimneys, doorway transoms, and clapboarded exteriors intact, these buildings are among the finest examples in the Eightmile River watershed.[19]

The following is a list with description of existing conditions of the contributing buildings, structures, and sites within the Millington Green Historic District.

FIG 82. 10th District Schoolhouse, c. 1854

FIG 83. Millington Green, East Haddam c. 1958
Note the openness of the landscape around Millington Green, the shaded quality of the Green in the foreground, and openess of the agricultural land behind the Congregational meetinghouse that burned in 1971.

FIG 85. Millington Green, East Haddam, 2004
Today the Green contains a small shrub-sized planting in the center, some signage, a flagpole, and a bench.

FIG 84. Site of Former Congregational Meetinghouse, 2004
The site of the former Congregational meetinghouse has been maintained as an open green space.

FIG 86. Congregational Meetinghouse, c. 1940s
This unknown artist's painting of the Millington Congregational meetinghouse shows the openess of the surrounding agricultural landscape.

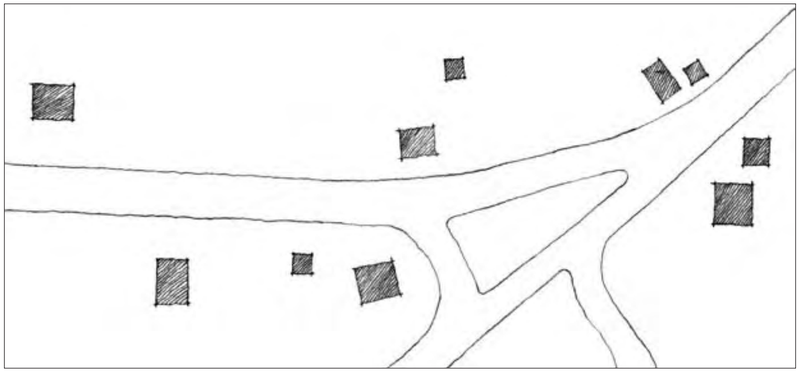

FIG 87. Figure Ground Diagram, Millington Green
This diagram shows the triangular parcel of land, around which the historic settlement patterns of Millington radiated. The green occupies a long triangular piece of land, which results in an awkward set of intersections, and a largely unused green space at the center of this now small community.

10th District Schoolhouse, c. 1854
Located at 3 Haywardville Road this lot consists of two buildings.

Daniel Brainerd House, c. 1752
Located at 79 Millington Road, this lot consists of one building.

Daniel Bulkley House, 1792
Located at 87 Millington Road, this lot consists of four buildings.

William Henry Cone House, c. 1840
Located at 82 Millington Road this lot consists of one building.

Ebenezer Dutton House, 1766
Located at 86 Millington Road, this lot consists of two buildings.

Congregational Parsonage, 1854
Located at 108 Millington Road, this lot consists of two buildings.

Millington Green, c.1730
This long triangular grassy parcel is located in the center of the Historic District.

Spatial Organization

Town-centered development, radiating around a town common or green is a typical pattern of early New England Colonial settlement. The exact pattern of building footprints around Millington Green is a reflection of the triangular shape of the Green itself. The oblong shape of the Green is a result of the circulation pattern of the junctions of Millington Road, Haywardville Road, and Tater Hill Road. These roads, as well as the historic homes, define the edges of the Green.

The historic homes all face the Green, with associated outbuildings located behind each dwelling. The only openness in Millington Green is the Green itself, the former site of the Congregational meetinghouse, and the small front yards of the historic homes. Because of the lack of open agricultural land, successional growth also defines the edge of the Green, obscuring views beyond.

Conclusion

The use of the land surrounding Millington Green has gone through a familiar succession of agricultural practice, abandonment, and subsequent reforestation. Similar to the Bingham and Hamburg Bridge study areas, the landscape around Millington Green has not been affected to a great degree by 20th century development. There is still at least one farm in operation northwest of the Green, with cattle left to graze in the successional fields and woods.

The establishment of the National Register District around Millington Green confirmed the integrity of the 18th and 19th century buildings and circulation patterns that are still in existence today. The Green itself has integrity in terms of shape and form, retaining a feeling of openness within the larger forested landscape.

PART THREE

INTEGRITY AND SIGNIFICANCE OF THE LANDSCAPE

FIG 88. The Eightmile River Watershed

Summary

The study areas of Millington Green, Hamburg Bridge, and the Bingham Family properties exhibit great historic integrity to their colonial, agrarian, maritime, and industrial origins. They are representative of other cultural landscapes, features, and characteristics throughout the Eightmile River watershed. By identifying the significance of each study area's landscape features and characteristics, the presence of historic integrity, especially of buildings, structures, and circulation patterns, within the entire watershed is strengthened.

Overall, the watershed remains a rural place, full of small hamlets, winding roads and hiking trails. There are no large supermarkets or other major shopping centers, with convenience stores outnumbered by general stores and farm stands. Small dispersed hamlets and farmsteads, as well as town greens and 18th and 19th century buildings, are connected by a pattern of circulation dating originally to the Colonial era. The overall historic pattern of settlement and circulation within the watershed still exists today. Many individual cultural landscapes within the watershed such as Hamburg Bridge, Sterling City, Millington Green, Salem, and the Bingham family properties, can be traced to their 18th or 19th century origins. They exhibit great historic integrity in terms of patterns of settlement, circulation, and architecture. These landscapes can be considered of outstanding cultural resource value. Because they are typical of conditions in the watershed as a whole, the larger cultural landscape of the Eightmile River watershed also should be considered to possess outstanding resource value.

FIG 89. New Development Within the Eightmile River Watershed

Water as a Resource

Throughout each layer of cultural history, water may have been the most significant and consistent natural resource within the Eightmile River watershed. The Eightmile River and its branches supplied the watershed inhabitants with a transportation corridor to the Connecticut River, a food supply, and maritime commerce throughout history. Today, the water within the Eightmile River watershed is valued as an outstanding natural and ecological resource. But the watershed offers more than clean water and a thriving ecosystem to its residents. For example, contemporary use of Devil's Hopyard State Park, Walden Preserve, Lake Hayward, and Hamburg Cove are all associated with recreational use. Almost all of the scenic waterways or associated conservation areas are managed for recreational use such as hiking, boating, and camping. The water within the Eightmile River watershed signifies much more than just a healthy ecosystem. It has become a recreational resource for the surrounding community as well as for visitors to the watershed. The historical significance of water in the landscape, and in the relationship of people to the landscape, make water quality management an important cultural, as well as natural, resource issue.

Development

The Eightmile River watershed landscape is a significant example of a successional agrarian landscape in southern New England that has been relatively undisturbed by 20th century urbanization or other modern development. There are several reasons why the watershed has seen less change than other comparable areas. The hydrology of the estuary at the mouth of the Connecticut River caused sand bars to accumulate, preventing the mouth of the river from becoming a major transportation corridor. A major harbor never developed at the mouth of the Connecticut, inhibiting population growth within the watershed and surrounding area. For those who did settle within the watershed, agricultural practices were limited by the rocky and steep topography. These factors hindered the amount of development within the watershed.

Suburban development within the past twenty-five years has also been actively controlled through the efforts of area residents. Residents are aware of the incompatibilities between the footprints and patterns of suburban development, and the 18th and 19th century patterns of development that still characterize their region. Because of their appreciation for this historic landscape character, each of the towns continues to make great efforts to limit growth and purchase land for conservation.

The most important difference between the Eightmile River watershed and other comparable rural landscapes in New England is the limited amount of modern development that has occurred throughout the past century. In much of New England, significant Colonial era landscapes have not only become forested, but they have been more affected by 20th century development as well. The fact that the watershed has escaped many of the effects of 20th century development, especially on large swaths of agricultural land and areas around Hamburg Bridge and Cove, makes it unusual in southern New England.

Vegetative succession on formerly agricultural lands is common throughout the Northeast. What is less common is to see such succession occur, since the 19th century, relatively undisturbed by later development. What is rarer still, is to have such a situation near the mouth of one of the largest and most historically significant rivers in the country, the Connecticut. This location made the Eightmile River watershed an important location, at least until the mid 19th century. Since then, what was a central location has been left in relative isolation. The result is a cultural landscape of particular interest.

Conclusion

The limited amount of 20th century development means that the overwhelming footprint of settlement, circulation and even land use patterns can be traced to 17th, 18th and 19th century origins. Remnants of the agricultural and industrial past can still be found throughout the watershed landscape. Moreover, many of the buildings, structures, and sites analyzed as cultural landscape study areas demonstrate the amount of historic integrity that has been retained, particularly in architectural form. Overall, the large number of 17th, 18th and 19th century buildings, structures, sites, and patterns of settlement, circulation, and vegetation, combined with the quantity and condition of intact archaeological sites within the watershed, sets the Eightmile River cultural landscape aside from other comparable watersheds in Connecticut, as possessing outstanding cultural resource value.

AFTERWORD

FIG 90. Sensitive Natural Resource Areas
Zoning procedures such as Transfer of Development Rights can allow towns to steer development pressure away from sensitive natural resource areas such as wetlands.

After having assessed the significance of the cultural landscape of the Eightmile River watershed as having outstanding resource value, it is important to consider how residents and officials within the watershed can manage change and growth. Land conservation within the Eightmile River watershed has become an important issue for many residents of the region. The East Haddam Land Trust, the Salem Land Trust, the Lyme Land Conservation Trust, and the Nature Conservancy are all active partners in the protection of the natural and cultural resources of the area. As of 2004, the total amount of land protected through public ownership and conservation easements within the watershed was nearly 11,000 acres, which is approximately 27% of the entire watershed.

Because many of the towns and villages within the Eightmile River watershed retain integrity to their 17th, 18th, and 19th century town-centered settlement patterns, encouraging compatible development is fundamental to preserving the character of the watershed. Moreover, the need to protect sensitive natural resources also requires towns and residents to continue to promote compatible land-use patterns for the future. The following management strategies are general examples that can be adopted and modified to protect the natural and historic resources of the Eightmile River watershed.

Planning

The most effective management process involves describing the resources the community has identified, assessing the sensitivities of the resources, and finally prescribing the strategies needed to protect or preserve the resources. The first stage always involves planning, as an organized approach to land-use. In particular, the development of a comprehensive

FIG 91. Historic Overlay District Zoning Bylaw
Revising zoning regulations in order to establish or modify a historic overlay district can help control the type of development that occurs, as well as provide management guidelines for current residents living within the district.

plan is the community's guide for the future, organizing what actions need to occur and in what order, for the community to achieve their short and long-term goals.

Developing a watershed-wide framework for future development and protection of critical resources could be the first step towards protecting resources and guiding growth. Such a plan would require a participatory process and involves citizens and local governments working together towards common goals.

Land-Use Regulations

Traditional zoning and subdivision regulations can be inflexible, as it is difficult to plan for all variables of development within one ordinance. In particular, zoning in rural areas often assumes that uses should be segregated. This factor often overlooks a community's character and can have adverse effects on natural resources.[20] The following strategies and ordinances are examples that offer more options and land protection than conventional zoning regulations. They should not be viewed as individual solutions, but as potential components of an overall strategy.

Conservation Easements

A conservation easement is a legal agreement between a landowner and a land trust or government agency that permanently protects the land while the landowner continues to own it. It often involves placing a restriction on a piece of property, limiting the use of the land, or even permanently preventing development in order to protect the associated natural and cultural resources. If a conservation easement is donated to a land trust, a landowner may be required to relinquish some of the rights associated with the land. A conservation easement may restrict any additional development or structures on the land, but still allow the land to operate as a farm without inhibiting agricultural practices.

Many landowners implement a conservation easement as a way to manage and protect their open space land from inappropriate development while still maintaining their private ownership. Granting an easement to a conservation organization or a land trust can result in reduced taxes.[21] Agricultural landowners within the watershed should be made aware of the tax benefits of donating an agricultural conservation easement to a local land trust.

Development Rights Programs

Similar to the conservation easement strategy is the Connecticut Farmland Preservation Program, the state Purchase of Development Rights program (PDR), which currently protects 130,000 acres of Connecticut's most productive farmland. The program entails the Department of Agriculture acquiring development rights to agricultural properties. While the farms remain in private ownership and continue to pay local property taxes, a permanent restriction on non-agricultural uses is placed on these properties.[22]

Another option is called the Transfer of Development Rights (TDR) which can be used to protect open space, agricultural land, natural resources, and historic or culturally significant land. Transfer of development rights is a planning technique for protecting land by transferring the “rights to develop” from one area and giving them to another. This strategy allows towns to guide development away from areas of sensitive natural and cultural resources. Placing conservation easements on property in agricultural areas could allow for an increase in development (a “bonus”), in other areas that are already being developed. The costs of purchasing the easements would be recovered from the developers who receive the building bonuses.[23]

Overall, towns can partake in development rights programs or strategies in order to protect highly sensitive areas of natural, cultural, and visual resources.

Overlay Zoning

As the Eightmile River watershed consists of many local governments, it is important for towns to work together towards unified goals for the management of growth and development within the watershed. Each town can consider revising zoning bylaws in order to enhance regulations and policies for proposed and existing development that are sensitive to height and visual quality, (so as not to impair scenic views and vistas), character (especially historic), and natural resources within the watershed.

Several local historic districts already exist within the watershed and are a testament to local desire to maintain visual character and historic development patterns in a certain area. The zoning ordinances associated with each historic district provide guidance for design control and compatibility among existing and future structures. Restrictions on building height, signage, and landscape design are some of the elements considered when creating a historic overlay zoning district.

Extending boundaries of local historic districts to include adjacent cultural landscapes of historical significance should be considered. For example, the boundaries of the Salem Historic District could be expanded to include the surrounding agricultural and conservation lands, including Walden Preserve and the historic John Whittlesy house further north along Route 85. Extending the boundaries of local historic districts to include adjacent cultural landscapes could also help protect the historic character of the watershed as a whole.

Revising zoning regulations in each of the three (or five) towns, in order to establish a watershed overlay district can help control the type of development that occurs within the entire watershed. Such an overlay district should include a unified approach to preserving the historic character of the cultural landscape.

The National Register of Historic Places

Listing a property in the National Register contributes to preserving historic properties in a number of ways including: recognition that a property is of significance to the Nation, the State, or the community; consideration in the planning for Federal or federally assisted projects; eligibility for Federal tax benefits; and qualification for Federal assistance for historic preservation, when funds are available.[25]

In order to be eligible for the process of identification and evaluation for the National Register program, historical significance must be present in one or more of the following: districts, sites, buildings, structures, and objects that possess integrity of location, design, materials, workmanship, feeling, and association, and which meet at least one of the following National Register criteria:

> a: That are associated with events that have made a significant contribution to the broad patterns of history; or

b: That are associated with the lives of persons significant in our past; or

c: That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction; or

d: That have yielded or may be likely to yield information in prehistory or history.[26]

A prime example of a nomination for a listing in the National Register of Historic Places is the Bingham family properties. The properties have already been significantly researched for historic relevance as well as managed to retain their historic character.

There are several other individual cultural landscapes within the watershed that should be considered for National Register listing, including the Bingham Family Properties, Sterling City, Pleasant Valley and other hamlets.

Further Research

Further research and inventory of cultural landscapes and other historic resources within the watershed should be done. Existing National Register properties should be re-examined for possible boundary expansion. This would require researching and documenting more cultural landscapes throughout the watershed, such as farms or hamlets, and characteristic buildings, such as churches, schoolhouses, and mills that have not yet been mentioned in this study. This type of research is already occurring in some areas of the watershed, such as the Millington schoolhouse in East Haddam.

One of the most powerful planning tools is the historic district at the town level. Further research for National Register listings can also become the basis for establishing or revising local historic district designations. This would be one of the most effective ways to preserve the cultural landscape of the Eightmile River watershed.

Another area of further research is the association of fine artists, particularly those of the American Impressionist movement, with the watershed landscape. At the turn of the 20th century, many painters came to Old Lyme and places within the Eightmile River watershed from various locations throughout the country. Inspired by the rural qualities of Connecticut life, the artists represented many famous views and vistas within the watershed in their works. Further research into the role of the work of the Eightmile River watershed painters and their contribution to the American Impressionist movement should be considered. This component of social history of the Eightmile River watershed will strengthen the historical and pictorial documentation of the cultural landscape.

The history of the recent land preservation movement within the watershed is another important theme in the social history of the landscape. Land preservation and conservation efforts within the watershed in some cases were important precedents for the land preservation movement at the national level. Local preservation efforts since the 1960s have been very active, and have contributed to the preservation of the cultural landscape that we see today.

All of the further research suggested here would require collaboration with local and regional institutions, and individuals, including the Florence Griswold Museum in Old Lyme, local and state libraries, historical societies, historians, archaeologists, officials, managers, and land conservation groups. Sharing watershed-wide, cultural resource data, perhaps through a unified database, will enrich the documentation of cultural resources within the watershed, giving the towns a strong basis for the protection of the watershed's cultural landscape. Recent NPS research and documentation using Geographic Information Systems (GIS) at the Delaware Water Gap National Recreation Area, for example, is one precedent for such a comprehensive approach.

In general, the social history of the watershed landscape-the history of the individuals and groups that have lived here and shaped the landscape-needs to be undertaken to complement a study of this type, which emphasizes analysis of physical landscape characteristics. Further research into settlement history, agricultural economics, and population trends, for example, are all needed to better contextualize this analysis of cultural landscape features.

Conclusion

The landscape of the Eightmile River watershed has resulted from combined ecological and cultural processes. The landscape embodies this combination of natural and cultural elements in each layer of its history. As the landscape of the watershed progresses, transforms, and continues to change, further cultural landscape research should be undertaken. Through cooperation between town governments, residents, and private non-profit partners, planning tools and strategies can help assure the continued integrity of the cultural landscape of the Eightmile River watershed, and the preservation of its outstanding resource value.

APPENDIX

NATIONAL REGISTER PROPERTIES

There are nine properties within the Eightmile River watershed listed in the National Register of Historic Places. There are three National Register Historic districts and two National Register Historic buildings. Three structures and one site are listed in the *Lower Connecticut Valley Woodland Period Archaeological Thematic Resource*. This Appendix lists the properties, as well as the structures, objects, sites, and buildings within each district.

East Haddam, Connecticut

Bridge No. 1603
CT State Park and Forest Depression-Era Federal Work Relief Program Structures TR
Devil's Hopyard Road over unnamed brook
Devil's Hopyard State Park, 07/29/93

Bridge No. 1604
CT State Park and Forest Depression-Era Federal Work Relief Program Structures TR
Devil's Hopyard Road over Muddy Brook
Devil's Hopyard State Park, 07/29/93

Bridge No. 1605
CT State Park and Forest Depression-Era Federal Work Relief Program Structures TR
Devil's Hopyard Road over unnamed brook
Devil's Hopyard State Park, 07/29/93

Millington Green Historic District
Bounded by Millington, Tater Hill, Haywardville and Old Hopyard Roads
Local Historic District, 12 contributing buildings and 1 contributing site, 07/25/96

Salem, Connecticut

Salem Historic District
CT Route 85, 09/22/90
Contributing
The Salem Green, 1831-1885: 1 site
Salem Grange, 1885: 1 building
Salem Congregational Church, c. 1840: 1 building
Salem Town House, 1749 and 1831: 1 building
Salem Public Library, c. 1929: 1 building
The Methodist Tavern, 1720: 1 building
1 house and 1 barn once part of the Music Vale Seminary, c. 1835: 2 buildings
Greek revival house, Pratt Rd.: 1 building
1 house, Chapman Road and Route 85, c. 1800: 1 building

Simon Tiffany House
Darling Road
1 house, 1 outbuilding, 1 garage, 2 fieldstone foundations,
stonewalls, 2 wells, and 1 root cellar, 06/30/83

Woodbridge Farm
29, 30 and 90 Woodbridge Road
2 buildings and 1 site, 12/01/97

Lyme, Connecticut

Hamburg Bridge Historic District
Joshuatown Road and Old Hamburg Road
18 parcels of land, 21 contributing buildings, and 10 contributing structures, 03/10/83

Hamburg Cove Site
Lower Connecticut River Valley Woodland Period Archaeological Thematic Resource
Address Restricted, 10/15/87

Other

Lower Connecticut Valley Woodland Period Archaeological Thematic Resource
Also in Haddam, Lyme, and Old Lyme, 07/31/87

ENDNOTES

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[4] Connecticut Historical Commission, *Eastern Coastal Slope: Historical and Architectural Overview and Management Guide*, (Hartford, CT: State Historic Preservation Office: 1996), 12.

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[9] Bacdayan, "Outstanding Cultural Value in the Eight Mile River Watershed: Lyme," 4.

[10] Correspondence with David Bingham. July 2004.

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[12] National Register of Historic Places, *Hamburg Bridge Historic District Nomination Form.* 8.

[13] National Register of Historic Places, *Hamburg Bridge Historic District Nomination Form*. 9.

[14] National Register of Historic Places, *Millington Green Historic District Nomination Form*. (United States Department of the Interior, National Park Service: 1996), 3.

[15] National Register of Historic Places, *Millington Green Historic District Nomination Form*, 6.

[16] National Register of Historic Places, *Millington Green Historic District Nomination Form*, 6.

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FIGURES

COVER

Eightmile River Watershed, October 2004. (Courtesy: NPS)

INTRODUCTION

FIG 1. A Landscape Mosaic
The cultural landscape of the Eightmile River watershed is a mosaic of buildings, roads, agricultural fields, water features, and forest, all shaped and influenced by human history and interaction with the land and natural processes. (Courtesy: NPS)

PART ONE: CONTEXTUAL HISTORY

FIG 2. Aerial View of Forest Succession, Eightmile River Watershed, 2004. (Courtesy: NPS)

FIG 3. Statewide Context
The Eightmile River watershed is approximately 62 square miles and includes the towns of East Haddam, Lyme, Salem and a small portion of Colchester and East Lyme. (Source: L.Todd/Smith, Allen R. 1974. *Connecticut: A Thematic Atlas*. Central Connecticut State College: Hartford, CT)

FIG 4. The Eightmile River Watershed
Ninety percent of the watershed is comprised of the towns of East Haddam, Lyme, and Salem. (Source: L.Todd/UConn MAGIC)

FIG 5. Early Map of Agricultural Land Salem, CT, 1769
This map, taken from *Chronicles of a Connecticut Farm 1769-1905*, demonstrates how patterns of early settlement were based on town-centered development, radiating agricultural land, and scattered farmsteads. (Source: Perkins, Mary E. 2002. *Chronicles of a Connecticut Farm 1769-1905*. The Salem Land Trust, The Sullivan Printing Company)

FIG 6. Huckleberry Hill From Candlewood Ledge Hillside, c. 1920s
During the 1920s, there was still open farmland above Hamburg Bridge. (Courtesy: Lyme Public Hall Archives)

FIG 7. Historical Agriculture in East Haddam
Pasture land and hay field side by side, a typical agricultural landscape during the 19th and early 20th century. (Source: Huka, Elisabeth. 1958. “The Changing Geography of an Old New England Town, East Haddam, Connecticut.” A Thesis, submitted to the Faculty of Clark University, Worcester, Massachusetts)

FIG 8. The Beginning of Agricultural Succession
Typical red cedar growth on a former hay field in East Haddam, 1958. (Source: Huka, Elisabeth. 1958. “The Changing Geography of an Old New England Town, East Haddam, Connecticut.” A Thesis, submitted to the Faculty of Clark University, Worcester, Massachusetts)

FIG 9. Agricultural Succession in Salem
View of the fields behind the Mumford House in Salem. Today, these fields are being managed to allow for a succession of native species. (Courtesy: David Bingham)

FIG 10. Diagram of Forest Cover by 1934
In the mid-nineteenth century, it is estimated that 50% of the watershed landscape was covered by forest. This diagram of forest cover vs. non-forested land shows that approximately 75% of the watershed was forested by 1934. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 11. Diagram of Forest Cover by 1995
The patterns of forest cover vs. non-forested land by 1995 show that approximately 90% of the watershed is forested today. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 12. Music Vale Barn, 2004
A remnant of the 19th century agriculture that occurred at the Music Vale Seminary. (Courtesy: David Bingham)

FIG 13. Etching of Hamburg Cove
Note the young successional vegetation on the far hillside and in the foreground. (Courtesy: Florence Griswold Museum)

FIG 14. Sailing at Hamburg Cove
The picturesque and romantic qualities of the Cove are emphasized with the exaggerated slopes of the surrounding landscape and the reflections in the water. (Courtesy: Florence Griswold Museum)

FIG 15. A Cultural Landscape
Hedgerows and field patterns are well-defined by successional forest growth. (Courtesy: NPS)

FIG 16. Old Patterns of Circulation
Views of the abandoned farm road running between the Mumford House and Route 82. (Photo: L.Todd)

FIG 17. Typical Road in Watershed
Smaller roads within the watershed are typically hilly, narrow, and windy, due to the rocky topography. (Photo: L.Todd)

FIG 18. Open View of Field From Road
A typical view of a “gap” in the vegetation seen from the road. The watershed landscape is dominated by trees, but there are glimpses and sudden views of large expanses of open fields, as seen from the road. (Photo: L.Todd)

FIG 19. Route 11 Overpass, Salem
This portion of the highway, although already built, is not in use. (Photo: L.Todd)

FIG 20. Route 156, Lyme
Route 156 was recently repaved and widened. (Photo: L.Todd)

FIG 21. Wolf Tree in Forest
A lone wolf tree towers over a young succesional forest in Millington. (Photo: L.Todd)

FIG 22. Looking down to Hamburg Cove Towards Czikowsky Farm Barn
Open farmland along Hamburg Cove, c. 1920s. (Courtesy: Lyme Public Hall Archives)

FIG 23. Looking down to Hamburg Cove Towards Czikowsky Farm Barn, 2004
Successional growth has completely blocked the view towards the barn, which is in use as a garage for the new residence built beside it. (Photo: L.Todd)

FIG 24. Reynolds General Store, Lyme. (Photo: L.Todd)

FIG 25. Salem Town Green, 2004
The white clapboard buildings are typical of town center buildings within the watershed. (Courtesy: David Bingham)

FIG 26. Salem Historical Society, 2004. (Courtesy: David Bingham)

FIG 27. Tiffany Farm, 2004
One of the last dairy farms in operation in the Eightmile River watershed. (Photo: L.Todd)

PART TWO: CULTURAL LANDSCAPE STUDY AREAS

FIG 28. Cultural Landscape Study Areas
The Bingham family properties in Salem (1), Hamburg Bridge in Lyme (2) and Millington Green in East Haddam (3). (Source: L.Todd/UConn MAGIC)

FIG 29. Bingham Family Properties Study Area. (Source: L.Todd/USGS)

FIG 30. Woodbridge Farm Property, National Register of Historic Places
The Woodbridge Farm district, shown in pink, is currently listed in the National Register of Historic places. (Source: L.Todd/USGS)

FIG 31. Diagram of Circulation c. 1880
Dirt roads appeared as a "web" of roads of roughly equal width and condition connecting various farmsteads. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 32. Diagram of Forest Cover c. 1880
Approximately 85% of the study area was non-forested and primarily used for agriculture. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 33. Diagram of Circulation c. 1934
By this time, Route 82 had been widened, but the road patterns of the 19th century remain intact. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 34. Diagram of Forest Cover c. 1934
Agricultural abandonment lead to reforestation. Approximately 50% of the study area remained non-forested. Note that Mitchell Pond was made during the turn of the 20th century for agricultural purposes. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 35. Diagram of Circulation c. 1995
This diagram shows circulation circa 1995. Note the addition of Route 11 in the upper right hand corner of the study area, and the abandonment of the Mumford Farm road, which was the Colonial era crossing of the East Branch of the Eightmile River. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 36. Diagram of Forest Cover c. 1995
Approximately 25% of the study area remains non-forested, with successional species increasing and maturing. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 37. View of the Brook Bridge, 1919
The Brook Bridge was the colonial era crossing of the East Branch of the Eight Mile River. The surrounding landscape was still used for agriculture during this period. (Courtesy: David Bingham)

FIG 38. View of the Brook Bridge, 2004
Today, the road has been abandoned and the bridge is used mainly by the Bingham family. Note the loss in views beyond the bridge due to the successional growth. (Photo: L.Todd)

FIG 39. View From the Camp, 1950
In the 1950s, there was still a significant visual connection from the Bingham family Camp looking across to Mitchell Pond, Marvel, Mitchell, and Mumford Farms. (Courtesy: David Bingham)

FIG 40. View From the Camp, 2004
The present day vista from the Bingham family Camp looking across to Mitchell Pond, Marvel, Mitchell, and Mumford Farms. (Photo: L.Todd)

FIG 41. The Mumford House, 1945
View looking down the driveway of the Mumford house and farm, 1948. (Courtesy: David Bingham)

FIG 42. The Mumford House, 2003
View of the Mumford house present day. The house dates to 1769 and was built on the site of a former homestead. (Courtesy: David Bingham)

FIG 43. View of the Red Hay Barn and Surrounding Fields
The land was originally used for various types of agriculture, but is now managed as a wetland and is rich in biodiversity and native species. (Courtesy: David Bingham)

FIG 44. Stonewall and Stile
A finely crafted stonewall and stile found on the Bingham family properties. Stone-walls run extensively throughout the forested landscape of the watershed. (Photo: L.Todd)

FIG 45. Bingham Family Properties: Buildings, Structures, and Sites. (Source: L.Todd/USGS)

FIG 46. View of the Tiffany House, 2004
The house dates to 1840 and historical records of the area depict the house site as an orchard. Some of the property is still in orchards. (Courtesy: David Bingham)

FIG 47. Woodbridge Cemetery, 2004
The cemetery is on the Woodbridge Farm property and sits below the Woodbridge House. It dates to 1790 and is still used by the Bingham family. (Courtesy: David Bingham)

FIG 48. The Bingham Family Camp
Built in 1906 by Hiram Bingham, the Camp sits on a hill overlooking the other farm properties. Note the rocky outcrops, typical of the watershed landscape. (Photo: L.Todd)

FIG 49. View of Marvel Farm
The farm dates to 1790 and once had an ice pond that served the entire valley. (Courtesy: David Bingham)

FIG 50. The Red Hay Barn, Mumford Farm, 1947. (Courtesy: David Bingham)

FIG 51. The Red Hay Barn, Mumford Farm, 2004. (Courtesy: David Bingham)

FIG 52. Typical Spatial Organization
Typical spatial organization of a farmstead in the study area. The farmhouse is set back from the road, and a farmyard or interior courtyard is defined by the farmhouse and associated outbuildings. (Drawing/Source: L.Todd/USGS)

FIG 53. Hamburg Bridge Study Area. (Source: L.Todd/USGS)

FIG 54. Hamburg Bridge Historic District
The area shown in pink is the district listed in the National Register of Historic Places. (Source: L.Todd/USGS)

FIG 55. The Eightmile River at Hamburg Cove, 1776. (Courtesy: Lyme Public Hall Archives)

FIG 56. Aerial View of Hamburg Cove, Lord's Dock, c. 1936
Note the openess of the landscape beyond the town green. (Courtesy: Lyme Public Hall Archives)

FIG 57. Candlewood Ledge c. 1900
Note the openess of the agricultural landscape, juxtaposed with an abandoned field above Hamburg Cove. (Courtesy: Lyme Public Hall Archives)

FIG 58. Hamburg Cove, Lord's Dock and Schooners c. 1906. (Courtesy: Lyme Public Hall Archives)

FIG 59. Diagram of Circulation c. 1934
Principle roads and selected buildings shown. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 60. Diagram of Forest Cover c. 1934
Agricultural abandonment lead to reforestation. At this time, approximately 60% of the study area remained non-forested. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 61. Diagram of Circulation c. 1995
The road pattern has remained virtually the same. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 62. Diagram of Forest Cover c. 1995
Approximately 20% of the study area remains non-forested. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 63. Grassy Riverbanks Along the Water's Edge
Grassy riverbanks belong to individual residents and provide visual continuity along each side of the river, and enhance the feeling of openness found along the water's edge. (Photo: L.Todd)

FIG 64. Old Hamburg Bridge and Reed's Landing
This mid-19th century painting was done by G.F. Bottume and originally titled "Canal Near Salem, Connecticut". The Lombardy poplars on the right side of the painting demonstrate that this landscape was "improved." The view shows the Old Joshua-town Road Bridge and the openess of the surrounding agricultural landscape. (Courtesy: Lyme Town Hall)

FIG 65. Old Hamburg Bridge and Reed's Landing, 2004
The vegetation growth along the riverbank, as well as the growth on the hill overlooking the river, makes it impossible to replicate the same view of the bridge and surrounding buildings and structures. (Photo: L.Todd)

FIG 66. Figure Ground Diagram, Hamburg Bridge
This diagram shows the pattern of development that evolved along the Eightmile River at Hamburg Bridge. The majority of houses and buildings were built along the road, on the opposite side of the river bank, allowing for the land adjacent to the water's edge to be used first and foremost for commercial activity. (Drawing/Source: L.Todd/USGS)

FIG 67. Typical Section, Hamburg Bridge
This section shows the relationship of building, road and green space along the Eight Mile River at Hamburg Bridge. Houses line the narrow road, on the opposite side of the river bank. Most of the land along the water's edge is undeveloped and serves as common green space for the community. (Drawing/Source: L.Todd/USGS)

FIG 68. Hamburg Bridge Over Eightmile River, pre-1936
The former stone and wood structure of the old Hamburg bridge. (Courtesy: Lyme Public Hall Archives)

FIG 69. Hamburg Bridge Over Eightmile River, 2004
Replacement concrete bridge built by the Army Corps of Engineers in the late 1930s after the hurrricane of 1936. (Photo: L.Todd)

FIG 70. Old Hamburg Road, Hamburg Bridge Historic District
The narrow road and building setbacks are characteristic of the pattern of development in the Hamburg Bridge Historic District. (Photo: L.Todd)

FIG 71. Eight Mile River, Hamburg Bridge Historic District
Today the Eight Mile River is mostly used for recreation. (Photo: L.Todd)

FIG 72. Millington Green Study Area

FIG 73. Millington Green Historic District
The area shown in pink is currently the historic district listed in the National Register of Historic Places. (Source: L.Todd/USGS)

FIG 74. Settlement Along Wall Street
View of old foundations and stone walls from past settlement along Wall Street. (Photo: L.Todd)

FIG 75. Remnants of Past Agricultural Use, Wall Street
An old pickup truck sits abandoned just off Wall Street. (Photo: L.Todd)

FIG 76. Diagram of Circulation c. 1934. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 77. Diagram of Forest Cover c. 1934
At this time, approximately 40% of the study area remained non-forested. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 78. Diagram of Circulation c. 1995
The road pattern has remained virtually unchanged, with the exception of Wall Street becoming a trail with limited public access. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 79. Diagram of Forest Cover c. 1995
Approximately 10% of the study area remains non-forested. (Drawing/Source: L.Todd/UConn MAGIC)

FIG 80. Wall Street, Millington, 2004
What was once the busiest commercial route in Millington has become an abandoned, overgrown trail in the woods. Access to the trail is through the driveway and backyard of the Daniel Bulkley House. (Photo: L.Todd)

FIG 81. Daniel Bulkley House, 1792
This clapboard house is an example of a historic home built on the north side of Millington Green. Note, Wall Street is located to the right of the house, and access to the trail is behind the house through the backyard. (Photo: L.Todd)

FIG 82. 10th District Schoolhouse, c. 1854. (Photo: L.Todd)

FIG 83. Millington Green, East Haddam c. 1958
Note the openess of the landscape around Millington Green, especially shaded quality of the Green in the foreground, and openess of the agricultural land behind the Congregational meetinghouse that burned in 1971. (Source: Huka, Elisabeth. 1958. “The Changing Geography of an Old New England Town, East Haddam, Connecticut.” A Thesis, submitted to the Faculty of Clark University, Worcester, Massachusetts)

FIG 84. Site of Former Congregational Meetinghouse, 2004
The site of the former Congregational meetinghouse has been maintained as an open green space. (Photo: L.Todd)

FIG 85. Millington Green, East Haddam, 2004
Today the Green contains a small shrub-sized planting in the center, some signage, a flagpole, and a bench. (Photo: L.Todd)

FIG 86. Congregational Meetinghouse, c. 1940s
This unknown artist’s painting of the Millington Congregational meetinghouse shows the openess of the surrounding agricultural landscape. (Courtesy: Millington Green resident)

FIG 87. Figure Ground Diagram, Millington Green
This diagram shows the triangular parcel of land, around which the historic settlement patterns of Millington radiated. The green occupies a long triangular piece of land, which results in an awkward set of intersections, and a largely unused green space at the center of this now small community. (Drawing/Source: L.Todd/USGS)

PART THREE: INTEGRITY AND SIGNIFICANCE OF THE LANDSCAPE

FIG 88. The Eightmile River Watershed. (Courtesy: NPS)

FIG 89. New Development Within the Eightmile River Watershed. (Courtesy: NPS)

AFTERWORD

FIG 90. Sensitive Natural Resource Areas
Zoning procedures such as Transfer of Development Rights can allow towns to steer development pressure away from sensitive natural resource areas such as wetlands. (Courtesy: NPS)

FIG 91. Historic Overlay District Zoning Bylaw
Revising zoning regulations in order to establish or modify a historic overlay district can help control the type of development that occurs, as well as provide management guidelines for current residents living within the district. (Courtesy: NPS)

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Interviews and Correspondence

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Appendix 6

Outstanding Resource Value Report: The Watershed Ecosystem

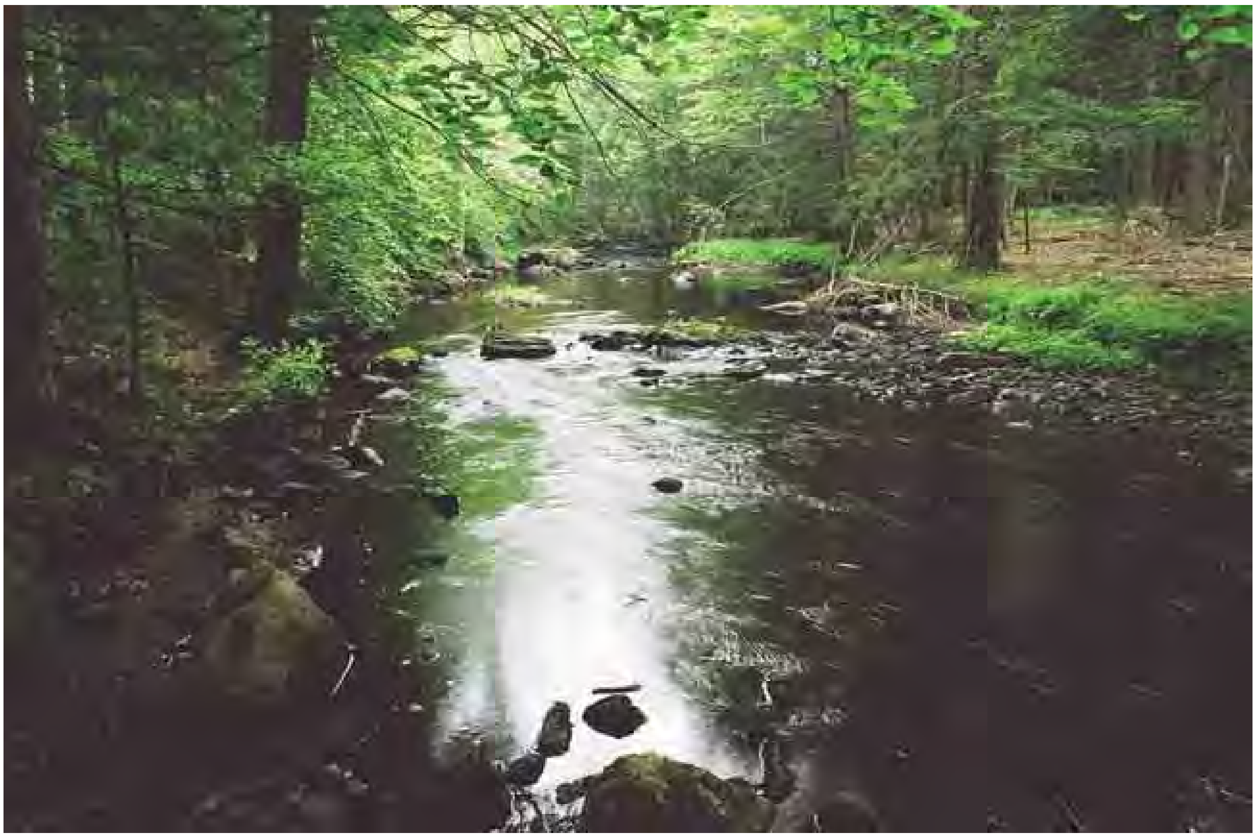
Eightmile River Watershed Management Plan

Eightmile River Watershed Outstanding Resource Value:
The Watershed Ecosystem
6/26/06

Authored by William H. Moorhead III

The following report is also available in its original color format from www.eightmileriver.org. Please note that this report was completed after printing of the draft appendices that were provided for public review during January of 2006. The version that appears here is of similar content but in a more complete form.

Eightmile River Watershed Biodiversity Report



Prepared for the Eightmile River Wild and Scenic Study Committee

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EXECUTIVE SUMMARY

The Eightmile River watershed is a relatively undeveloped drainage basin that occupies 62.4 mi^2 of hilly, mostly forested terrain in southeastern Connecticut. In 2004, the author was commissioned by the Eightmile River Wild and Scenic Study Committee to: 1) assess the biodiversity values and significance of the Eightmile River watershed, especially with respect to imperiled plants and animals; 2) identify and document those physical, biological, and ecological elements that make the watershed exemplary and unique as an intact, functioning watershed ecosystem; 3) create maps depicting unique species and natural community/habitat resources; 4) identify and document anadromous and resident fish species; and 5) develop a set of management recommendations for the watershed. This study was commissioned in support of an anticipated application for Federal Wild & Scenic River designation for the entire watershed. The author, whose primary area of expertise and background is botany and classification of vegetation and natural communities, has researched existing information relevant to the biodiversity of the watershed, and presents it in this report.

The Eightmile River is a tributary to the lower Connecticut River. The confluence of the two rivers is approximately 8 miles from the mouth of the larger river at Long Island Sound (whence the Eightmile River reportedly gets its name), and the entire watershed is within ~18 miles of Long Island Sound. At the point of confluence, the Connecticut River and the downstream-most 2.4± miles of the Eightmile River are tidal with halinities close the boundary between freshwater (< 0.5 ppt) and oligohaline (0.5-5.0 ppt). Most of this tidal section the Eightmile River is a relatively long, narrow, shallow embayment of the Connecticut River known as Hamburg Cove. The Connecticut River is doubtless a dominant influence on ambient water levels and water chemistry of Hamburg Cove, except perhaps when the Eightmile River is in flood, and then for relatively short periods. However, the Eightmile River, by way of these relatively short periods of intense floods, is believed to be a prime factor resulting in the dominance of coarse sediments in Hamburg Cove, which in turn is a critical factor in the occurrence of species and communities of high biodiversity significance.

Beyond the tidally influenced sections, the Eightmile River and its major tributaries are clear, picturesque streams with long, mostly medium-high gradient, mostly forested sections punctuated by occasional small impoundments (man- and beaver-made) and occasional low-gradient shrub-swampy or marshy sections. The landscape of the watershed may be characterized overall as one of rolling, more or less irregular, low hills and ridges separated by numerous small, narrow drainage corridors and hollows, and in places broader valleys and basins. Ambient hill-top elevations gradually decrease across the watershed from 500-650 ft at the north end to 300-400 ft at the southern end. However, beyond these generalizations, there is considerable landscape-level geomorphologic variation within the watershed, and several geologic and geomorphologic features of the watershed have recognized as exceptional in

various contexts. Among these features are an exceptional number of different bedrock types (Lundgren 1966), and the occurrence of a series of strike ridges whose east-west orientation is unique, in New England, to a small area in southeast Connecticut that includes the Eightmile watershed.

As the first step in the assessment of the biodiversity significance of the Eightmile River watershed, an inventory was completed of rare plants and wildlife known or believed to be extant in the watershed. This inventory drew in largest part on existing information, but it was also augmented by limited primary field survey by the author, focusing mainly on rare plants and natural communities. Important sources of existing information included the Connecticut Dept. of Environmental Protection's (CT-DEP) Wildlife and Fisheries Divisions, the CT-DEP Natural Diversity Data Base (NDDB, i.e., the state natural heritage program), scientists from area universities and other institutions, local naturalists, and a variety of published studies. Rare plants and wildlife were defined as species listed as "Endangered", "Threatened", or "Special Concern" under Connecticut's Endangered Species Act, species listed as "important", "very important", or "most important" in Connecticut's Comprehensive Wildlife Management Strategy, and other species identified as being of special conservation concern by other organizations, such as ICUN and the New England Wildflower Society. A total of 160 such species, referred to in this report as "at risk" species, are either known to be currently extant in the watershed, or documented recently enough (i.e., within the last 25 years) to suspect they are extant. This list is comprised of 37 vascular plants, 6 amphibians, 77 bird species, 11 fish species, 10 invertebrate species, 6 reptiles and turtles, and 13 mammals. The watershed hosts 5 globally rare species: two plants, *Bidens eatonii* Eaton's Beggar's-ticks (G2) and *Eriocaulon parkeri* Parker's Pipewort (G3), and three insects, *Callophrys irus* Frosted Elfin (G3, a butterfly), *Gomphus ventricosus* Skillet Clubtail (G3, a dragonfly), and *Enallagma minusculum* Little Bluet (G3G4, a damselfly). Also, the watershed is a breeding season and winter foraging area for one species listed as Threatened under the U. S. Endangered Species Act: the Bald Eagle. The Eightmile River watershed is the New England regional stronghold for two regionally rare plants, *Scutellaria integrifolia* Hyssop Skullcap and *Aristolochia serpentaria* Virginia Snakeroot, and the Connecticut stronghold for a third regionally rare plant, *Xyris smalliana* Small's Yellow-eyed Grass.

The biodiversity significance of the Eightmile River watershed was evaluated in two contexts: state and regional (with "regional" defined as New England) and using two measures of species rarity, state and global. Biodiversity significance may be defined in many ways, but for the purposes of this analysis, the number of extant rare species was considered to be a surrogate for high biodiversity significance. This approach was used because it is generally accepted that high densities of rare species are, more often than not, the "icing on the cake", i.e., rare species most often occur in places that have unusually high species (and natural community) richness. Using data compiled by NatureServe and originating with the six New England state natural heritage programs, the Eightmile River watershed was compared to all other watersheds in New England, in terms of extant globally rare species (species ranked G1-G3 by NatureServe) and extant state-rarest species (species ranked S1-S2 by local heritage programs). Comparing numbers of extant rare species per unit area of watershed ("extant" being defined as having been observed within the last 25 years), the Eightmile River watershed ranks very high in both state and regional contexts. Due to differences between watershed/drainage basin classification systems at the state and federal level, a direct comparison was not possible. But a direct comparison of the two component HUC12 basins that comprise the Eightmile River watershed, the Eightmile River [mainstem] basin and the East Branch Eightmile River basin, was possible, and the two HUC12 basins rank in the 98th and 90th percentile, respectively, of the 1,931 HUC12 basins in New England in terms of total extant globally rare species per unit area, and in the 95th and 89th percentile, respectively, in terms of total extant combined state-rare and globally rare species per unit area.

The Eightmile River watershed's biodiversity significance in a state context was evaluated with the assistance of the Connecticut Department of Environmental Protection's Natural Diversity Data Base (CT-DEP-NDDB), which is the state's natural heritage program. A direct comparison to Connecticut's other regional basins was possible, and for this comparison rare species were defined as all species listed as Endangered, Threatened, or Special Concern under the Connecticut's Endangered Species Act (this includes all globally rare species as well), as well as any other species assigned a state conservation status rank of S2S3 or lower. In this comparison, the Eightmile watershed, with 49 extant state-rare species (0.7853 spp/mi^2), exceeds all but four of Connecticut's regional drainage basins, in terms of extant state-rare species per unit area. The four basins that exceed the Eightmile (the Wood, Tenmile, Hollenbeck, and Blackberry River basins) are in the two subregions of New England that have the highest numbers of extant rare species in New England: northwestern Connecticut and vicinity, and southwestern Rhode Island and vicinity.

That the Eightmile hosts a relatively high number of extant globally and state-rare species is a function largely of the existence in the watershed of intact special habitats/natural communities. As a general rule, the rarest species in any landscape are habitat specialists that are rare because their specialized habitats are rare. This certainly holds true for the Eightmile watershed, and the majority of its globally and state-rare species and other uncommon species are associated with special habitats and natural communities that cover relatively small portions of the watershed, such as freshwater and oligohaline intertidal habitats, medium fens, sandy and peaty shorelines of natural sandy-bottomed lakes, acidic and sweet seasonally wet meadows, acidic cliffs, rocky outcrops of interbedded amphibolite and marble, dry grasslands, xeric sand barrens, and Atlantic White Cedar swamps. Also, the majority (but not all) of rare and uncommon species hosted by the watershed are associated with non-forested habitats, some of which are naturally open (such as medium fens and intertidal sand-gravel flats), but many of which are open- or semi-open-canopy habitats due to past or on-going manipulation by man.

An exceptional biodiversity feature of the Eightmile River watershed is the association of a high-profile "at risk" bird species, the Cerulean Warbler (*Dendroica cerulea*), with a forest habitat type, or complex of types, that is not itself rare, but occurs on an unusually large scale in the watershed. This neotropical migrant is not yet globally rare, but is in a rangewide decline that is believed to be due to fragmentation of large mature forest stands. The Eightmile watershed, throughout much of which the Cerulean Warbler breeds, comprises the greatest part of a regional stronghold for this species. This warbler is considered one of the most area-sensitive bird species (i.e., large unbroken mature forest blocks are required to support robust breeding populations), and it is believed that the Eightmile watershed's robust breeding population is related to the size and types of its forest blocks in juxtaposition with the watershed's near-coastal geographic position, and resulting relatively mild climate (the center of the Cerulean Warbler's breeding range is the central Appalachians – it is reaching its northern range limit in New England). Thus, the existence of a large breeding population of Cerulean Warblers is evidence that the Eightmile River watershed has a unique combination of forest size, type, and geographic position.

This study approached the evaluation of river and watershed ecosystem quality by looking for indicators (biological, ecological, and physical) of ecosystem and habitat intactness and functioning. The above-mentioned Cerulean Warbler is one such biological indicator. Other important biological indicators identified were vernal-pool-dependant amphibians, such as Spotted Salamander and Wood Frog. Both species require a landscape with two habitat elements juxtaposed: sufficient densities of undegraded vernal pool habitat for breeding sites, and large, unfragmented accessible upland forest habitat for adult foraging. Both species are found throughout the Eightmile watershed, and populations are evidently very robust in many places. These robust populations are evidence of intact and functioning complex of habitat types.

Another important biological indicator in the watershed is stream macrobenthos (i.e., the communities of invertebrates that dwell on the bottoms of streams). The CT-DEP has sampled the Eightmile River and East Branch Eightmile River, and have concluded, based on the macrobenthic species assemblage present, that the Eightmile [mainstem] is essentially pristine, while the East Branch Eightmile River ranks in the upper half of sampling sites statewide, in terms of water and habitat quality.

Several landscape level indicators of habitat intactness were assessed and used to compare the Eightmile River watershed to other watersheds in a Connecticut context. These parameters were road miles/unit area of watershed (using GIS data from the CT-DEP's Environmental and Geographic Information Center), the proportion of a watershed that is occupied by large roadless blocks (using a coverage developed by The Nature Conservancy), the total forested proportion of the watershed, and the percent developed area of the watershed (using a land use coverage developed by University of Connecticut Center for Land Use Education and Research from 2002 satellite imagery). The Eightmile watershed, with 2.65 road miles/square mile of watershed, has the third lowest road miles/mi^2 of the 44 regional watersheds in CT (range: 1.57 to 16.5 road mi/mi^2). The Eightmile watershed ranks 2^{nd} from the top in terms of percentage of watershed occupied by roadless blocks of 1000 ac or greater (72.2% for the Eightmile watershed). Only two of Connecticut's 44 regional watersheds have a greater percentage of forested area than the Eightmile watershed. Of special note, in light of the above-discussed hypothesis regarding the large breeding population of Cerulean Warblers centered in the Eightmile watershed, is that it exceeds all other <u>near-coastal</u> Connecticut watersheds in percentage forested area, by 9 to 81 percentage points. Finally, the Eightmile watershed, with 6.74% developed land, has a lower percentage of developed area than all except four of Connecticut's 44 regional watersheds, and a lower percentage of developed land than <u>all</u> 15 other <u>near-coastal</u> watersheds. For all four landscape level parameters, the Eightmile watershed is either comparable to, or is exceeded only by, the four above-mentioned Connecticut watersheds that have the highest numbers of extant rare species in New England (the Wood, Tenmile, Hollenbeck, and Blackberry River basins).

In summary, the Eightmile River watershed ranks very high in a state and regional context in terms of biodiversity values and biodiversity significance. This is indicated by a high number of species identified as "at risk" by various conservation organizations, and it is indicated by the relatively high numbers of the subset of "at risk" species that are classified as globally rare and state-rare, compared with all other watersheds in Connecticut and New England. It is a unique regional stronghold for several specific rare/at risk species. In addition, in terms of a number other parameters that are indicators of ecosystem integrity, intactness, and function, the Eightmile watershed is comparable to, or exceeded only by, a few watersheds in southern New England that have the largest concentrations of extant rare species in all of New England.

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I. INTRODUCTION

The Eightmile River watershed is a relatively undeveloped drainage basin that occupies 62.4 mi^2 of hilly, mostly forested terrain in southeastern Connecticut. In 2004, this assessment of the biodiversity values and significance of the Eightmile River watershed was commissioned by the Eightmile River Wild and Scenic Study Committee, in support of a plan to seek Federal Wild and Scenic River designation for the entire watershed. The author, whose primary area of expertise and background is botany and classification of vegetation and natural communities, has researched existing information relevant to the biodiversity of the watershed, and has presented it in this report.

II. DESCRIPTION OF THE STUDY AREA

The Eightmile River watershed, as addressed in this report, occupies approximately 62.4 mi^2 in southeastern Connecticut (see location map in Figure 1). The long axis of the watershed is roughly north-south: it is about 12.6 mi long by 7.5 mi wide at its widest point in east-west dimension. The watershed straddles the border between New London county and Middlesex County, and occupies parts of five towns: Lyme, East Haddam, Colchester, Salem, and East Lyme. The watershed straddles an east-west-running boundary between two "ecoregions", as they have been defined by The Nature Conservancy (The Nature Conservancy 2001). The northern-most 90% of the watershed lies in the Lower New England/Northern Piedmont Ecoregion, while the southern-most 10% is in the North Atlantic Coast Ecoregion.

The Eightmile River is a tributary from the east to the Connecticut River, which is tidal in this area. The downstream end of the watershed is considered to be at the mouth of Hamburg Cove in Lyme, which is nearly 8 miles upstream from the mouth of the Connecticut River. Measured from the mouth of Hamburg Cove, the downstream-most 2.4± miles of the Eightmile River are tidally influenced. The halinity regime of this tidal reach of the Eightmile River is either completely fresh, or perhaps varies seasonally to oligohaline, especially toward the mouth of the cove. Hamburg Cove is essentially a freshwater tidal embayment of the Connecticut River that extends 2.2± miles upstream to the point where the Eightmile River's downstream flow is dominant between high tides. The river is tidal for another 0.2± miles above this point, but this section clearly has stream character rather than that of an embayment. Above the head of tide, the distance in stream-miles to the head of the watershed's most distant perennial headwater is about 14.6 miles. The entire watershed is within 18± miles of the coast (i.e., the north shore of Long Island Sound).

Above the tidally influenced sections, the Eightmile River and its major tributaries are clear, picturesque streams with long, mostly medium-high gradient stretches through mostly deciduous forested terrain. Forested sections of the Eightmile River and its major tributaries are punctuated by occasional small impoundments (man- and beaver-made), occasional swampy or marshy sections. In overview, the landscape of the watershed may be characterized as one of rolling low hills, ridges, and lines of hills that are separated by numerous small, narrow drainage corridors and hollows, and in places broader valleys and basins. Ambient hill-top elevations gradually decrease across the watershed from 500-650 ft at the north end to 300-400 ft at the southern end. However, beyond these generalizations, there is considerable landscape-level geomorphologic variation within the watershed, and several bedrock-geologic and geomorphologic features of the watershed have recognized as exceptional in various contexts. Among these features are an exceptional number of different bedrock types (Lundgren 1966), and the occurrence of a series of strike ridges whose east-west orientation is unique, in New England, to small area in southeast Connecticut that includes the Eightmile watershed.

An overview map of major habitat types of the Eightmile River watershed is presented in Figure 2. This major habitat coverage was derived from a more detailed, finer resolution vegetation/habitat coveraged synthesized by the author during this investigation. This finer resolution vegetation/habitat map is presented in Figures 4 and 5. The area and relative percentage of the watershed occupied by each vegetation/habitat unit is found in Table 1.

Based on the author's analysis, approximately 17% of the watershed may be classified as wetland, and ~83% as non-wetland.

The most abundant physiognomic vegetation type in the Eightmile River watershed is forest, which occupies ~75.5% of the watershed (unless otherwise noted, this percentage and those that follow are derived from the author's vegetation/habitat map). Most of this forest is deciduous forest (~73% of the watershed), while only a very small portion is evergreen and mixed evergreen-deciduous forest (slightly more than 2% of the watershed). Eastern Hemlock (*Tsuga canadensis*) is the dominant evergreen component in most of this portion of the watershed. In spite of its small cumulative area, this evergreen and mixed evergreen-deciduous forest portion is a significant ecological element of the watershed, because two-thirds of it occurs in a single complex of more nearly 600 acres, along the Eightmile River [mainstem] in the Devil's Hopyard – Burnham Brook area.

The entire watershed has been assigned to the Central Hardwoods-Hemlock forest, *sensu* Westveld *et al*. (Westveld *et al*. 1956; Dowhan 1976), in which oaks and low heaths dominate dry sites, oaks and hickories are dominant forest trees on dry-mesic sites, and Sugar Maple (*Acer saccharum*) and Tuliptree (*Liriodendron tulipifera*) and are dominant forest tree species on mesic sites of higher fertility (Dowhan 1976). According to a map of forest dominance types in the watershed, based on Landsat satellite imagery from 1988, 1990, and 1992 (Bonneau 1997), two dominance types comprise 81% of the total forested area of the watershed: Oak-Hickory (54%) and Mixed Deciduous (27%). According to this mapping, the matrix forest of the watershed is made up of a mosaic of these two forest types, and seven other dominance types, occurring as many small islands in the matrix and each having cumulative areal percentages ranging from <1% to 6%, make up the remaining 19% of the watershed's forests: Oak/Pine, Red Maple, Hemlock, Birch, Tulip Poplar, Oak/Mountain Laurel, and Pine. The author has not conducted a rigorous ground-truthing of this forest type mapping, but his field work and aerial photo analyses have confirmed, at least, that these forest dominance types exist in the watershed, and that the cumulative area hierarchy of the two major types versus the seven minor types, collectively, is essentially correct. In addition to the dominance types recognized , the author has identified, though his field work, a number of other major and minor forest dominance types that occur in the watershed, such as Oak (with little or no Hickory), Hickory (with little or no oak), Beech, Sugar Maple-White Ash, Atlantic White Cedar, Oak-Hemlock (to name only a few). It appears that, of these additional dominance types not recognized in the Landsat-derived mapping, the deciduous types have most often been found in areas mapped as Oak-Hickory and Mixed Deciduous, while the evergreen and mixed evergreen-deciduous types occur in areas mapped as Hemlock, Oak/Pine, Pine, or Oak/Mountain Laurel. Thus, based on the author's work, it appears that Oak-Hickory and Mixed Deciduous forests are indeed major forest dominance types in the watershed, but that other types collectively make up a greater proportion of the forests in the watershed than is presented in the Landsat-derived mapping.

The Eightmile River watershed's forests may also be viewed as an assemblage of floristic alliances, associations, and subassociations/communities, *sensu* the International Vegetation Classification (Grossman et al. 1998) and the complementary Vegetation Classification for Connecticut (Metzler and Barrett 2006). The watershed vegetation has not yet been classified and mapped using these classification schemes, but based on the author's recent field work, it has been possible to identify the major forest associations occur in the watershed. The watershed's non-wetland forested matrix is primarily a complex mosaic of the following three associations: Northern red oak / Flowering dogwood (*Quercus rubra* / *Cornus florida*) forests, Northern red oak - Black oak - Chestnut oak (*Quercus rubra - Quercus velutina - Quercus prinus*) forests, and Sugar maple – White ash – American basswood (*Acer saccharum – Fraxinus americana - Tilia americana*) forests. The first two associations together almost certainly occupy more area the third association, but their importance relative to each other is hard to estimate. The watershed's forested wetlands, which comprise 15% of the watershed's total forested area, appear to be primarily made up of three associations: Red maple / Skunk cabbage (*Acer rubrum* / *Symplocarpus foetidus*) seasonally flooded forests, Red maple / Highbush blueberry (*Acer rubrum* / *Vaccinium corymbosum*) seasonally flooded forests, and Red maple – Pin oak (*Acer rubrum - Quercus palustris*) seasonally flooded forests. The first two associations together comprise the greatest portion of the watershed's wetland forests. The last association, which comprises only 4% of the watershed's forest wetlands, has disproportionately high biodiversity significance, because this unit is where forested vernal pools fit in this classification. Also known to occur in the watershed, and possibly occupying a significant area, is a seventh association that straddles the boundary between wetland and non-wetland forests: the Northern red oak – Yellow birch (*Quercus rubra - Betula alleghaniensis*) forests association.

About 15% of the forested portion of the watershed, or ~11% of the total watershed area and ~65% of the total wetland area in the watershed, is forested wetland. All except a small portion of this is deciduous forested basin and seepage swamp in which Red Maple (*Acer rubrum*) is the dominant, or a co-dmominant, tree species. Trees commonly co-occurring in wetlands with Red Maple are Yellow Birch (*Betula alleghaniensis*), Black Gum (*Nyssa sylvatica*), Swamp White Oak (*Quercus bicolor*), and Pin Oak (*Quercus palustris*). In the small proportion of evergreen and mixed deciduous forested wetlands that occur in the watershed, Eastern Hemlock (*Tsuga canadensis*), White Pine (*Pinus strobus*) are the most prevalent co-dominant species, but a few places, all in the vicinity of Cedar Lake, Atlantic White Cedar (*Chamaecyparis thyoides*) is dominant or co-dominant.

The 24.5% of the watershed that is not forested is comprised of non-forested wetlands (~6%), open and semi-open upland habitats (~7%), mesic to seasonally wet open and semi-open habitats (~3%), developed areas and roads (~9%).

Two thirds of the non-forested wetland portion of the watershed is divided nearly equally between of two classes of wetlands: open water habitats and deciduous forest/scrub-shrub wetlands. Open water habitats occupy, which include natural and man-made lakes and ponds, man-made and beaver-made impoundments, and tidal open water, occupy about 800 ac (12% of the watershed's wetlands area and 2% of the total watershed area). More than half of the total open water of is comprised of the five largest water bodies in the watershed: fresh to oligohaline tidal Hamburg Cove (170 ac), Lake Hayward [formerly known as Shaw Lake] (175 ac), Uncus Pond [formerly known as Hog Pond] (75 ac), Norwich Pond (30 ac), and Cedar Lake (25 ac). The latter four water bodies are the four largest lakes/ponds in the watershed, and also are all natural (though Lake Hayward is dammed and has been raised above its original level).

Deciduous forest/scrub-shrub wetlands, which comprise 13% of the total wetlands area and 2% of the total watershed area, are deciduous-shrub-dominated wetlands that also have open stands of deciduous trees with cumulative tree canopy coverage in the range of 30-60%. This wetland class has been subdivided on the basis of hydrologic regime. About 28% of the wetland area mapped as deciduous forest/scrub-shrub has been classified as "seasonally flooded/exposed", while ~69% has been classified as "seasonally flooded", and the remaining 3% have been assigned several other hydrologic regimes. Seasonally flooded/exposed wetlands are those that have been identified as potential and/or field-verified breeding sites for vernal pool indicator species.

The remaining 10% of non-forested wetland area in the watershed is comprised of a great number of wetland types, which are presented in Figures 4 and 5 and Table 1. Much of this diversity of wetland type can be attributed to past and current activities of humans and beaver in the watershed.

Approximately 10% of the watershed is occupied by open (i.e., without trees) and semi-open (i.e., having trees but with less than ~60% cumulative tree canopy coverage) upland habitats and mesic to seasonally wet habitats (this latter category occurs on non-hydric soils with a seasonally high water table). These include a great variety of grasslands, variously dense to sparse evergreen, deciduous, and deciduous shrublands, evergreen, deciduous, and mixed woodlands and savannas (i.e., sparse woodlands), xeric sand barrens, and xeric rocky outcrop communities. Of the nearly 4000 ac of open and semi-open non-wetland habitats in the watershed only a few acres, at most, occupied by a portion of the xeric rocky outcrop communities, can be said to be occurring in an unforested state "naturally" (i.e., in the absence of past or current human disturbance/manipulation). Virtually all of the open and semi-open habitats non-wetland habitats in the watershed are unforested because of human disturbance/manipulations of the land and/or vegetation, either on-going or in the recent past. Among the most important of these disturbances/manipulations are those associated with agriculture and animal husbandry, such as raising of row crops, grazing, and hay production, timber harvest and silvicultural treatments, highway and electrical transmission right-of-way management, sand and gravel mining, and wildlife habitat management practices. A small portion of open and semi-open habitat, all in Nehantic State Forest, is being maintained by prescribed burning by the CT-DEP Forestry Division (Gluck pers. comm.).

The town of Salem, in the northeast part of the watershed, is a concentration area in the Eightmile River watershed for open and semi-open habitats, and within Salem, the Salem Valley area, transected by the East Branch Eightmile River, is a concentration of open and semi-open habitats.

Grasslands occupy nearly 1600 ac, or ~4%, of the watershed, and they comprise largest single type (36%) of the non-wetland open and semi-open habitats class. In the Eightmile River watershed vegetation/habitat map, total grasslands are subdivided into “mesic to seasonally wet grassland”, which occur on non-hydric soils with a seasonally high water table, and “grassland”, which occur on well-drained soils with moisture regimes that range from mesic to dry to xeric. The cumulative area ratio of “mesic to seasonally wet grassland” to “grassland” is 40:60. Both units are considered non-wetland types, but soils data from the National Soil Information System (USDA-NRCS 2003) and the author’s field observations indicate that a portion of the “mesic to seasonally wet grasslands” unit is on hydric/wetland soils. Also, “hidden” in both grassland units, as depicted in the vegetation/habitat map, is some amount of herbaceous habitat in which non-grasses, such as forbs, such as goldenrod (*Solidago* spp.), or sedges (*Carex* spp., *Scirpus* spp., etc.), comprise the dominant vegetation, rather than grasses. More than 50% of the watershed’s grassland area is concentrated in the town of Salem, and almost half of Salem’s grassland area is concentrated in the Salem Valley area, along the East Branch Eightmile River.

The watershed’s grasslands are comprised of several floristic types. All are either currently managed, or have been managed until very recently, to prevent succession to shrubland, woodland, and forest. The most abundant types of grassland in the watershed are hayfield and pasture, which are dominated by introduced cool-season grasses. However, a substantial portion of the watershed’s grasslands, especially those on dry to xeric sandy soils, are dominated by native warm-season grasses. Little Bluestem (*Schizachyrium scoparium*) is the most widespread and most abundant of these, while Big Bluestem (*Andropogon gerardii*) and Indian Grass (*Sorghastrum nutans*) are somewhat less widespread, and much more restricted, as dominant species, to seasonally wet sandy floodplain and deep till soils. Both the “short-grass prairie” (Little Bluestem dominant) and the “tall-grass prairie” (Big Bluestem dominant) types of grassland occur “naturally” in the watershed, in the sense that no one planted and cultivated the native warm-season grasses (though disturbance by man was and is required to maintain open conditions and prevent invasion by woody species and succession). These warm-season grasslands have developed spontaneously on sites formerly managed more intensively as hayfields, pasture, crop fields, and on sites of sand and gravel extraction or filling.

The bulk of the balance of the open and semi-open non-wetland habitat class is comprised of a great variety of early successional types, the greatest portion of which represents various stages of “old field succession”. Lesser but significant portions represent post-logging succession, succession in abandoned sand-and-gravel mines, and succession in the corridor of an unfinished limited access highway segment. Another significant portion may be said to represent “arrested” stages succession. These are habitats such as scrub in electrical transmission rights-of-way, fields with open stands of trees and/or shrubs, woodland and/or scrubby habitat that is periodically burned, and other habitats that are managed to prevent further succession.

The 9% of the watershed that is classified as developed land is comprised predominantly of single-family residential development (6.8%), followed by roads (1.3%), and less than 1% combined industrial, commercial, public, and municipal development. Development is concentrated in certain areas: Lake Hayward and vicinity, the Rte. 85 corridor in Salem, and Hamburg Cove and vicinity.

As of May 2005, approximately 11,000 acres, or 28% of the watershed, was protected by conservation ownership or easement, based on recent research by The Nature Conservancy (Geisler and Frohling 2005). Nearly ¾ of this protected land is state-owned State Forest, State Park, and other types of conservation land. The remainder is protected by ownership, or conservation easements held by, local land trusts, The Nature Conservancy, towns and other entities.

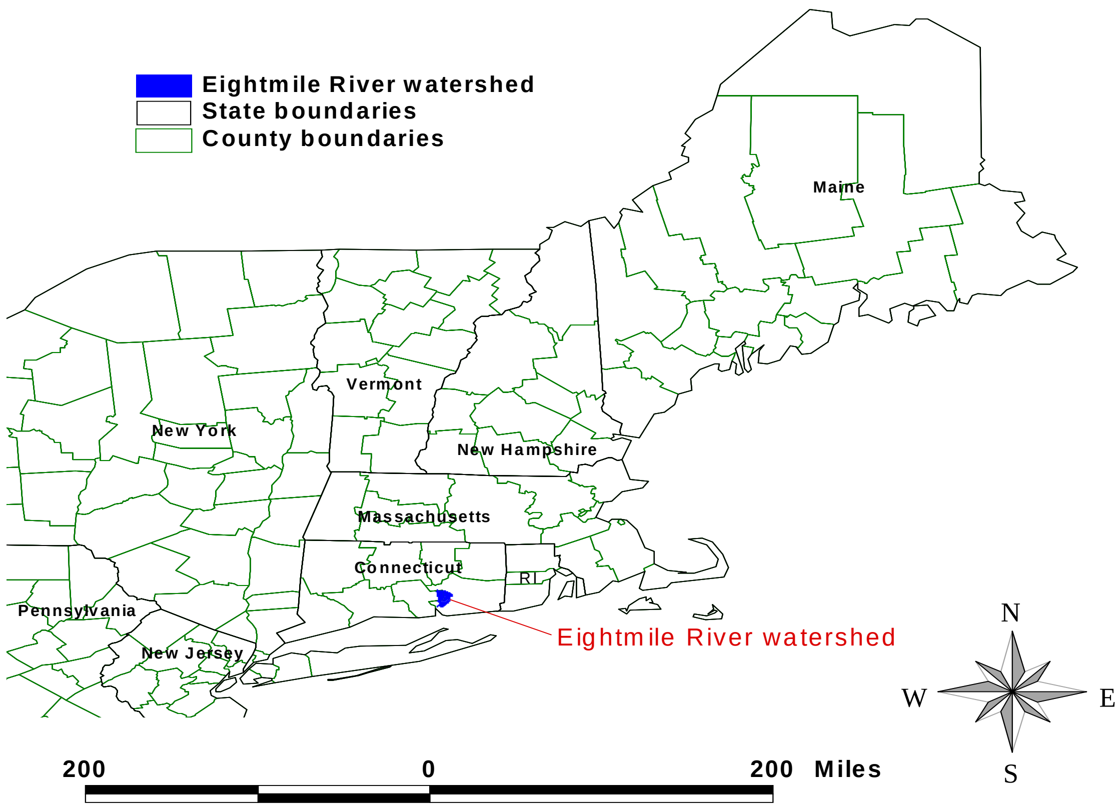

Figure 1. Location Map for Eightmile River watershed, New London and Middlesex Counties, Connecticut, USA.

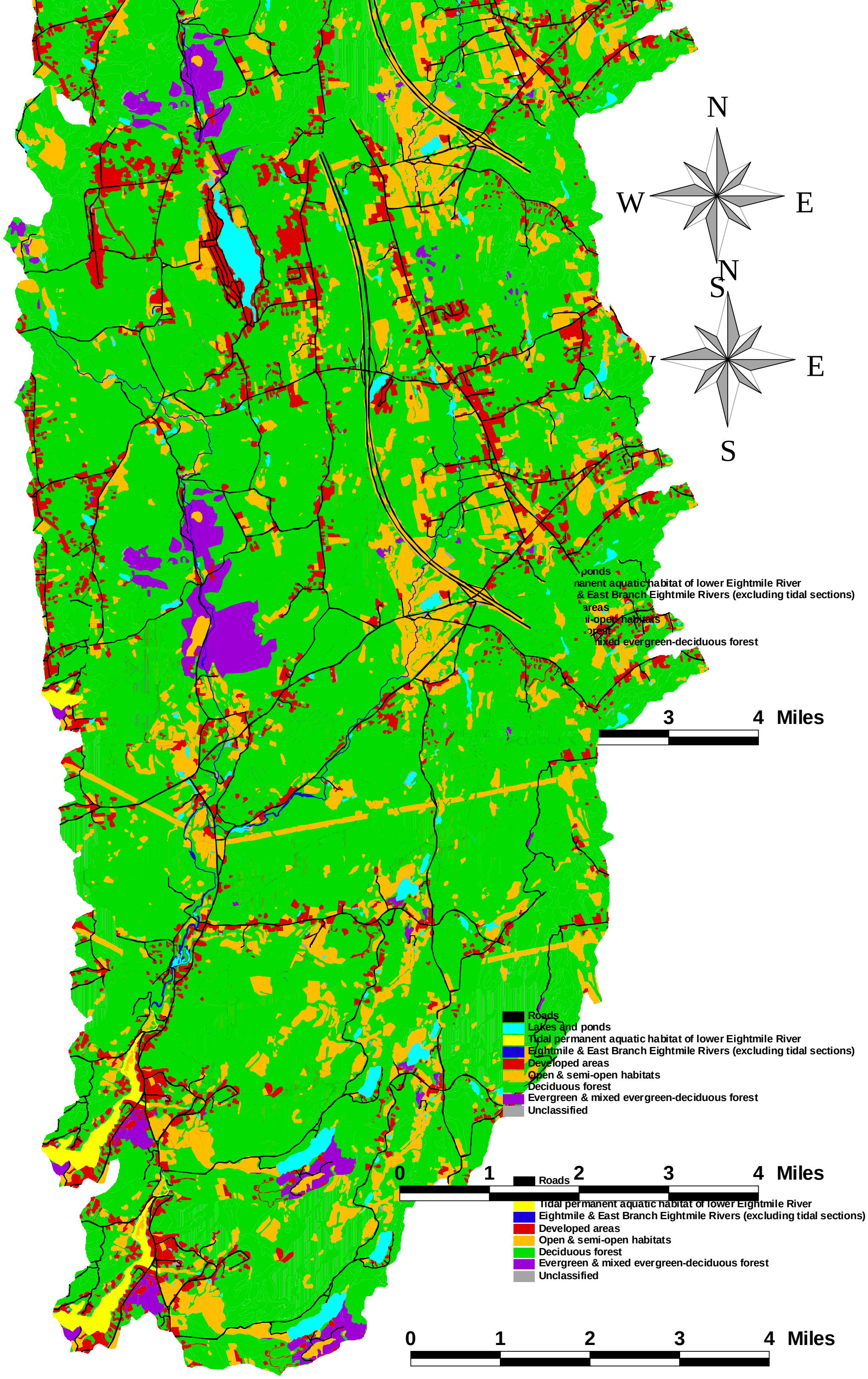

Figure 2. Map of Major Habitat Types of the Eightmile River Watershed

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Figure 3. Eightmile River watershed, in relation to federal HUC10 (regional) and HUC12 (subregional) drainage basin classifications.

The Eightmile River watershed, as addressed in this report, does not occupy the same hierarchical levels in state versus federal (i.e., USDA-NRCS) drainage basin classification schemes (SEE Figure 1). According to the Connecticut Department of Environmental Protection (CT-DEP), the watershed is a naturally defined drainage basin at the regional hierarchic level, and it is comprised of 4 subregional basins: Eightmile River [main stem] (31.5 sq mi), East Branch Eightmile River (16.4 sq mi), Beaver Brook (8.3 sq mi), and Harris Brook (6.2 sq mi). By the USDA-NRCS scheme, the Eightmile River watershed (as considered herein) is not recognized as a discrete unit at either the regional or subregional basin level: it is comprised of two subregional (HUC12 level) basins, the Eightmile River (HUC12 code 010802050905 = Eightmile River + Beaver Brook above) and the East Branch Eightmile River (HUC12 code 010802050903 = East Branch Eightmile River + Harris Brook above). At the next USDA-NRCS level up, regional basins (HUC10 level), the Eightmile River watershed is combined with several other nearby watersheds on both sides of the Connecticut River to make up the HUC10-level regional “Connecticut River - Salmon River to mouth” basin. This disparity between the state and federal organization of drainage basins is highlighted here to avoid possible confusion (i.e., the Eightmile River [state-regional basin] ≠ Eightmile River [federal subregional basin]), and to preface some of the complexities involved in analyses of the Eightmile River watershed in a regional context.

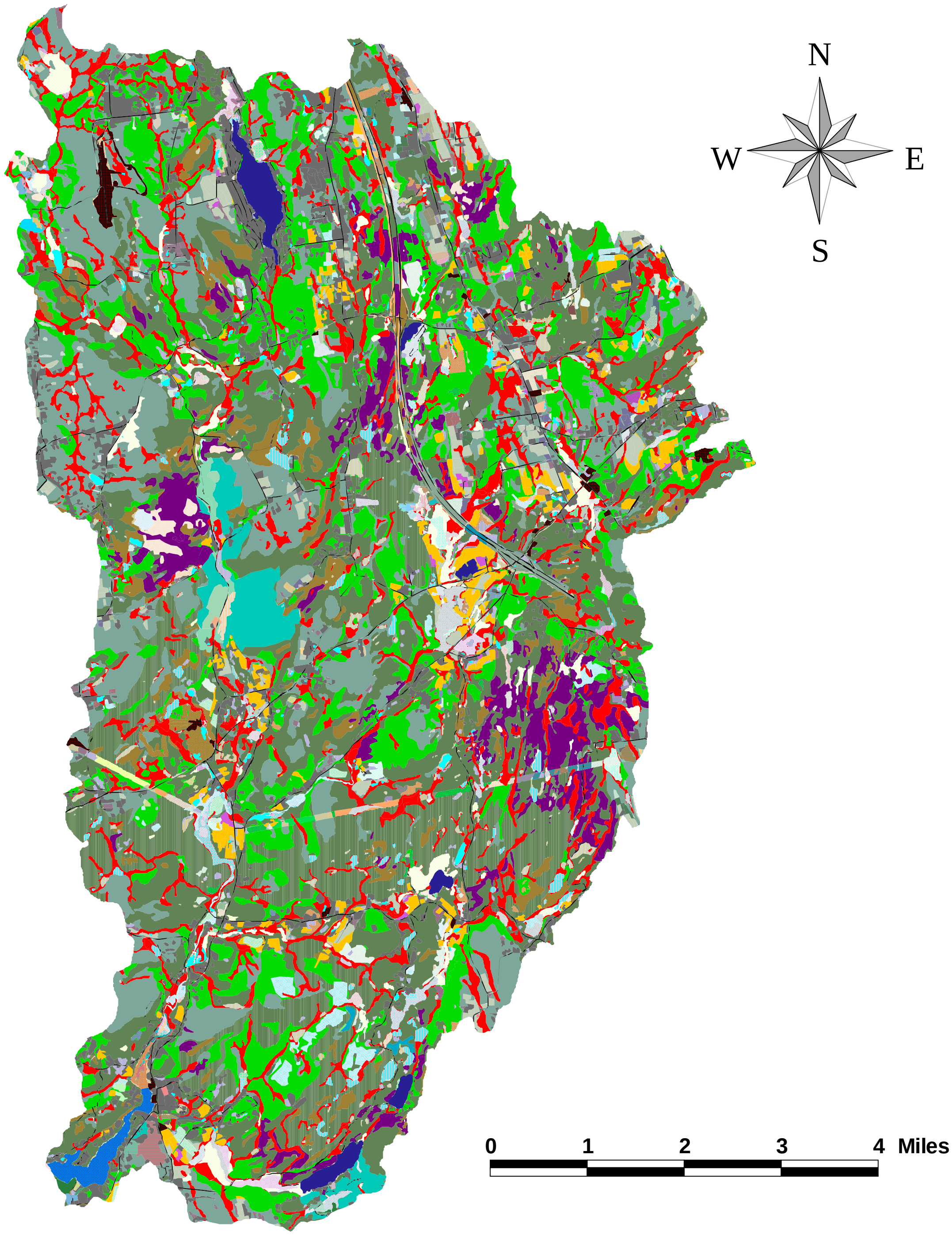

Figure 4. Vegetation/Habitat Map of the Eightmile River Watershed (map legend in next figure) legend

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- cemetery
- closed landfill (grassland)
- commercial development
- dry deciduous forest
- dry to mesic atv course (pine savanna)
- dry to mesic deciduous forest
- dry to mesic deciduous scrub (powerline ROW)
- dry to mesic evergreen forest
- dry to mesic hemlock forest
- dry to mesic mixed evergreen-deciduous forest
- dry to mesic mixed evergreen-deciduous woodland
- dry to mesic mixed hemlock-deciduous forest
- dry to mesic mixed hemlock-deciduous forest (post hemlock decline)
- dry to mesic mixed juniperus-deciduous scrub (powerline ROW)
- dry to mesic mixed juniperus-deciduous scrub (powerline ROW)
- dry to mesic parklike evergreen savanna (hwy ROW)
- dry to mesic pine forest
- dry to mesic scrubby deciduous woodland (post-hemlock decline)
- dry to mesic turf (hwy ROW)
- dry to seasonally wet deciduous forest
- dry to seasonally wet scrub
- early post-clear-cut herbaceous
- evergreen plantation forest
- farm development
- freshwater intertidal emergent herbaceous
- freshwater intertidal emergent herbaceous (Phragmites)
- freshwater intertidal mud flat community
- freshwater intertidal sand/gravel/cobble flat community
- freshwater intertidal scrub-shrub
- freshwater intertidal scrub-shrub/emergent herbaceous
- freshwater spring intertidal scrub-shrub/emergent herbaceous
- freshwater tidal permanent open water/vascular aquatic bed
- freshwater tidal stream
- freshwater tidal vascular aquatic bed
- freshwater-oligohaline tidal permanent open water/vascular aquatic bed
- golf course
- grassland
- grassy deciduous savanna
- grassy deciduous woodland
- grassy juniper savanna
- grassy juniper woodland
- grassy mixed juniper-deciduous savanna
- grassy mixed juniper-deciduous shrubland
- grassy mixed juniper-deciduous woodland
- grassy open deciduous shrubland
- grassy pine savanna
- grassy pine woodland
- grassy sparse deciduous shrubland
- grassy sparse evergreen shrubland
- grassy sparse juniper shrubland
- industrial development
- juniper-scrubby mixed woodland
- lake beach
- lake/open water
- low sand barren vegetation
- mesic deciduous forest
- mesic evergreen forest
- mesic hemlock forest
- mesic mixed hemlock-deciduous forest
- mesic mixed white pine-deciduous forest
- mesic to seasonally wet atv course (pine savanna)
- mesic to seasonally wet deciduous forest
- mesic to seasonally wet deciduous scrub
- mesic to seasonally wet deciduous woodland
- mesic to seasonally wet early post-clear-cut herbaceous
- mesic to seasonally wet grassland
- mesic to seasonally wet grassy deciduous savanna
- mesic to seasonally wet grassy deciduous woodland
- mesic to seasonally wet grassy evergreen woodland
- mesic to seasonally wet grassy juniper savanna
- mesic to seasonally wet grassy juniper woodland
- mesic to seasonally wet grassy mixed juniper-deciduous savanna
- mesic to seasonally wet grassy mixed juniper-deciduous woodland
- mesic to seasonally wet grassy pine savanna
- mesic to seasonally wet grassy sparse deciduous shrubland
- mesic to seasonally wet mixed evergreen-deciduous forest
- mesic to seasonally wet mixed hemlock-deciduous forest
- mesic to seasonally wet mixed juniper-deciduous scrubby grassland
- mesic to seasonally wet mixed juniper-deciduous-scrubby deciduous woodland
- mesic to seasonally wet mountain laurel scrub
- mesic to seasonally wet parklike deciduous savanna
- mesic to seasonally wet parklike deciduous woodland
- mesic to seasonally wet parklike mixed evergreen-deciduous woodland
- mesic to seasonally wet scrub
- mesic to seasonally wet scrubby deciduous woodland
- mesic to seasonally wet scrubby disturbed land
- mesic to seasonally wet scrubby grassland
- mesic to seasonally wet scrubby juniperus savanna
- mesic to seasonally wet scrubby juniperus woodland
- mesic to seasonally wet scrubby mixed juniper-deciduous woodland
- mesic to seasonally wet shrubby grassland
- mesic to seasonally wet unclassified open and semi-open habitat
- mixed evergreen-deciduous-scrubby sand barren
- mixed evergreen-deciduous-scrubby sand barren (hwy ROW)
- mixed juniper-deciduous scrub
- mixed juniper-deciduous scrubby grassland
- mountain laurel scrub
- mountain-laurel-scrubby grassland
- municipal development
- oak/mountain laurel forest
- oligohaline tidal permanent open water
- parklike deciduous savanna
- parklike deciduous woodland
- parklike evergreen savanna
- permanently flooded aquatic bed
- pine forest
- pine-oak/mountain laurel forest

- plant nursery field
- pond
- post-logging deciduous woodland
- public development
- recently cleared and grubbed land
- residential development
- road
- row crops
- rv/trailer park
- sand barren grassland
- sand/gravel mine - active
- saturated deciduous forest/scrub-shrub
- saturated emergent herbaceous
- saturated evergreen scrub-shrub
- saturated scrub-shrub fen
- saturated scrub-shrub/leatherleaf fen
- saturated scrub-shrub/sphagnum fen
- saturated sphagnum/cranberry fen
- saturated sphagnum/leatherleaf fen
- scrub
- scrub-shrub swamp
- scrub-shrub/wet meadow mosaic
- scrubby deciduous woodland
- scrubby disturbed land
- scrubby juniperus savanna
- scrubby juniperus woodland
- scrubby mixed juniper-deciduous woodland
- seasonally flooded deadwood swamp/scrub-shrub, beaver-influenced
- seasonally flooded deciduous forest
- seasonally flooded deciduous forest/deadwood/emergent herbaceous
- seasonally flooded deciduous forest/emergent herbaceous
- seasonally flooded deciduous forest/scrub-shrub
- seasonally flooded deciduous scrub-shrub
- seasonally flooded emergent herbaceous
- seasonally flooded emergent herbaceous (Phalaris)
- seasonally flooded emergent herbaceous (Phragmites)
- seasonally flooded evergreen forest
- seasonally flooded evergreen forest/emergent herbaceous
- seasonally flooded mixed evergreen-deciduous forest
- seasonally flooded mixed evergreen-deciduous forest/scrub-shrub
- seasonally flooded mixed hemlock-deciduous forest
- seasonally flooded scrub-shrub
- seasonally flooded scrub-shrub/emergent herbaceous
- seasonally flooded scrub-shrub/emergent herbaceous, beaver influenced
- seasonally flooded/exposed deadwood swamp/emergent herbaceous
- seasonally flooded/exposed deciduous forest
- seasonally flooded/exposed deciduous forest/emergent herbaceous
- seasonally flooded/exposed deciduous forest/scrub-shrub
- seasonally flooded/exposed emergent herbaceous
- seasonally flooded/exposed emergent herbaceous/unvegetated
- seasonally flooded/exposed mixed evergreen-deciduous forest
- seasonally flooded/exposed scrub-shrub
- seasonally flooded/exposed scrub-shrub/emergent herbaceous
- seasonally saturated deciduous forest
- seasonally saturated deciduous forest/scrub-shrub
- seasonally saturated emergent herbaceous
- seasonally saturated evergreen forest
- seasonally saturated mixed evergreen-deciduous forest
- seasonally saturated parklike evergreen savanna
- seasonally saturated scrub-shrub
- seasonally saturated scrub-shrub/emergent herbaceous
- seasonally saturated/temporarily flooded mixed evergreen forest
- semipermanently flooded aquatic bed
- semipermanently flooded aquatic bed, beaver-influenced
- semipermanently flooded deadwood swamp/aquatic bed, beaver-influenced
- semipermanently flooded deadwood swamp/emergent herbaceous
- semipermanently flooded deadwood swamp/emergent herbaceous, beaver-influenced
- semipermanently flooded deadwood swamp/open water
- semipermanently flooded deadwood swamp/open water, beaver-influenced
- semipermanently flooded deadwood swamp/scrub-shrub
- semipermanently flooded deadwood swamp/scrub-shrub, beaver-influenced
- semipermanently flooded deciduous forest/scrub-shrub, beaver-influenced
- semipermanently flooded emergent herbaceous
- semipermanently flooded emergent herbaceous, beaver-influenced
- semipermanently flooded emergent herbaceous/aquatic bed
- semipermanently flooded emergent herbaceous/aquatic bed, beaver-influenced
- semipermanently flooded emergent herbaceous/floating-leaved aquatic bed
- semipermanently flooded emergent herbaceous/floating-leaved aquatic bed, beaver-influenced
- semipermanently flooded emergent herbaceous/open water, beaver-influenced
- semipermanently flooded scrub-shrub
- semipermanently flooded scrub-shrub/aquatic bed
- semipermanently flooded scrub-shrub/aquatic bed, beaver-influenced
- semipermanently flooded scrub-shrub/emergent herbaceous
- semipermanently flooded scrub-shrub/emergent herbaceous, beaver-influenced
- semipermanently flooded scrub-shrub/floating-leaved aquatic bed, beaver-influenced
- shrubby grassland
- sparse forby juniper shrubland
- sparse grassy juniper shrubland
- temporarily flooded deciduous high floodplain forest
- temporarily flooded deciduous low floodplain forest
- temporarily flooded deciduous low floodplain forest/emergent herbaceous
- temporarily flooded deciduous low floodplain forest/scrub-shrub
- temporarily flooded emergent herbaceous
- temporarily flooded grassland
- temporarily flooded grassy mixed juniper-deciduous woodland
- temporarily flooded high floodplain scrub
- temporarily flooded low floodplain emergent herbaceous
- temporarily flooded mixed evergreen-deciduous forest
- temporarily flooded mixed hemlock-deciduous forest
- temporarily flooded scrubby grassland
- temporarily flooded unclassified open and semi-open habitat
- temporarily flooded/seasonally saturated grassland
- turf, playing field
- unclassified
- unclassified open and semi-open habitat
- upper perennial stream
- xeric mixed evergreen-deciduous scrubby woodland on rocky outcrop

Figure 5. Legend for Vegetation/Habitat Map of the Eightmile River Watershed (SEE

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previous Figure).

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
dry to mesic deciduous forest	11,181.6	27.98024%
mesic deciduous forest	5,447.8	13.63218%
mesic to seasonally wet deciduous forest	5,329.3	13.33565%
seasonally flooded deciduous forest	4,012.1	10.03974%
residential development	2,709.6	6.78033%
oak/mountain laurel forest	1,725.2	4.31717%
dry deciduous forest	1,076.3	2.69329%
grassland	898.9	2.24938%
mesic to seasonally wet grassland	673.1	1.68422%
seasonally flooded deciduous forest/scrub-shrub	604.7	1.51309%
dry to mesic mixed hemlock-deciduous forest (post hemlock decline)	569.7	1.42561%
road	539.0	1.34886%
lake/open water	344.5	0.86211%
unclassified open and semi-open habitat	300.0	0.75061%
seasonally flooded/exposed deciduous forest	248.9	0.62273%
seasonally flooded/exposed deciduous forest/scrub-shrub	246.7	0.61723%
scrubby deciduous woodland	230.7	0.57724%
pond	196.6	0.49204%
commercial development	186.0	0.46555%
seasonally flooded scrub-shrub/emergent herbaceous	143.9	0.36010%
freshwater-oligohaline tidal permanent open water/vascular aquatic bed	142.1	0.35564%
pine-oak/mountain laurel forest	134.6	0.33675%
mixed evergreen-deciduous-scrubby sand barren	127.1	0.31809%
golf course	119.7	0.29950%
sand/gravel mine - active	118.3	0.29593%
mesic to seasonally wet unclassified open and semi-open habitat	116.9	0.29257%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
grassy mixed juniper-deciduous woodland	104.0	0.26022%
semipermanently flooded scrub-shrub/emergent herbaceous, beaver-influenced	101.9	0.25496%
seasonally flooded scrub-shrub	95.9	0.23993%
unclassified	95.3	0.23846%
mesic hemlock forest	81.5	0.20393%
row crops	70.3	0.17598%
temporarily flooded deciduous high floodplain forest	58.8	0.14723%
dry to mesic turf (hwy ROW)	56.7	0.14192%
mesic to seasonally wet scrubby deciduous woodland	55.1	0.13799%
rv/trailer park	52.3	0.13087%
shrubby grassland	50.6	0.12666%
farm development	49.2	0.12319%
semipermanently flooded deadwood swamp/scrub-shrub	48.7	0.12186%
seasonally flooded emergent herbaceous	47.6	0.11909%
mesic to seasonally wet scrubby grassland	46.0	0.11500%
dry to mesic scrubby deciduous woodland (post-hemlock decline)	45.0	0.11262%
mesic to seasonally wet mixed evergreen-deciduous forest	44.9	0.11238%
grassy juniper savanna	43.9	0.10977%
seasonally saturated deciduous forest	42.8	0.10698%
seasonally flooded mixed evergreen-deciduous forest	40.3	0.10092%
temporarily flooded deciduous low floodplain forest	37.4	0.09355%
public development	37.0	0.09253%
grassy sparse deciduous shrubland	34.8	0.08702%
semipermanently flooded deadwood swamp/scrub-shrub, beaver-influenced	34.0	0.08500%
mesic to seasonally wet grassy sparse deciduous shrubland	28.7	0.07187%
early post-clear-cut herbaceous	24.2	0.06056%
dry to mesic mixed juniperus-deciduous scrub (powerline ROW)	23.6	0.05895%
upper perennial stream	23.1	0.05780%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
mesic to seasonally wet scrub	22.4	0.05614%
scrubby mixed juniper-deciduous woodland	22.3	0.05570%
dry to mesic deciduous scrub (powerline ROW)	21.9	0.05488%
freshwater tidal permanent open water/vascular aquatic bed	21.5	0.05373%
semipermanently flooded deadwood swamp/emergent herbaceous, beaver-influenced	20.7	0.05187%
scrub	20.1	0.05039%
seasonally saturated/temporarily flooded mixed evergreen forest	19.9	0.04979%
grassy pine savanna	19.6	0.04914%
semipermanently flooded scrub-shrub/emergent herbaceous	19.2	0.04808%
grassy deciduous woodland	19.2	0.04808%
parklike deciduous savanna	17.7	0.04430%
grassy mixed juniper-deciduous savanna	17.4	0.04363%
mesic to seasonally wet mixed hemlock-deciduous forest	17.0	0.04256%
freshwater intertidal emergent herbaceous	16.7	0.04171%
dry to mesic mixed evergreen-deciduous forest	16.5	0.04141%
dry to seasonally wet deciduous forest	16.0	0.04015%
plant nursery field	16.0	0.03994%
mesic to seasonally wet deciduous scrub	15.6	0.03896%
mountain laurel scrub	14.3	0.03587%
semipermanently flooded deadwood swamp/open water, beaver-influenced	14.3	0.03573%
xeric mixed evergreen-deciduous scrubby woodland on rocky outcrop	14.1	0.03517%
semipermanently flooded emergent herbaceous/aquatic bed	14.0	0.03507%
dry to mesic mixed juniperus-deciduous scrub (powerline ROW)	13.4	0.03341%
dry to mesic atv course (pine savanna)	13.3	0.03328%
semipermanently flooded emergent herbaceous/floating-leaved aquatic bed, beaver-influenced	13.0	0.03254%
seasonally flooded evergreen forest	12.9	0.03226%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
mesic to seasonally wet grassy mixed juniper-deciduous woodland	12.6	0.03159%
grassy juniper woodland	12.6	0.03143%
semipermanently flooded emergent herbaceous/aquatic bed, beaver-influenced	12.6	0.03141%
post-logging deciduous woodland	12.0	0.03009%
seasonally flooded/exposed scrub-shrub	11.9	0.02984%
sparse grassy juniper shrubland	11.9	0.02980%
mesic to seasonally wet grassy deciduous savanna	11.9	0.02970%
temporarily flooded mixed hemlock-deciduous forest	11.9	0.02966%
mesic to seasonally wet scrubby disturbed land	11.7	0.02929%
parklike deciduous woodland	11.6	0.02906%
semipermanently flooded scrub-shrub/aquatic bed	11.5	0.02866%
industrial development	11.3	0.02835%
seasonally flooded deciduous forest/emergent herbaceous	11.2	0.02808%
semipermanently flooded emergent herbaceous	11.0	0.02743%
grassy pine woodland	10.8	0.02705%
semipermanently flooded scrub-shrub/floating-leaved aquatic bed, beaver-influenced	10.7	0.02687%
semipermanently flooded deciduous forest/scrub-shrub, beaver-influenced	10.5	0.02637%
mesic to seasonally wet mixed juniper-deciduous scrubby grassland	10.5	0.02632%
semipermanently flooded deadwood swamp/emergent herbaceous	10.0	0.02504%
seasonally flooded emergent herbaceous (Phalaris)	9.9	0.02484%
seasonally flooded/exposed scrub-shrub/emergent herbaceous	9.8	0.02449%
recently cleared and grubbed land	9.6	0.02403%
grassy deciduous savanna	9.6	0.02402%
seasonally saturated mixed evergreen-deciduous forest	9.3	0.02332%
mesic to seasonally wet grassy juniper savanna	9.3	0.02315%
grassy mixed juniper-deciduous shrubland	9.1	0.02288%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
juniper-scrubby mixed woodland	9.1	0.02285%
seasonally flooded/exposed emergent herbaceous	8.9	0.02218%
seasonally flooded emergent herbaceous (Phragmites)	8.8	0.02204%
grassy sparse evergreen shrubland	8.7	0.02177%
semipermanently flooded scrub-shrub	8.7	0.02171%
temporarily flooded deciduous low floodplain forest/emergent herbaceous	8.4	0.02106%
mixed juniper-deciduous scrubby grassland	7.7	0.01917%
dry to mesic parklike evergreen savanna (hwy ROW)	7.6	0.01901%
saturated scrub-shrub/leatherleaf fen	7.1	0.01782%
permanently flooded aquatic bed	7.0	0.01752%
mesic to seasonally wet grassy pine savanna	7.0	0.01743%
seasonally flooded scrub-shrub/emergent herbaceous, beaver influenced	7.0	0.01739%
sand barren grassland	6.9	0.01731%
seasonally saturated deciduous forest/scrub-shrub	6.9	0.01728%
turf, playing field	6.7	0.01665%
seasonally saturated scrub-shrub/emergent herbaceous	6.5	0.01627%
temporarily flooded grassland	6.4	0.01613%
mountain-laurel-scrubby grassland	6.4	0.01599%
dry to mesic pine forest	6.0	0.01507%
temporarily flooded unclassified open and semi-open habitat	6.0	0.01501%
freshwater intertidal sand/gravel/cobble flat community	5.8	0.01463%
Cemetery	5.7	0.01423%
dry to seasonally wet scrub	5.4	0.01355%
seasonally flooded/exposed emergent herbaceous/unvegetated	5.1	0.01284%
semipermanently flooded emergent herbaceous, beaver-influenced	4.7	0.01179%
sparse forby juniper shrubland	4.7	0.01171%
pine forest	4.6	0.01162%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
mesic mixed hemlock-deciduous forest	4.5	0.01132%
grassy open deciduous shrubland	4.3	0.01069%
closed landfill (grassland)	4.2	0.01057%
seasonally flooded mixed hemlock-deciduous forest	4.2	0.01045%
freshwater tidal stream	4.1	0.01024%
seasonally flooded mixed evergreen-deciduous forest/scrub-shrub	4.1	0.01017%
mesic to seasonally wet atv course (pine savanna)	4.0	0.00997%
freshwater intertidal emergent herbaceous (Phragmites)	3.9	0.00982%
temporarily flooded deciduous low floodplain forest/scrub-shrub	3.8	0.00959%
semipermanently flooded deadwood swamp/aquatic bed, beaver-influenced	3.8	0.00957%
scrubby juniperus woodland	3.8	0.00957%
temporarily flooded scrubby grassland	3.8	0.00954%
mesic to seasonally wet deciduous woodland	3.7	0.00937%
saturated deciduous forest/scrub-shrub	3.6	0.00908%
saturated scrub-shrub fen	3.6	0.00906%
seasonally saturated emergent herbaceous	3.6	0.00905%
semipermanently flooded emergent herbaceous/floating-leaved aquatic bed	3.3	0.00837%
scrubby juniperus savanna	3.3	0.00835%
saturated scrub-shrub/sphagnum fen	3.3	0.00833%
mesic to seasonally wet parklike deciduous woodland	3.2	0.00808%
seasonally flooded/exposed deciduous forest/emergent herbaceous	3.0	0.00760%
parklike evergreen savanna	3.0	0.00752%
semipermanently flooded scrub-shrub/aquatic bed, beaver-influenced	2.9	0.00716%
saturated evergreen scrub-shrub	2.8	0.00709%
dry to mesic evergreen forest	2.6	0.00656%
mesic to seasonally wet mixed juniper-deciduous-scrubby deciduous woodland	2.6	0.00651%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
dry to mesic mixed evergreen-deciduous woodland	2.6	0.00651%
low sand barren vegetation	2.4	0.00608%
freshwater intertidal scrub-shrub	2.4	0.00595%
freshwater intertidal scrub-shrub/emergent herbaceous	2.3	0.00580%
freshwater tidal vascular aquatic bed	2.3	0.00567%
seasonally saturated scrub-shrub	2.2	0.00559%
mesic to seasonally wet grassy evergreen woodland	2.2	0.00551%
mesic to seasonally wet grassy juniper woodland	2.2	0.00547%
scrub-shrub/wet meadow mosaic	2.1	0.00535%
grassy sparse juniper shrubland	2.1	0.00529%
mesic to seasonally wet parklike deciduous savanna	1.9	0.00483%
temporarily flooded low floodplain emergent herbaceous	1.8	0.00440%
temporarily flooded mixed evergreen-deciduous forest	1.7	0.00424%
mesic mixed white pine-deciduous forest	1.6	0.00401%
semipermanently flooded emergent herbaceous/open water, beaver-influenced	1.6	0.00397%
semipermanently flooded aquatic bed, beaver-influenced	1.6	0.00394%
seasonally flooded deadwood swamp/scrub-shrub, beaver-influenced	1.5	0.00375%
mesic to seasonally wet grassy mixed juniper-deciduous savanna	1.5	0.00365%
semipermanently flooded deadwood swamp/open water	1.3	0.00335%
mesic evergreen forest	1.3	0.00332%
evergreen plantation forest	1.2	0.00288%
oligohaline tidal permanent open water	1.1	0.00283%
mixed juniper-deciduous scrub	1.1	0.00274%
mesic to seasonally wet early post-clear-cut herbaceous	1.1	0.00271%
scrub-shrub swamp	1.0	0.00261%
mixed evergreen-deciduous-scrubby sand barren (hwy ROW)	1.0	0.00256%
saturated sphagnum/cranberry fen	1.0	0.00252%
mesic to seasonally wet grassy deciduous woodland	0.9	0.00216%

Table 1. Cumulative acreage and percentage of total Eightmile River watershed area occupied by each Vegetation/Habitat Map unit (SEE Figures 4 and 5), listed in order of descending cumulative area in the watershed.

Vegetation/Habitat Map unit	Cumulative acres in watershed	Cumulative % of total watershed area
semipermanently flooded aquatic bed	0.8	0.00189%
dry to mesic hemlock forest	0.7	0.00182%
seasonally flooded/exposed deadwood swamp/emergent herbaceous	0.7	0.00181%
seasonally flooded/exposed mixed evergreen-deciduous forest	0.6	0.00138%
mesic to seasonally wet parklike mixed evergreen-deciduous woodland	0.5	0.00114%
seasonally flooded evergreen forest/emergent herbaceous	0.4	0.00101%
temporarily flooded grassy mixed juniper-deciduous woodland	0.4	0.00100%
municipal development	0.3	0.00084%
freshwater intertidal mud flat community	0.3	0.00077%
scrubby disturbed land	0.3	0.00074%
seasonally saturated evergreen forest	0.3	0.00070%
lake beach	0.3	0.00066%
mesic to seasonally wet scrubby juniperus savanna	0.2	0.00060%
freshwater spring intertidal scrub-shrub/emergent herbaceous	0.2	0.00058%
seasonally flooded deciduous scrub-shrub	0.2	0.00056%
saturated emergent herbaceous	0.2	0.00051%
temporarily flooded high floodplain scrub	0.2	0.00046%
mesic to seasonally wet mountain laurel scrub	0.2	0.00046%
temporarily flooded/seasonally saturated grassland	0.2	0.00038%
mesic to seasonally wet scrubby mixed juniper-deciduous woodland	0.1	0.00037%
mesic to seasonally wet scrubby juniperus woodland	0.1	0.00035%
seasonally flooded deciduous forest/deadwood/emergent herbaceous	0.1	0.00029%
mesic to seasonally wet shrubby grassland	0.1	0.00028%
seasonally saturated parklike evergreen savanna	0.1	0.00022%
temporarily flooded emergent herbaceous	0.1	0.00017%
saturated sphagnum/leatherleaf fen	0.0	0.00003%

III. MATERIALS AND METHODS.

The objectives of this investigation were to first characterize as accurately as possible the existing biodiversity of the Eightmile River watershed, using existing information rather than primary field survey and inventory and then 1) compare the biodiversity of the Eightmile watershed to that of other watersheds in a state and regional context, and 2) to draw conclusions as to whether and to what to extent the Eightmile watershed is a unique, functioning, intact ecosystem.   The methodology used to achieve these objectives is laid out in this section.

Biological and Ecological Inventory

The basic biological units of biodiversity in the watershed are species (and, in many cases, subspecies or varieties); the basic ecological units of biodiversity are natural communities, or habitats. The author assembled information on these elements of biodiversity in the Eightmile River watershed, with emphasis on species, species groups, and natural communities/habitats of special conservation concern. This was partly because a comprehensive inventory of all species and natural communities/habitats in the watershed would require an effort and resources well beyond those available for this study, and partly because equivalently comprehensive data does not exist for all or most other watersheds in the region, so comparisons of this total biodiversity would not be possible. The efforts of state natural heritage programs over the last 20 or more years to inventory species and natural communities of special conservation concern have generated a body of data that allows comparison of watersheds, in terms of numbers of extant rare species and significant natural communities.

To do such a comparison, the author decided to use total number of known extant rare species in a watershed as a surrogate for total biodiversity in the watershed, and perform comparisons of the Eightmile River watershed to other watersheds in two contexts: state and regional, with the region defined as New England. The author elected not to attempt to do a similar comparison of natural communities, because 1) the classification of natural communities is not sufficiently mature and consistent between state heritage programs, and 2) because of this, distributions of natural communities is much more poorly known than distributions of rare species (this opinion is based on the author’s experience of the last 16 years of working for and with several state natural heritage programs). The details of the analysis are presented in Section IV.

Prior to performing this analysis, however, the author was tasked with assembling and screening the most current and reliable information on occurrences of species and natural communities/habitats of special conservation concern. The author performed a limited scope primary survey for rare plants and significant natural communities in the watershed in 2003 (the bulk of the survey), 2004, and 2005. The author queried the state natural heritage program (in Connecticut known as the Natural Diversity Data Base, a part of the Connecticut Department of Environmental Protection (CT-DEP-NDDB)), CT-DEP wildlife and fisheries resource managers, local and regional professional and amateur naturalists, scientists at local universities and other research institutions. The author vetted reports of rare species in species groups outside of his expertise, by contacting experts in those species groups. Specific sources of information and assistance in interpreting information are cited in the sections below dealing with each species group.

The author also reviewed a number of published and unpublished inventories of portions of the watershed, from which he extracted data on species of special conservation concern in the watershed. Specific sources are mentioned in the relevant sections below.

Vegetation/habitat map

The vegetation/habitat map of the Eightmile watershed, presented as Figures 4 and 5, was synthesized as part of this investigation by the author, in collaboration with Ken Geisler, GIS specialist for the Connecticut field office of The Nature Conservancy. The purposes of the map are 1) to provide a basic ecological description of the watershed, and 2) to provide a tool for the management of the watershed. It is most accurately thought of as a first approximation of existing ecological conditions in the watershed. This map is a digital ESRI Arcview 3.2a vector data coverage. It should be viewed as a work in progress which can and should be refined and updated over time to become a more and more sophisticated management tool.

The map is a synthesis of existing GIS coverages of the watershed, the author's 2003 field survey data for communities, the author's interpretation of low-altitude aerial photography of the watershed, and a limited amount of ground-truthing field work by the author in 2005, which included driving "windshield survey", on-foot survey, and a low-altitude fixed-wing early fall (2005) fly-over of the watershed. The single most weighted element in this synthesis was the analysis and interpretation of the following low altitude aerial photograph imagery: 1) CT-DEP black-and-white 1:12,000 stereo aerial photographs from spring 2000, covering the entire watershed, and 2) digital geo-referenced true-color 1-meter-resolution "stitched" aerial imagery acquired in spring 2004, covering only the western half of the watershed.

The vegetation/habitat map classifies the Eightmile River watershed on the basis of land use, vegetation physiognomy, leaf phenology and life form of the dominant plants, hydrology/moisture regime, and, to a limited extent, dominant species. The author's definitions for the above parameters substantially follow, for non-wetland habitats, the higher levels (i.e., class, subclass, formation, etc.) of the International Vegetation Classification (Grossman *et al.* 1998) and the Vegetation Classification for Connecticut (Metzler & Barrett, in press). For wetland habitats, the author used the National Wetlands Inventory (NWI) classification (Cowardin *et al.* 1979), as modified and interpreted for Connecticut by Metzler and Barrett (Metzler and Barrett 1982). The original NWI mapping of Connecticut was done using flight year 1980 and 1981 1:80,000 aerial stereo photography, and has since been transformed into a digital coverage. The author reviewed and updated, as appropriate, the classification the NWI wetland coverage for the Eightmile River watershed. This was done by analyzing more recent and lower altitude aerial B&W aerial stereo photography (flight year 2000, at oldest), flight year 2004 digital true color photography (for the western half of the watershed only), several hours of fixed-wing fly-over survey of the watershed in fall 2004 (concentrating on current classification of the larger wetlands in the watershed), and a few hundred hours of on-the-ground survey.

The following existing digitized GIS coverages were analyzed and used in varying measure, as explained below, to generate the Eightmile River watershed vegetation/habitat map:

- **USDA-NRCS soil series mapping.** The NRCS soils mapping was the single most important element used to define the total wetland coverage for the Eightmile River watershed. It was used also to assign moisture regime modifiers to upland forest types. Based on the USDA-NRCS soils mapping, the total proportion of hydric/wetland soils in the watershed is approximately three times higher than the wetland proportion according to either NWI or CLEAR. The author's decision to favor the USDA-NRCS hydric soils coverage over NWI and CLEAR data was based primarily on the evidence of his field and low-altitude stereo aerial photo interpretation, and it was supported by communication from Dr. Nels E. Barrett, who mapped the NWI wetlands in Connecticut (Barrett pers. comm.), and data from the National Soil Information System (USDA-NRCS 2003) presenting estimated percentages of soil series other than the nominal series occurring in Connecticut soil map units (USDA-NRCS-NASIS 2003).

- **National Wetlands Inventory (NWI) wetlands mapping.** Digitized NWI wetlands mapping was reviewed to determine if wetland polygon classification was consistent with current conditions and non-forested wetlands were checked for accuracy of wetland boundaries. Polygons were reclassified and boundaries edited as necessary, based on review of the more recent aerial photography, and for a subset, observations from the air during a fixed-wing fly-over and/or on-the-ground survey. Polygons so vetted were then pasted into the vegetation/habitat map.

- **Larry Bonneau's Forest Type coverage.** In the mid-1990s, Larry Bonneau, now with the Center for Earth Observation, Yale University, produced a landcover classification that featured forest dominance types, using Landsat Thematic Mapper ™ satellite imagery from 1988, 1990, and 1992, for a 264-square-mile area that included the Eightmile River watershed (Bonneau 1997). This map was converted from raster data to vector data by Ken Geisler, and the author experimented, with Ken Geisler's assistance, with various ways of incorporating it into the vegetation/habitat map. The Bonneau map is a very intricate mosaic, and its incorporation into the vegetation/habitat map would have produced a much more complex map than the version presented in this report. The author decided that this added complexity would have implied a higher user accuracy for the Bonneau forest dominance type map than was suggested by the author's analyses of recent low-altitude aerial photography and his on-the-ground field survey. The author's field data suggested that, as noted also in the meta-data report (Bonneau 1997), the user accuracy varied for different forest types. The author drew on the forest types that appeared, based on his own knowledge of the watershed, to have higher user accuracy, and did not incorporate types that either appeared to have lower user accuracy, or for which the author had no data on which to decide. Using stereo-aerial analysis and field data, the author reviewed and edited the Bonneau forest type coverages as necessary before pasting them into the vegetation/habitat map

- **UCONN CLEAR 2002 land-use coverage, developed from satellite imagery.** CLEAR land-use coverage, which was developed for an area orders of magnitude larger than the Eightmile River watershed and has a minimum pixel resolution of 30 x 30 m, was not used directly to synthesize the vegetation/habitat map. However, a primary goal of the author's approach to the creation of the vegetation/habitat map was to test the CLEAR data cumulative area totals for certain critical land use categories (e.g., % developed area, % forest, etc.) in the Eightmile River watershed. Since the CLEAR data potentially allowed a comparison of the Eightmile watershed to other watersheds in a context slightly larger than Connecticut, the author's test of the CLEAR data against his analysis using low-altitude stereo-aerial photography provided an indication of what magnitude differences in cumulative land-use category totals should be considered significant/real.

- **Potential and verified vernal pool coverage developed by Lower Connecticut River Conservation District.** In 2003, consulting naturalist and soil scientist Ed Pawlak produced for the Lower Connecticut River Conservation District a mapping of potential vernal pools of an area that included the Eightmile River watershed, based on his analysis of flight year 2000 1:12,000 B&W stereo aerial photography. This mapping was heads-up/on-screen digitized for the Conservation District, and a subset of the potential vernal pools was visited by trained volunteers in 2004 for field verification. The field-verification process confirmed that that majority of the potential vernal pools were actual vernal pools, based on the presence of obligate vernal pool animal species and certain other physical parameters. The author reviewed these potential vernal pool polygons via stereo aerial photo interpretation, and assigned the appropriate NWI classification code, invented and assigned then a special hydrologic modifier, "seasonally flooded/exposed", and pasted them directly into the vegetation/habitat map. The author decided to invent the special hydrologic modifier, rather than use the term "vernal pool" because of the current confusion and debate over the meaning of the term "vernal pool".

- **Data from the author's 2003-2005 vegetation reconnaissance data and mapping of significant natural communities.** Portions of this data were incorporated directly into the vegetation/habitat map, and resulted in the creation of some floristically defined units. This data was also used to assess the accuracy of portions of other GIS coverages, such as Larry Bonneau's above-mentioned map

For all non-forested vegetation/habitat units and some of the forest units, vegetation/habitat unit coverage for the entire watershed was produced by the author, via analysis of flight year 2000 black-and-white stereo-aerial-photo analysis, for the east half of the watershed, and analysis of both flight year 2000 black-and-white stereo-aerial-photography and flight year 2004 digital aerial photography of the western half of the watershed. These non-forested units were converted to digital polygon coverage via "on-screen digitizing", also known as "head's-up digitizing", over flight year 1990 1-meter-resolution black-and-white orthophotography for the eastern half of the watershed, and flight year 2004 1-meter-resolution geo-rectified color aerial imagery for most of the western half of the watershed.

IV. Rare Species.

A summary of “at-risk” plant and animal species known from the Eightmile River watershed is presented in Table 2. This summary includes both species considered to be “rare”, “threatened”, or “endangered”, in a state, regional, and/or global context, and species that have been identified by various organizations as of special concern for conservation, due to documented declines and threats, such as loss of habitat, etc. A total of 160 such species are found in the watershed. This list is comprised of 37 vascular plants, 6 amphibians, 77 bird species, 11 fish species, 10 invertebrate species, 6 reptiles and turtles, and 13 mammals.

On this list are five species considered to be globally rare, and one species, the Bald Eagle, that is Federally listed as Threatened. The five globally rare species are: two plants, *Bidens eatonii* Eaton’s Beggar’s-ticks and *Eriocaulon parkeri* Parker’s Pipewort, and three insects, *Callophrys irus* Frosted Elfin (a butterfly), *Gomphus ventricosus* Skillet Clubtail (a dragonfly), and *Enallagma minusculum* Little Bluet (a damselfly). Based on its current Natureserve global rarity rank (“grank”) of G2, *Bidens eatonii* Eaton’s Beggar’s-ticks is the rarest of the rare species known to be extant in the Eighmile River watershed; (see Appendix A for a full explanation of G- and S-ranks). Next rarest are *Eriocaulon parkeri* Parker’s Pipewort, Frosted Elfin, and Skillet Clubtail, all ranked G3. The Little Bluet is borderline globally rare, with a Grank of G3G4. These globally rare species are associated with several different specific habitats, or habitat-complexes, at different localities in the Eightmile watershed. In every case, these globally rare species occur in places that also support multiple state- and regionally rare species. The two globally rare plants, *Bidens eatonii* and *Eriocaulon parkeri*, occur together and are restricted to a subset of the freshwater [perhaps seasonally oligohaline] intertidal habitats in Hamburg cove and upstream of the cove nearly to the head-of-tide. Co-occurring in these habitats with these global rarities are nine state-rare plants, and one additional state-rare plant occurs in a different habitat in close proximity to the intertidal zone. In addition, a state-rare mussel occurs in this reach (Walden & Parasiewicz 2005). Thus, with a total of 13 species, this area supports the largest concentration of globally rare and state-rare species in the Eightmile watershed.

The butterfly *Callophrys irus* Frosted Elfin is associated with dry to xeric open habitats in the eastern part of the watershed. At one locality, it is associated with a former sand and gravel excavation since developed into scrubby sand barren, and at another locality it is associated with open scrubby grass/sedge-land habitat about rocky summit bedrock outcrops, in a powerline ROW. These habitats both exist in their present state as a result of past disturbance by man, and in both cases on-going management is required to maintain the open conditions required by the butterfly. In both cases, inappropriate management actions could threaten the existence of the butterfly.

The globally rare dragonfly, *Gomphus ventricosus* Skillet Clubtail, is associated with pool habitat in the Eightmile River, in a stretch of the river where three state-rare species (two plants and one turtle) also occur.

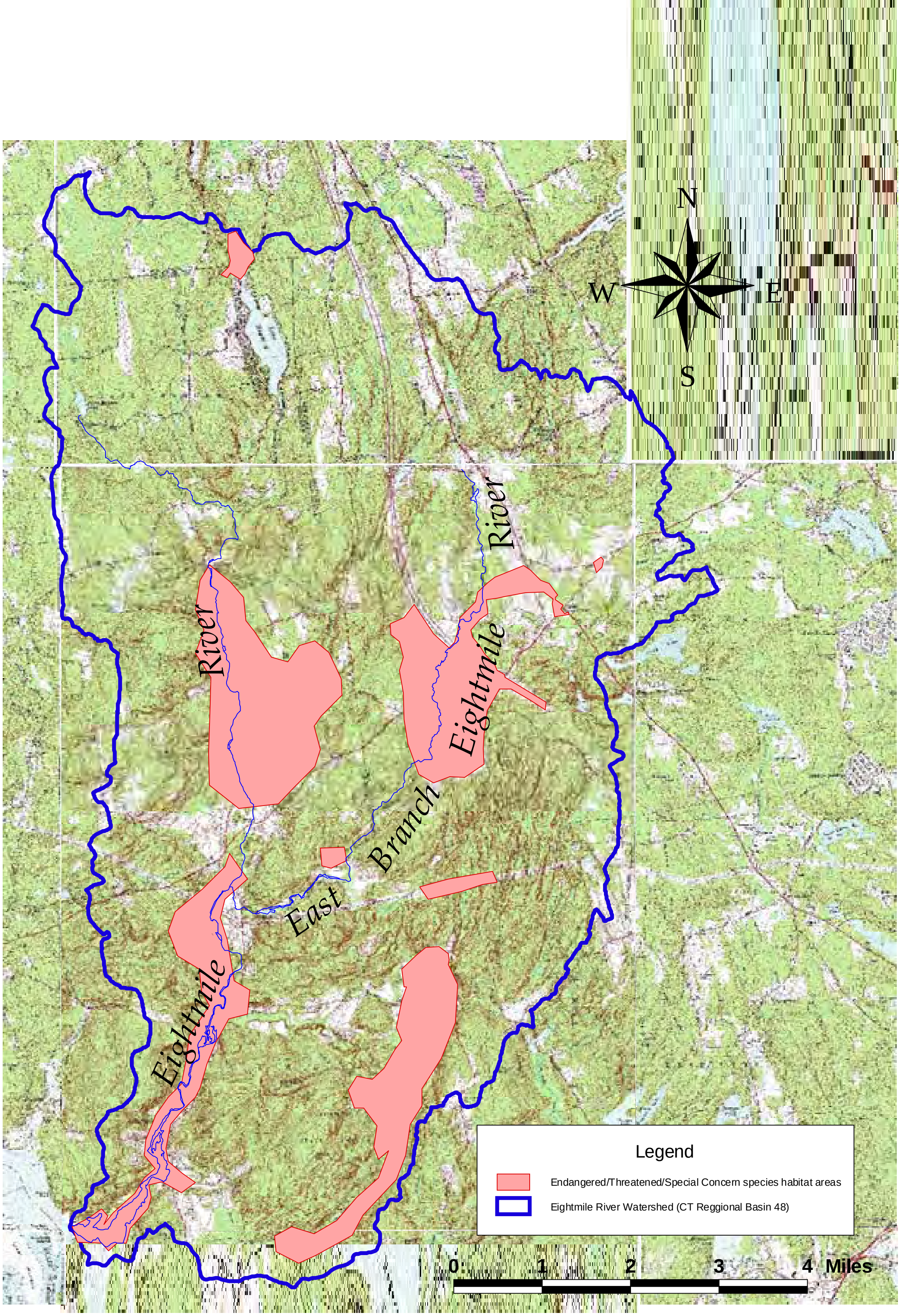

Figure 6. Concentration areas for rare species and significant natural community occurrences known to-date in the Eightmile River watershed.

The globally rare damselfly *Enallagma minusculum* Little Bluet is associated with one of the natural lakes in the Eightmile watershed.

While it is the only Federally Listed species among the at-risk species using the watershed, the Bald Eagle has a Grank of G4 and is no longer considered globally rare. Bald Eagles nest very close to the Eightmile watershed, and use it, especially in the Hamburg cove area, as a breeding-season foraging area and as part of their wintering grounds.

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank[16]	State Rank[16]	Legal Status	State CWCS[21] ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Acalypha virginica	Virginia Copperleaf	Vascular Plant	G5	SU	State-Special Concern	n/a		Occurs in managed forest clearings
Aristida longespica	Needlegrass	Vascular Plant	G5	SU	State-Special Concern	n/a		In sandy acid seasonally wet meadow community
Aristolochia serpentaria	Virginia Snakeroot	Vascular Plant	G4	S2S3	State-Special Concern	n/a	New England regional concern taxon	With several large occurrences, Eightmile watershed is a New England stronghold for this taxon. Largest populations in managed power line ROW
Asclepias purpurascens	Purple Milkweed	Vascular Plant	G5?	S1	State-Special Concern	n/a	New England regional concern taxon	Associated with old fields on thick till deposits; Eightmile hosts 3 of the ca. 8 extant occurrences known in New England
Asplenium montanum	Mountain Spleenwort	Vascular Plant	G5	S2	State-Threatened	n/a	New England regional concern taxon	Large meta-occurrence associated with Escarpment (i.e., gorge and cliffs) landscape element
Bidens eatonii	Eaton's	Vascular	G2	S1	State-	n/a	New England	Globally rarest taxon

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
	Beggar-ticks	Plant			Threatened		regional concern taxon	known in the watershed; large meta-occurrence associated with sand/gravel/cobble fresh-oligohaline intertidal habitat
Carex bushii	Bush's sedge	Vascular Plant	G4	S2	State-Special Concern	n/a	New England regional concern taxon	Large meta-occurrence associate with meadows, mostly on thick till deposits
Castilleja coccinea	Indian paintbrush	Vascular Plant	G5	S1	State-Endangered	n/a	New England regional concern taxon	Historic (last observed 1962); still extant just outside of watershed
Crassula aquatica	Pygmyweed	Vascular Plant	G5	S1	State-Endangered	n/a		Associated with sand/gravel/cobble fresh-oligohaline intertidal habitat
Desmodium glabellum	Dillen's Tick-trefoil	Vascular Plant	G5	S2	State-Special Concern	n/a	New England regional concern taxon	Associated with managed forest openings, and, especially, electrical transmission line ROW
Eleocharis equisetoides	Horse-tail Spikerush	Vascular Plant	G4	S1	State-Endangered	n/a		Sandy and peaty shores/littoral of oligotrophic ponds
Elymus villosus	Slender Wild-	Vascular	G5	SU		n/a	New England regional concern	

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
	rye	Plant					taxon	
Eriocaulon parkeri	Parker's Pipewort	Vascular Plant	G3	S1	State-Endangered	n/a	New England regional concern taxon	Large meta-occurrence associated with sand/gravel/cobble fresh-oligohaline intertidal habitat
Hydrocotyle umbellata	Water pennywort	Vascular Plant	G5	S1	State-Endangered	n/a		With several large occurrences, Eightmile is a stronghold in Connecticut for this species
Isotria medeoloides	Small Whorled Pogonia	Vascular Plant	G2	S1	State-Endangered	n/a	New England regional concern taxon	One historic occurrence, without precise locality data, was either in the watershed, or at most only 1.5 mi outside. This, in combination with a recently discovered occurrence only 4.5 mi outside of the watershed, and the abundance of potential habitat in the watershed, suggests this species may occur in the

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								watershed.
Lespedeza repens	Creeping Bush-clover	Vascular Plant	G5	S1	State-Special Concern	n/a	New England regional concern taxon	One of 2 known extant occurrences in CT/New England. Habitat is man-made sand barren in highway ROW
Limosella subulata	Mudwort	Vascular Plant	G4?Q	S2S3	State-Special Concern	n/a		Associated with sand/gravel/cobble fresh-oligohaline intertidal habitat
Liparis liliifolia	Lily-leaved Twayblade	Vascular Plant	G5	S1	State-Endangered	n/a	New England regional concern taxon	Eightmile hosts 2 of 6 extant occurrences known in New England
Lycopus amplectens	Clasping-leaved Water-horehound	Vascular Plant	G5	SU	State-Special Concern	n/a		Several large occurrences associated with peaty and sandy acid pond shores and Atlantic White Cedar swamp communities
Mimulus alatus	Winged Monkey-flower	Vascular Plant	G5	S3	State-Special Concern	n/a	New England regional concern taxon	Fresh tidal shores and wet meadows
Ophioglossum pusillum	Adder's tongue	Vascular Plant	G5	S1	State-Threatened	n/a	New England regional concern taxon	Acidic forested seepage wetland in southern part of

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								watershed
Orontium aquaticum	Golden club	Vascular Plant	G5	S2S3	State-Special Concern	n/a		Fresh tidal shores
Oxalis violacea	Violet Wood-sorrel	Vascular Plant	G5	S2S3	State-Special Concern	n/a	New England regional concern taxon	Dry rich forest
Panicum rigidulum var. pubescens		Vascular Plant	G5T5?	SU	State-Special Concern	n/a	New England regional concern taxon	Acid sandy seasonally wet and spring-fresh-tidal meadows
Pedicularis lanceolata	Swamp lousewort	Vascular Plant	G5	S1S2	State-Threatened	n/a	New England regional concern taxon	Fresh tidal shores and wet meadows
Platanthera flava	Pale green orchid	Vascular Plant	G4	SU	State-Special Concern	n/a		Freshwater intertidal shore habitat and managed wet meadow habitat on thick till deposits
Podostemum ceratophyllum	Threadfoot	Vascular Plant	G5	S3	State-Special Concern	n/a		Several occurrences in cobbly riffle habitat in Eightmile River (both tidal and non-tidal sections)
Ranunculus micranthus		Vascular Plant	G5	SNR		n/a	New England regional concern taxon	Open amphibolite/marble outcrops in power line ROW

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Rhynchospora macrostachya	Beaked Rush	Vascular Plant	G4	S1S2	State-Threatened	n/a		First discovered in the 8mile in 2004, growing in an acidic lake shore-shrub swamp interface
Sagittaria subulata	Arrowleaf	Vascular Plant	G4	S3	State-Special Concern	n/a	New England regional concern taxon	Fresh-oligohaline intertidal flat and shore habitat
Salix petiolaris6	Slender Willow	Vascular Plant	G5	SH	State-Special Concern (Historic)	n/a		Beaver-influenced open-canopy shrub-swamp
Sanicula canadensis	Short-styled Sanicle	Vascular Plant	G5	SU		n/a	New England regional concern taxon	
Schizachne purpurascens	Purple oat	Vascular Plant	G5	S3S4	State-Special Concern	n/a		Rich forest, in Burnham Brook area
Scleria triglomerata	Nutrush	Vascular Plant	G5	S1	State-Endangered	n/a	New England regional concern taxon	In sandy acid seasonally wet meadow community
Scutellaria integrifolia	Hyssop Skullcap	Vascular Plant	G5	S1	State-Endangered	n/a	New England regional concern taxon	Eightmile hosts 2 of the 3 extant occurrences known in New England
Silene stellata	Starry Campion	Vascular Plant	G5	SU	State-Special	n/a	New England regional concern	Sandy riverside levee forest habitat

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
					Concern		taxon	
Sphenopholis nitida	Shiny Wedge Grass	Vascular Plant	G5	SU		n/a	New England regional concern taxon	Dry oak-hickory forest in Salem[7,14]
Sphenopholis pensylvanica	Swamp Wedgescale	Vascular Plant	G4	SU		n/a	New England regional concern taxon	Recently discovered in a mossy forested seep in Salem[7,14]
Vitis novae-angliae	New England Grape	Vascular Plant	G4G5Q	S1	State-Special Concern	n/a		Occurs in managed forest clearings
Xyris smalliana	Small's Yellow-eyed Grass	Vascular Plant	G5	S1	State-Endangered	n/a	New England regional concern taxon	With 3 large occurrences, Eightmile is a stronghold for this species in Connecticut
Vermivora chrysoptera x pinus back-cross with one of parent species	"Lawrence's Warbler"	Bird	not ranked	not ranked	Golden-winged Warbler, grandparent and possibly parent, is State-Endangered	Golden-winged Wabler, grandparent and possibly parent, is listed as Most Important	This taxon is a backcross of a F1 hybrid with one of the parents. One of the F1 hybrid's parents, the Golden-winged Wabler is on IUCN Red List: "Near Threatened" Audubon Watch-	Recently summer observations in edge habitat in Salem[1]. State Wildlife Unit does not currently consider presence of Golden-winged x Blue-winged hybrids and backcrosses at a site to be indicative of presence of Golden-winged Warblers

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
							list: RED; Partners in Flight Breeding Tier IB. High Continental Priority – Low Regional Responsibility	
Empidonax virescens	Acadian Flycatcher	Bird	G5	S4B		Very Important		BBA: 3/1/2 (8mile ws appears to be a concentration area in CT)
Empidonax alnorum	Alder Flycatcher	Bird	G5	S5B	State-Special Concern	Very Important		BBA: 0/0/0 Uncommon summer resident[1] 2004 observations of probable breeding[1]
Anas rubripes	American Black Duck	Bird	G5	S3B, S4N	none	Very Important	Audubon Watch-list: YELLOW Partners in Flight Breeding Tier 1A. High Continental Priority – High Regional Responsibility/Wintering Tier I	Common summer resident[1] BBA: 1/2/0 2004 observations of breeding[1]
Falco sparverius	Amercian	Bird	G5	S2	State-	Very		BBA:1/2/1

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
	Kestrel				Threatened	Important		Uncommon resident[1]
Setophaga ruticilla	American Redstart	Bird	G5	S5B		Important		Common summer resident[1] BBA: 7/1/0 2004 observations of breeding[1]
Scolopax minor	American Woodcock	Bird	G5	S5	S5	Very Important	Audubon Watch-list: YELLOW Partners in Flight Breeding Tier 1A. High Continental Priority – High Regional Responsibility	Common resdient[1] BBA: 0/4/2 2004 observations of breeding[1]
Haliaeetus leucocephalus	Bald Eagle	Bird	G4	S1B, S3N	State-Endangered; Federally Threatened	Very Important		Nests nearby and 8mile ws is part of breeding season foraging area; significant winter usage near mouth[2]
Icterus galbula	Baltimore Oriole	Bird	G5	S5B		Important	Partners in Flight Breeding Tier IIA. High Regional Concern	Common summer resident[1] BBA: 8/0/0 2004 observations of breeding[1]
Riparia riparia	Bank swallow	Bird	G5	S5B		Important		BBA: 4/1/0

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								Uncommon summer resident[1]
Strix varia	Barred Owl	Bird	G5	S5		Important		BBA: 2/1/1 Uncommon resident[1]
Ceryle alcyon	Belted Kingfisher	Bird	G5	S5B		Important		BBA: 1/1/3 Uncommon resident[1]
Mniotilta varia	Black-and-white Warbler	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IIA: High Regional Concern	BBA: 3/3/0 Common summer resident[1]
Coccyzus erythropthalmus	Black-billed Cuckoo	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IIA : High Regional Concern	Uncommon summer resident[1] BBA: 0/2/2
Dendroica fusca	Blackburnian Warbler	Bird	G5	S5B		Important	Partners in Flight Breeding Tier IIC : High Regional Threats	BBA: 0/1/0 (Devil's Hopyard block)
Dendroica caerulescens	Black-throated Blue Warbler	Bird	G5			Very Important		BBA: 0/0/0 Uncommon summer resident[1]
Dendroica virens	Black-throated Green Warbler	Bird	G5	S5B		Important		BBA: 0/2/0 Uncommon summer resident[1]

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Polioptila caerulea	Blue-gray Gnatcatcher	Bird	G5	S5B		Important		Common summer resident[1] BBA: 5/1/2 2004 observations of breeding[1]
Vireo solitarius	Blue-headed Vireo	Bird	G5	S5B		Very Important		BBA: 0/1/0 Detected in summer 2003 in watershed at Devil's Hopyard4
Vermivora pinus	Blue-winged Warbler	Bird	G5	S5B		Very Important	Audubon Watch-list: YELLOW Partners in Flight Breeding Tier 1A. High Continental Priority – High Regional Responsibility	Common summer resident[1] BBA: 6/1/1 2004 observations of breeding[1]
Dolichonyx oryzivorus	Bobolink	Bird	G5	S4B	State-Special Concern	Very Important		BBA: 0/1/0 New nesting areas documented in recent years; breeding population growing[1]; 2004 observations of breeding[1]
Buteo platypterus	Broad-winged Hawk	Bird	G5	S5B		Important		BBA: 4/0/3 Uncommon summer

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								resident[1]
Certhia americana	Brown Creeper	Bird	G5	S5		Important		BBA: 1/1/5 Uncommon resident[1]
Toxostoma rufum	Brown Thrasher	Bird	G5	S5B	State-Special Concern	Very Important		BBA: 2/0/2 Uncommon summer resident[1]
Wilsonia canadensis	Canada Warbler	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier 1B. High Continental Priority – Low Regional Responsibility	BBA: 1/3/1 Uncommon summer resident[1]
Dendroica cerulea	Cerulean Warbler	Bird	G4	S3B		Very Important	IUCN Red list: “Globally vulnerable” Audubon Watch-list: RED Partners in Flight Breeding Tier IB : High Continental Priority – Low Regional Responsibility	Uncommon summer resident, perhaps on increase[1] BBA: 4/0/0 Single most important bird species in 8mile – breeding confirmed and/or summer observations throughout most of watershed, excepting northern tip. 8mile generally considered an important area/stronghold for this species in

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								southern New England[2, 10]
Dendroica pensylvanica	Chestnut-sided Warbler	Bird	G5	S5B		Very Important		BBA: 1/2/2 Uncommon summer resident[1]
Chaetura pelagica	Chimney Swift	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IIA : High Regional Concern	Common summer resident1 BBA: 3/2/1 2004 observations of breeding[1]
Gavia immer	Common Loon	Bird	G5	S1B	State-Special Concern (breeding populations)	Very Important		Regular migrant and winterer2 BBA: 0/0/0
Gallinula chloropus	Common Moorhen	Bird		S2B	State Endangered	Very Important		BBA: 0/1/0
Corvus corax	Common Raven	Bird	G5	S2B, SNAN		Very Important		Rare winter visitor[1] BBA: 0/0/0 Recent breeding season observations suggest possible or soon nesting in watershed.

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Accipiter cooperii	Cooper's Hawk	Bird	G5	S2B		Important		BBA: 0/1/1
Tyrannus tyrannus	Eastern Kingbird	Bird	G5	S5B		Important		Uncommon summer resident[1] BBA: 5/2/1
Sturnella magna	Eastern Meadowlark	Bird	G5	S4B	State-Special Concern	Very Important		Uncommon summer resident[1] BBA: 0/1/1 2004 documentation of breeding[1]
Otus (= Megascops) asio	Eastern Screech Owl	Bird	G5	S5		Important		Uncommon resident1 BBA: 0/0/1
Pipilo erythrophthalmus	Eastern Towhee	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IIA. High Regional Concern	Common(±) summer resident[1] BBA: 4/3/1
Contopus virens	Eastern Wood-pewee	Bird	G5	S5B		Important		Common summer resident[1] BBA: 4/3/1
Spizella pusilla	Field Sparrow	Bird	G5	S5B		Very Important		Common summer resident[1] BBA: 3/2/2 Observations of

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								nesting in 20041
Dumetella carolinensis	Gray Catbird	Bird	G5	S5B		Important		BBA: 8/0/0
Ardea herodias	Great Blue Heron	Bird		S3B		Important		BBA: 0/1/1 2005 observations of breeding[1]
Bubo virginianus	Great Horned Owl	Bird	G5	S5		Important		Uncommon resident[1] BBA: 3/2/2
Myiarchus crinitus	Great-crested Flycatcher	Bird	G5	S5B		Very Important		Common summer resident[1] BBA: 4/2/2
Butorides virescens	Green Heron	Bird	G5	S5B		Very Important		Uncommon summer resident[1] BBA: 0/2/2 2004 observations of breeding[1]
Catharus guttatus	Hermit Thrush	Bird	G5	S5B		Very Important		Uncommon summer resident[1] BBA: 1/2/0
Lophodytes cucullatus	Hooded Merganser	Bird	G5	S3B		Very Important		BBA: 1/3/4
Wilsonia citrina	Hooded Warbler	Bird	G5	S4B		Important		Uncommon summer resident[1] BBA: 1/3/4 (8mile ws

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								appears to be part of a mid-SE-CT concentration area)
Passerina cyanea	Indigo Bunting	Bird	G5	S5B		Very Important		Uncommon summer resident[1] BBA: 4/1/0
Oporornis formosus	Kentucky Warbler	Bird	G5	S3B			Partners in Flight Breeding Tier 1B. High Continental Priority – Low Regional Responsibility	Rare summer resident[1] BBA: 0/0/3 (8mile ws appears a concentration area)
Empidonax minimus	Least Flycatcher	Bird	G5			Very Important		Common summer resident[1] BBA:3/2/3
Asio otus	Long-eared Owl	Bird	G5	S1B		Very Important	Partners in Flight Wintering Tier IIA: High Regional Concern	Recently documented wintering[1]
Seiurus motacilla	Louisiana Waterthrush	Bird	G5	S5B		Important	IUCN Red list: "Near-threatened" Partners in Flight Breeding Tier IIB. High Regional Responsibility	Uncommon summer resident[1] BBA: 3/1/2
Dendroica magnolia	Magnolia Warbler	Bird	G5	S4B		Important		Uncommon migrant[1]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								Detected in summer 2003 in watershed at Devil's Hopyard and Nehantic State forest[4] BBA: 0/0/0
Colinus virginianus	Northern Bobwhite	Bird	G5	S4		Very Important		Rare to uncommon resident[1] Native populations unlikely[2] BBA: 2/1/3
Colaptes auratus	Northern Flicker	Bird	G5	S5		Important		Common resident[1] BBA: 6/1/1
Accipiter gentiles	Northern Goshawk	Bird	G5	S4B		Important		Uncommon resident[1] BBA: 0/1/1 (8mile ws is effective island of probable/possible breeding in SE CT)
Parula americana	Northern Parula	Bird	G5	S1B	State-Special Concern			Detected during June counts but breeding not confirmed[1]
Stelgidopteryx serripennis	Northern Rough-winged Swallow	Bird	G5	S5B		Important		Common summer resident[1] BBA: 0/3/1 2004 observations of breeding[1]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Seiurus noveboracensis	Northern Waterthrush	Bird	G5	S5B		Important		Uncommon summer resident[1] BBA: 0/0/0 2004 observations of breeding[1]
Icterus spurius	Orchard Oriole	Bird	G5	S5B		Important		Uncommon summer resident[1] BBA: 0/0/2
Pandion haliaetus	Osprey	Bird	G5	S3B		Important		Nests near ws and likely forages in ws, especially near mouth2 BBA: 0/0/0
Seiurus aurocapillus	Ovenbird	Bird	G5	S5B		Important		Common summer resident[1] BBA: 7/0/1 2004 observations of breeding[1]
Dryocopus pileatus	Pileated Woodpecker	Bird	G5	S5		Important		Uncommon resident[1] BBA: 1/0/4
Dendroica discolor	Prairie Warbler	Bird	G5	S5B		Very Important	Audubon Watch-list: YELLOW Partners in Flight	Common summer resident[1]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
							Breeding Tier 1A : High Continental Priority – High Regional Responsibility	BBA: 4/4/0
Protonotaria citrea	Prothonotary Warbler	Bird	G5	SNA			Partners in Flight Breeding Tier 1B. High Continental Priority – Low Regional Responsibility	Peripheral breeding area, if at all
Carpodacus purpureus	Purple Finch	Bird	G5	S4B		Important	Partners in Flight Breeding Tier : High Regional Concern	Uncommon resident[1]
Progne subis	Purple Martin	Bird	G5	S1B	State Threatened	Important		Uncommon summer resident, as forager, at least – nests regularly near watershed1 BBA: 0/0/1
Melanerpes erythrocephalus	Red-headed Woodpecker	Bird	G5	S1	State-Endangered	Very Important	IUCN Red list: "Globally vulnerable" Audubon Watch-list: YELLOW Partners in Flight Breeding Tier 1B.	Rare resident1 BBA: 0/0/1

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
							High Continental Priority – Low Regional Responsibility/Wintering Tier I	
Buteo lineatus	Red-shouldered Hawk	Bird	G5	S3B		Important		Uncommon summer resident1 BBA: 2/2/3
Pheucticus ludovicianus	Rose-breasted Grosbeak	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IIA: High Regional Concern	Common summer resident1 BBA: 4/2/2
Archilochus colubris	Ruby-throated Hummingbird	Bird	G5	S5		Important		BBA: 2/2/1 2004 observations of breeding[1]
Bonasa umbellus	Ruffed Grouse	Bird	G5	S5		Very Important		Uncommon resident[1] BBA: 5/0/2
Passerculus sandwichensis	Savannah Sparrow	Bird	G5	S3B	State-Special Concern	Very Important		Probable breeder, but uncommon in watershed[1] BBA: 0/2/0
Aegolius acadicus	Northern Saw-whet Owl	Bird	G5	S2S3B	State-Special Concern	Very Important		At least one report of nesting in 198618
Piranga olivacea	Scarlet Tanager	Bird	G5	S5B		Important	Partners in Flight Breeding Tier IIA.	Common summer resident[1]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
							High Regional Concern	BBA: 5/3/1 2004 observations of breeding[1]
Accipiter striatus	Sharp-shinned Hawk	Bird	G5	S2B	State Endangered	Very Important		Uncommon Summer Resident[1](but no breeding sites recently) BBA: 0/0/0
Asio flammeus	Short-eared Owl	Bird	G5	SHB, S1N	State-Threatened (wintering populations)	Very Important		Recently (2004) documented as early spring migrant[1]
Actitis macularia	Spotted Sandpiper	Bird	G5	S5B		Important		Uncommon summer resident[1] BBA: 0/0/0 (but probable breeder in several adjacent blocks)
Catharus fuscescens	Veery	Bird	G5	S5B		Important		Common summer resident[1] BBA: 5/2/1
Vireo gilvus	Warbling Vireo	Bird	G5	S5B		Important		Common summer resident[1] BBA: 2/1/0
Caprimulgus	Whip-poor-will	Bird	G5	S3B	State-	Very	Partners in Flight Breeding Tier IIC:	Uncommon summer

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
vociferus					Endangered	Important	High Regional Threats	resident[1] BBA: 0/3/0
Vireo griseus	White-eyed Vireo	Bird	G5	S5B		Important		Uncommon summer resident[1] BBA: 2/3/1
Empidonax traillii	Willow Flycatcher	Bird	G5	S5B		Important	Audubon Watch-list: YELLOW Partners in Flight Breeding Tier 1A: High Continental Priority – High Regional Responsibility	Uncommon summer resident[1] BBA: 0/0/3
Troglodytes troglodytes	Winter Wren	Bird	G5	S5B		Important		Rare winter visitor, migrant, and irregular breeder[1] BBA: 0/1/0 (i.e., probable in Devil's Hopyard block)
Hylocichla mustelina	Wood Thrush	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier 1A. High Continental Priority – High Regional Responsibility	Common summer resident[1] BBA: 5/3/0
Helmitheros vermivorus	Worm-eating Warbler	Bird	G5	S5B		Very Important	Partners in Flight Breeding Tier IA.	Common summer resident[1]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
							High Continental Priority – High Regional Responsibility	BBA: 4/2/2
Coccycus americanus	Yellow-billed Cuckoo	Bird	G5	S5B		Very Important		Common summer resident[1] BBA: 0/3/3
Icteria virens	Yellow-breasted Chat	Bird	G5	S1B	Endangered	Most Important		Observed in 2006 singing during breeding season[20]
Vireo flavifrons	Yellow-throated Vireo	Bird	G5	S5B		Important		Common summer resident; 2004 observations of breeding[1] BBA: 5/3/0
Alosa aestivalis	Blueback Herring	Fish	G5			Most Important		Recent detections in Hamburg cove only[9]
Alosa pseudoharengus	Alewife	Fish	G5	S3		Most Important (anadromous populations only)		Recent detections in Hamburg cove only[9]
Anguilla rostrata	American Eel	Fish	G5	S5		Most Important		

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Salmo salar	Atlantic Salmon	Fish	G5	SH		Very Important		Recent confirmed detections of juvenile fish (likely stocked); unconfirmed reports of adult returns.
Enneacanthus obesus	Banded Sunfish	Fish	G5	S3	State-Special Concern	Most Important		
Salvelinus fontinalis	Brook Trout (wild)	Fish	G5	S5		Most Important		Credible reports from headwaters, but not yet confirmed
Esox niger	Chain Pickerel	Fish	G5	S5		Very Important		
Erimyzon oblongus	Creek Chubsucker	Fish	G5	S3		Very Important		
Esox americanus	Redfin Pickerel	Fish	G5	S4		Very Important		
Morone saxatilis	Striped Bass	Fish	G5	S3		Very Important		Recent detections in Hamburg cove only[9]
Osmerus mordax	Rainbow Smelt	Fish	G5	S1	State-Threatened (Anadromous populations only)	Most Important		Historic records only (1959 or earlier) from at or near mouth of Hamburg Cove[9]
Petromyzon marinus	Sea Lamprey	Fish	G5	S5		Very Important		

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Paraleptophlebia assimilis	A mayfly	Invertebrate	G4	SNR	State-Special Concern	Important		
Ladona deplanata	Blue corporal	Invertebrate	G5	S1S2	State-Special Concern	Important		
Ligumia nasuta	Eastern Pondmussel	Invertebrate	G4G5	S1S2	State-Special Concern	Important		
Lycaena epixanthe	Bog Copper	Invertebrate	G4G5	S2	State-Special Concern	Important		
Margaritifera margaritifera	Eastern Pearlshell	Invertebrate	G4	SU	State-Special Concern	Important		
Callophrys irus	Frosted Elfin	Invertebrate	G3	S2S3	State-Threatened	Very Important		At least 2 occurrences recently documented in watershed
Callophrys henrici	Henry's Elfin	Invertebrate	G5	S2	State-Special Concern	Important		
Tabanus fulvicallus	A horse fly	Invertebrate	GNR	SNR	State-Special Concern	Important		
Enallagma minusculum	Little Bluet	Invertebrate	G3G4	S1S2	State-Special Concern	Important		

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Gomphus adelphus	Mustached Clubtail	Invertebrate	G4	S2	State-Threatened	Very Important		8mile hosts the only reliable population in Connecticut[17]
Gomphus ventricosus	Skillet Clubtail	Invertebrate	G3	S2	State-Special Concern	Important		
Merycomyia whitneyi	A Tabanid fly	Invertebrate	GNR	SNR	State-Special Concern	Important		
Clethrionomys gapperi	Southern Red-backed Vole	Mammal	G5	S5		Important		
Felis rufus	Bobcat	Mammal	G5	S2?		Very Important		
Lasiurus borealis	Red Bat	Mammal	G5	S3	State-Special Concern	Most important		Documented in the 8mile by recent mist net survey[19]
Microtus pinetorum	Woodland Vole	Mammal				Important		
Mustela frenata	Long-tailed Weasel	Mammal	G5	S5		Important		
Mustela vison	Mink	Mammal	G5	S5		Important		Documented in the 8mile by recent mist net survey[19]
Myotis lucifugus	Little Brown Bat	Mammal				Important		Documented in the 8mile by recent mist

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Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
								net survey[19]
Myotis septentrionalis	Northern Long-eared Bat	Mammal	G			Important		Documented in the 8mile by recent mist net survey[19]
Napaeozapus insignis	Woodland Jumping Mouse	Mammal	G5	S5		Very Important		
Ondatra zibethicus	Muskrat	Mammal	G5	S5		Important		
Sylvilagus transitionalis	New England Cottontail	Mammal	G4	S2		Most Important		Recently documented in 8mile Nehantic SF[5,12] and scrubby highway ROW habitat7, and in transmission ROW habitat just E and W of 8mile[5,12.]
Ursus americanus	Black Bear	Mammal	G5	S3		Important		
Zapus hudsonius	Meadow Jumping Mouse	Mammal	G5	S5		Very Important		
Desmognathus fuscus	Dusky Salamander	Amphibian	G5	S4		Important		Locally common (e.g., at Pleasant Valley)[8]
Notophthalmus viridescens	Eastern Newt	Amphibian	G5	S5		Important		
Hyla versicolor	Gray Treefrog	Amphibian	G5	S5		Important		

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Ambystoma opacum	Marbled Salamander	Amphibian	G5	S4		Important		Locally abundant (e.g., at Pleasant Valley)[8]
Ambystoma maculatum	Spotted Salamander	Amphibian	G5	S5		Important		Robust meta-population
Rana sylvatica	Wood Frog	Amphibian	G5	S4		Important		Robust meta-population
Agkistrodon contortrix	Copperhead	Reptile	G5	S3		Important		Fairly recently documented (1993) just S of 8mile, ca. Rogers Lake[11]
Heterodon platirhinos	Eastern Hognose Snake	Reptile	G5	S3S4	State-Special Concern	Very Important		One recent observation (2003)[11,] at Pleasant Valley; observations in 1990s at Burnham Brook and Salem Valley Basin[1, 5]
Thamnophis sauritus	Eastern Ribbon Snake	Reptile	G5	S3S4	State-Special Concern	Very Important		Confirmed near watershed; recent reliable reports from within watershed[7]
Liochlorophis (= Opheodrys) vernalis	Eastern Smooth Green Snake	Reptile	G5	S3S4		Important		No records within watershed; one 1983 record outside but near watershed[11]

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank16	State Rank16	Legal Status	State CWCS21 ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed
Clemmys (= Glyptemys) guttata	Spotted Turtle	Reptile	G5	S4		Very Important	IUCN Red list: "Globally vulnerable"	Recent documentation (2002-2005) of wide distribution in watershed[11,13,14]
Clemmys insculpta	Wood Turtle	Reptile	G4	S3	State-Special Concern	Very Important	IUCN Red list: "Globally vulnerable"	Recent documentation (1999-2004) at several sites along both branches of 8mile River[9,11]
Terrapene carolina	Eastern Box Turtle	Reptile	G5	S4	State-Special Concern	Very Important		Fairly recent records from Pleasant Valley area (1999)[11], the Salem Valley Basin area (2001)[1,] and the Burnham Brook area (1990), where 2 nests were observed[18.]

TABLE NOTES:

[1]Bingham

[2]Comins

[3]BBA = Connecticut Breeding Bird Atlas (Bevier et al. 1994). Volunteers surveyed 1/6-quadragle blocks over period 1982-1985, documenting breeding with 3 levels of confidence, depending on nature of observations: confirmed, probable, and possible. Eight survey blocks significantly overlap 8mile ws. Key to code, using example, "4/2/2" = breeding confirmed in 4 blocks / breeding probable in 2 blocks/ breeding possible in 2 blocks.

[4]Craig et al. 2003

[5]CT-DEP 4/2005

Table 2. Summary of at-risk species known to occur in the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Global Rank[16]	State Rank[16]	Legal Status	State CWCS[21] ranking	Other rankings re conservation concern	Comments specific to Eightmile Watershed

[6]State rank and state legal status out of date for this taxon: several occurrences have recently been documented state-wide

[7]The Maguire Group 2005

[8]Natoli pers. comm...

[9]Walden and Parasiewicz 2005, citing Whitworth et al. 1968 and/or CT-DEP fish survey data

[10]Askins pers. comm.

[11]Gruner and Klemens 2004

[12]Kilpatrick pers. comm.

[13]Connecticut River Conservation District 2004

[14]Moorhead observations 2003-2005

[15]Brumback et al. 1996. In this table "New England regional concern" taxa are those ranked in the Brumback et al. publication as "Division 1: Globally Rare Taxa occurring in New England" and "Division 2: Regionally [= New England} Rare Taxa"

[16]see Appendix A for the explanation of global and state ranks

[17]Wagner pers. comm.

[18]Goodwin 1991a

[19]Dickson (pers. comm.)

[20]Harvey 2006

[21]Connecticut's Comprehensive Wildlife Conservation Strategy

Birds

A comprehensive inventory of the birds of the Eightmile watershed has not yet been performed, but a number of studies of avifauna have focused on several parts of the watershed. Devil's Hopyard and the Burnham Brook area, in East Haddam, have been have been sites of rigorous and longitudinal bird inventories (Goodwin 1991a). Scientific bird inventories have been performed in Nehantic State Forest in Lyme and East Lyme, and in Devil's Hopyard State Park in East Haddam (Craig, Atshul, and Beal 2003). Yearly June and December bird censuses are performed in a circular area that includes much of the Salem portion of the watershed (Bingham, pers. comm.), and biologists with The Maguire Group, consultants to the Connecticut Dept. of Transportation (CT-DOT), have recently performed surveys of birds in the proposed Route 11 extension corridor in Salem and East Lyme. In addition, volunteers reported to the 1982-1986 Connecticut Breeding Bird Atlas Project for all the blocks (a "block" = 1/6 of a 7½-minute USGS topographic quadrangle map) that overlap with the Eightmile watershed.

From these sources, the author has compiled a list, presented in Table 2, of about 91 birds of special conservation concern that have been documented in and near the Eightmile River watershed in recent decades.

Figure 7. Male Cerulean Warbler (*Dendrioca cerulea*). Photo credit: © PAUL J. FUSCO - ALL RIGHTS RESERVED.

By general consensus of local/regional ornithologists (Comins pers. comm.; Askins, pers. comm.) the Eightmile watershed's most important role with respect to avian biodiversity is as a stronghold for the Cerulean Warbler (*Dendroica cerulea*), which is known to breed throughout most of the Eightmile watershed. This species has been identified as a species of special conservation concern by three international bird conservation organizations, the ICUN, Audubon, and Partners in Flight. This forest interior species evidently requires large blocks of deciduous forest, and is especially sensitive to forest fragmentation (Askins 2000). It appears that it is no coincidence that the Eightmile watershed, with its large blocks of unbroken forest (SEE Figure 7), is a stronghold for the Cerulean Warbler.

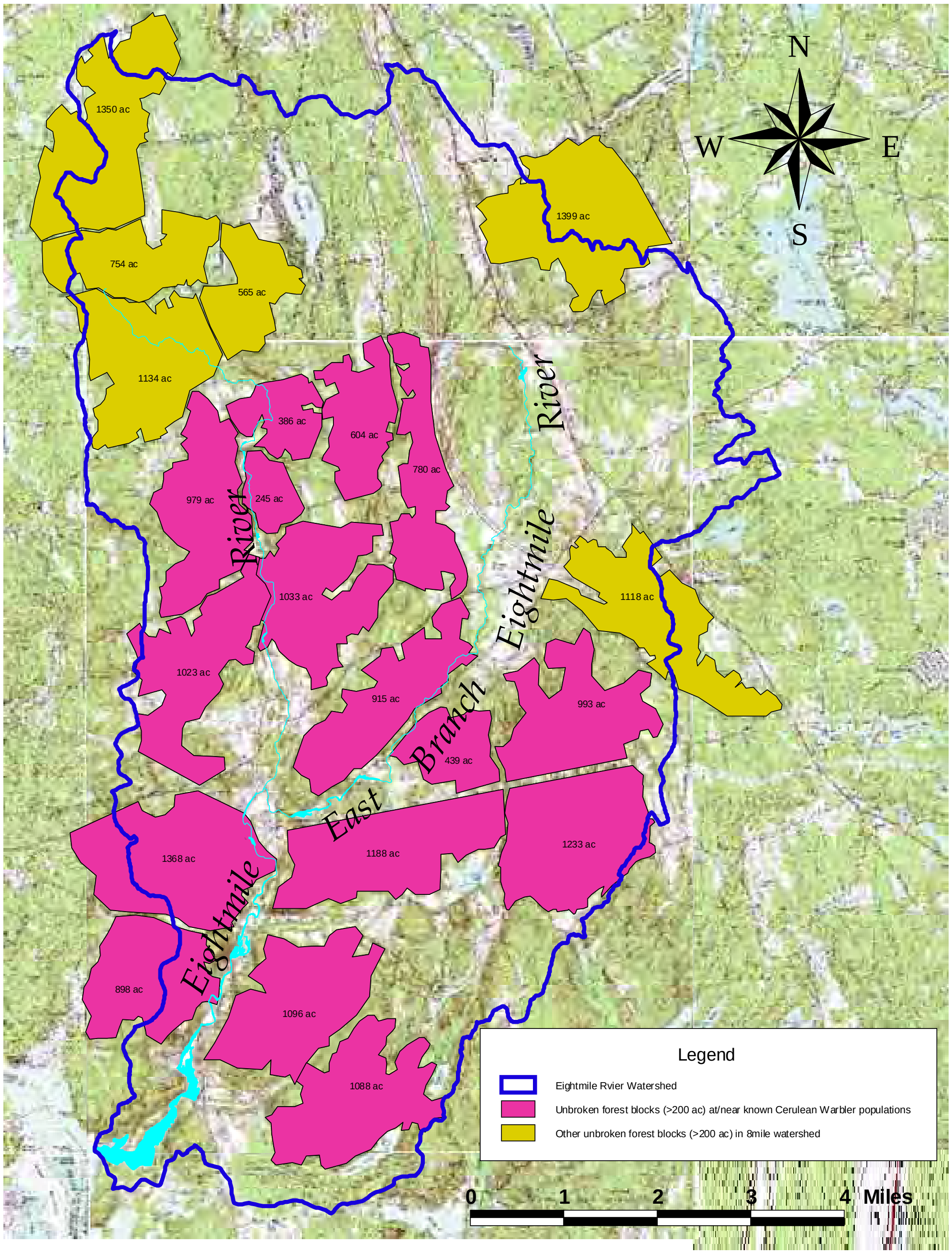

Figure 8. Unbroken forest blocks in the Eightmile River watershed, in relation to documented Cerulean Warbler breeding sites.

Portions of the Eightmile watershed have been identified by Audubon Connecticut as meeting the criteria for designation as an “Important Bird Area” in the state (Patrick Comins, pers. comm.).

Figure 9. Current nesting habitat in Salem for Bobolink (*Dolichonyx oryzivorus*) a State-listed Species of Special Concern (Bingham pers. comm.).

Invertebrates

As shown in Table 2, twelve invertebrate species listed as State-Threatened or State-Special Concern have been recently documented in the Eightmile watershed: 3 butterflies, 3 dragonflies, 1 mayfly, 1 damselfly, 2 mussels, and 2 Tabanid flies (i.e., horseflies and deerflies). A comprehensive inventory of the invertebrate fauna of the Eightmile watershed has not yet been performed, but a number of places in the watershed have for some time been recognized by amateur and professional invertebrate specialists as "hot spots" for various invertebrate fauna, and there is a considerable compilation of invertebrate data for the Eightmile watershed. Dr. David Wagner, at UCONN, and Michael Thomas, with the Connecticut Agricultural Experiment Station, have reviewed and compiled Odonata records, and the Connecticut Butterfly Society has compiled records of Lepidoptera from the Connecticut Butterfly Atlas Project. In addition, the CT-DEP-NDDB has researched and compiled records of other invertebrates (e.g., Diptera) believed to be rare in a state and/or global context.

Figure 10. Bog Copper (Lycaena epixanthe) with host plant, Large Cranberry (Vaccinium macrocarpon), and Rose Pogonia (Pogonia ophioglossoides), a nectar source, in medium fen community.

The twelve State-listed invertebrates are dependent upon several habitats in the Eightmile watershed. Four of the species - 2 dragonflies, 1 mayfly, and 1 mussel species - are associated with lotic sections of the Eightmile River itself and its larger tributaries. Three of the species - one butterfly and both Tabanid fly species - are associated with bog-like medium fen habitat. Two species – one dragonfly and a globally rare damselfly – are associated with certain sandy-bottomed natural ponds/small lakes. One of the butterflies, the globally rare Frosted Elfin, is associated with sand barrens and open rocky outcrop habitat. The third butterfly species appears to be associated with a large scrubby swamp complex. Finally, one mussel species occurs in the fresh-tidal Hamburg Cove.

In addition to documenting State-listed and globally, professional and amateur naturalists have compiled total taxa lists for certain groups of invertebrates. The Connecticut Butterfly Atlas Project documented 70 of the ~120 butterfly species known from Connecticut in blocks overlapping the Eightmile watershed.

Reptiles and Amphibians

A comprehensive, systematic inventory of the reptiles and amphibians of the Eightmile River watershed has not yet been performed, but there exists a considerable body of data on the herpetofauna of the watershed and its near vicinity, from which the author has compiled the list presented in Table 3. Sources for the data presented in Table 3 include: a GIS database of reptile and amphibian data for the Eightmile river watershed and its near vicinity, based on voucher specimens, photographs, and reliable observations by professional and avocational herpetologists (Gruner and Klemens 2004); observations by naturalist Dr. David Bingham, of Salem, CT; the biological survey of the Route 11 corridor by biologists with The Maguire Group, consultants to the Connecticut Dept. of Transportation (Zemba, Hall, and Hageman pers. comms.); a vernal pool inventory conducted by the Connecticut River Conservation District, using volunteers trained by a professional herpetologist (Connecticut River Conservation District 2004); a compilation of species documented over several decades at the Burnham Brook Nature Conservancy Preserve in East Haddam (Goodwin 1991); observations by educator and avocational herpetologist Ed Natoli, of Salem, CT; Michael Klemens' 1993 Amphibians and Reptiles of Connecticut; and the author's field observations, 2003-2005.

Based on these sources, at least 28 species of reptiles and amphibians have been documented within the Eightmile River watershed in recent decades, and an additional 2 species outside, but near, the watershed (Gruner and Klemens 2004). Among these are 4 State-listed species, all in the "Special Concern" category and all reptiles: *Heterodon platirhinos* (Hog-nosed Snake), and *Thamnophis sauritus sauritus* (Eastern Ribbon Snake), *Clemmys insculpta* (Wood Turtle), *Terrapene c. carolina* (Eastern Box Turtle). All of these species are also classified in Connecticut's Comprehensive Wildlife Conservation Strategy (CWCS) as "Very Important". Also occurring in the watershed is a reptile species that is not yet State-listed as Endangered, Threatened, or Special Concern, but is classified in the CWCS as "Very Important": *Clemmys guttata* (Spotted Turtle), which is considered by local naturalists to be not uncommon in the Eightmile River watershed.

Table 3. Reptiles and amphibians documented in and near the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Family	State Legal Status	State CWCS status	Comments on status in Eightmile watershed
Hyla versicolor	Gray Treefrog	Amphibian	Treefrogs			Abundant[5]
Pseudacris cucifer cucifer	Northern Spring Peeper	Amphibian	True Frogs			Common to abundant[5]
Rana catesbeiana	Bullfrog	Amphibian	True Frogs			Present[5]
Rana clamitans melanota	Green Frog	Amphibian	True Frogs			Common to abundant[5]
Rana palustris	Pickerel Frog	Amphibian	True Frogs			Common to abundant[5]
Rana sylvatica	Wood Frog	Amphibian	True Frogs			Common to abundant[5]
Bufo americanus americanus	Eastern American Toad	Amphibian	Toads			Common[5]
Bufo fowleri	Fowler's Toad	Amphibian	Toads			Outside but near watershed; Natoli doubts it occurs in 8mile[1]
Ambystoma maculatum	Spotted Salamander	Amphibian	Mole Salamanders			Common to abundant[1]
Ambystoma opacum	Marbled Salamander	Amphibian	Mole Salamanders			Locally abundant[1]
Desmognathus fuscus	Northern Dusky Salamander	Amphibian	Lungless Salamanders			Locally common[1]
Eurycea bislineata	Northern Two-lined Salamander	Amphibian	Lungless Salamanders			Common[1]
Hemidactylium scutatum	Four-toed Salamander	Amphibian	Lungless Salamanders			Common[1]

Table 3. Reptiles and amphibians documented in and near the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Family	State Legal Status	State CWCS status	Comments on status in Eightmile watershed
Notophthalmus viridescens viridescens	Red-spotted Newt	Amphibian	Newts			Not uncommon[1]
Plethodon cinereus	Red-backed Salamander	Amphibian	Lungless Salamanders			Abundant[1]
Agkistrodon contortrix moke	Northern Copperhead	Reptile	Pit Vipers		Important	Fairly recently (1993) observed outside but near watershed[2]
Carphophis amoenus	Eastern Worm Snake	Reptile	Harmless Snakes			Historic records (1980) for 2 localities within watershed. Current status unknown.
Coluber constrictor	Northern Black Racer	Reptile	Harmless Snakes			Two recent observations (2000, 2005) in Salem[1]
Elaphe alleghaniensis	Eastern Rat Snake	Reptile	Harmless Snakes			Very common[1]
Heterodon platirhinos	Eastern Hognose Snake	Reptile	Harmless Snakes	Special Concern	Very Important	Apparently local. Recently (2003) observed at one locality, and fairly recently (1990s) at a second locality.
Lampropeltis triangulum triangulum	Eastern Milk Snake	Reptile	Harmless Snakes			Very common[1]
Liochlorophis (= *Opheodrys*) *vernalis*	Eastern Smooth Green Snake	Reptile	Harmless Snakes		Important	One recent observation recently in Pleasant Valley (2002 or 2003)[1]
Nerodia sipedon	Northern Water	Reptile	Harmless			Very common[1]

Table 3. Reptiles and amphibians documented in and near the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Family	State Legal Status	State CWCS status	Comments on status in Eightmile watershed
sipedon	Snake		Snakes			
Storeria dekayi dekayi	Northern Brown Snake	Reptile	Harmless Snakes			Common[1]
Thamnophis sauritus sauritus	Eastern Ribbon Snake	Reptile	Harmless Snakes	Special Concern	Very Important	Recently observed at one locality in the watershed (Zemba pers. comm.); 1985 and 1979/1980 reports for a second locality[6]
Thamnophis sirtalis sirtalis	Eastern Garter Snake	Reptile	Harmless Snakes			Very common[1,5]
Chrysemys picta subsp.	Painted Turtle	Reptile	Pond and Marsh Turtles			Common to absent[1]
Clemmys guttata	Spotted Turtle	Reptile	Pond and Marsh Turtles		Very Important	Not uncommon[1]
Clemmys insculpta	Wood Turtle	Reptile	Pond and Marsh Turtles	Special Concern	Very Important	Several recent observations along both branches of the 8mile River[2,3,4]
Sternotherus odoratus	Common Musk Turtle	Reptile	Pond and Marsh Turtles			Observed at least once, in 1999[1]
Terrapene carolina	Eastern Box Turtle	Reptile	Pond and Marsh Turtles	Special Concern	Very Important	Apparently local; recent (1999, 2001) records for three localities[2,4], fairly recent (1990) for a 4th locality[6]

[1]Natoli pers. comm.
[2]Gruner and Klemens 2004
[3]Walden and Parasiewicz 2005
[4] Bingham pers. comm.
[5]Author's field observations (2003-2005)

Table 3. Reptiles and amphibians documented in and near the Eightmile River watershed.

Taxon	Common name	Higher Taxonomic Group	Family	State Legal Status	State CWCS status	Comments on status in Eightmile watershed
[6]Goodwin 1991a [7]Klemens 1993						

Mammals

A comprehensive inventory of the mammals of the Eightmile River watershed has not yet been performed, but various surveys of limited scope have been performed in or near the watershed in the last several decades. Based on these surveys, together with reliable reports of observations, and the author's field observations, approximately 39 terrestrial mammal species (36 native and 3 naturalized non-native) have been documented naturally occurring in, or very close to, the Eightmile watershed. Several more species may reasonably be expected to occur in the watershed. All of these species are terrestrial mammals, as opposed to marine. To the best of the author's knowledge, no marine mammals have been documented using Hamburg Cove, but since harbor seals have been recently observed in the Connecticut River well upstream of the Cove, it is reasonable to expect that harbor seals either have used, or will use, Hamburg Cove.

Thirteen of the mammal species (See Table 2) documented in or near the watershed within the last several decades are included in Connecticut's Comprehensive Wildlife Conservation Strategy (CWCS), as "Important", "Very Important", or "Most Important" species.

One of these species, the Red Bat (*Lasiurus borealis*), is State-listed as Special Concern, and listed in the CWCS as a "Most Important" species. The Red Bat has been documented within the Eightmile watershed by recent CT-DEP mist net survey. This tree-roosting bat uses air space over the Eightmile River as movement corridor and for foraging. It habitat preference is for an admixture of open and treed habitat (Jenny Dickson, pers. comm.). The Red Bat is the only State-listed mammal documented in the watershed.

Among the ten CWCS-listed species, those ranked rarest statewide are Bobcat (*Felis rufus*) and New England Cottontail (*Sylvilagus transitionalis*), which are ranked "S2?" and "S2", respectively, and "Very Important" and "Most Important", respectively, in the CWCS.

Bobcat sign (tracks, droppings) has been detected within the watershed as recently as 1984 (Goodwin 1991), and there have been several recent reliably reported sightings of Bobcat in 3 of the 5 towns that overlap with the watershed (CT-DEP 2003). The author could not confirm whether these sightings were also within the watershed. For unknown reasons, Bobcat are more abundant in the western Connecticut than they are in eastern Connecticut, in spite of an apparent abundance of suitable habitat in the many places in eastern Connecticut, such as the Eightmile watershed. This statewide distribution pattern appears to be stable, and thus it does not appear that the Eightmile watershed is, or will be, a stronghold for Bobcat, in state or regional context (Paul Rego, pers. comm.).

The New England Cottontail has recently been documented at two places in the Eightmile watershed, and a third location just outside of the watershed. It is associated with scrubby habitat in rights-of-way, and with forested habitat with a well-developed shrubby understory

(Howard Kilpatrick, pers. comm.; Anthony Zemba, pers. comm.).

Black Bear (*Ursus americanus*), which CWCS-listed as an “Important” species, has been recently sighted in at least 3 of the 5 towns overlapping with the Eightmile watershed, and also in towns bordering the watershed. The author could not confirm if any of these sightings were within the watershed, but there is abundant suitable habitat in the watershed and it is reasonable to assume that the watershed is being used, at least, by dispersing/wandering non-breeding Black Bear. The Eightmile watershed is outside the part of Connecticut where Black Bear is considered to be established (i.e., where they are regularly breeding), and thus the watershed is not at present considered to be an important area for bears. The Black Bear population and the areas where they are considered established are expanding in Connecticut, however, and it it is reasonable to expect that the watershed, with it’s low level of development, large unbroken forest blocks, and large portion of protected land, will in the future support a breeding population of Black Bear (Paul Rego, pers. comm.).

In addition to the CWCS-listed mammals that have been documented in or near the Eightmile watershed, there are at least three additional species (1 bat, 2 small mammals) that are considered possible or likely to occur, based on our current understanding of their habitat requirements and statewide distribution (Jenny Dickson, pers. comm. [bats]; James Fischer, pers. comm. [small mammals]). These are:

- Eastern Pipistrelle (*Pipistrella subflavus*) – CWCS listing: “Important”
- Southern Bog Lemming (*Synaptomys cooperi*) - CWCS listing: “Most Important”, State-Special concern
- Northern Water Shrew (*Sorex palustris*) - CWCS listing: “Most Important”.

Besides “at risk” species, several other mammals deserve special mention. Like the Black Bear, Fisher (*Martes pennanti*) were extirpated in Connecticut, and have become re-established in Connecticut over the last 40 years, both via introduction in the western part of the state, and via dispersal from Massachusetts in the east. They have been especially successful in the eastern part of the state (Paul Rego, pers. comm.). There have been recent sightings and road-kills in most of the Eightmile watershed towns (CT-DEP 2003). The author observed Fisher tracks in several places in the Eightmile watershed in the winter of 2004-2005, and was scolded by a live Fisher in a tree just outside the watershed at another location. By all appearances, Fisher are well-established in the Eightmile watershed.

Plant

The Eightmile River watershed hosts extant populations of 34 plants considered rare, endangered, threatened, and otherwise of conservation concern in global, regional, and/or state contexts (See Table 2). Of these, two species are globally rare: *Bidens eatonii* Eaton's Beggar-ticks (G2) and *Eriocaulon parkeri* Parker's Pipewort (G3); intertidal wetland habitats support robust, regional stronghold populations of both species. Twenty-four plants (including the two globally rare species) have been identified as being of New England regional conservation concern (Brumback et al. 1996). And finally, the watershed hosts 28 State-listed plants, i.e., plants listed in Connecticut as Endangered, Threatened, or Special Concern (this total includes the above-mentioned 2 globally rare species and 16 additional species of New England regional concern species; 6 of the New England regional concern species are not State-listed in Connecticut). Of the above-mentioned plants, the author personally observed populations of 30 of the 33 rare plants during the period 2003-2005, and the observation of one additional species was reliably reported in 2003 (Mattrick pers. comm.). Thus, 31 of the 33 rare plants believed extant in the watershed have been confirmed extant within the last 4 years. The remaining two species, the fern *Ophioglossum pusillum* Adder's Tongue and the grass, *Schizachne purpurascens* Purple Oat, were documented as recently as 1998 and 1990, respectively. The author has confirmed that the sites for these species are still intact, so it is reasonable to follow the NatureServe convention (i.e., last observed within the last 25 years), and consider the species to be extant in the watershed.

Figure 11. . State-Endangered and regionally rare *Scutellaria integrifolia* (Hyssop Skullcap)

The Eightmile River watershed is of special significance for several of the rare plants of New England regional conservation concern. The watershed hosts most of the individual plants still known to exist in New England of *Scutellaria integrifolia* Hyssop Skullcap (See Fig. 11). The watershed hosts the most robust occurrences, and the largest concentration of occurrences, of *Aristolochia serpentaria* Virginia Snakeroot that are known in New England. The watershed hosts the majority of the known Connecticut occurrences, and perhaps also the majority of individual plants known in New England, of *Xyris smalliana* Small's Yellow-eyed Grass (See Fig. 14). The watershed is a critical regional stronghold for these three plants in New England. Four additional plants are notable for the robustness of their populations and/or numbers of occurrences in the watershed: *Asplenium montanum* Mountain Spleenwort, *Carex bushii* Sedge, *Pedicularis lanceolata* Swamp Lousewort, *Mimulus alatus* Winged Monkey-flower, and *Asclepias purpurascens* Purple Milkweed (See Fig. 12). This last species occurs in low numbers, but in a relatively large number of individual occurrences (3-4) for a single locality.

The total number of extant occurrences of State-listed plants currently known in the Eightmile watershed (as of May 2006 and to the best of the author's knowledge) is about 58 occurrences. Forty-nine of these occurrences were observed and confirmed extant by the author in the period 2003-2006, while observations of 3 additonal occurrences were reliably reported during the same period. The remaining 6 occurrences were last observed as long ago as 1982 and as recently as 2002, and it is reasonable to suspect that they are all still extant. .

In 2004, based on the results of the author's 2003 survey of the watershed for rare plants, the author estimated that the actual number of State-listed and regionally rare plant occurrences in the Eightmile watershed is probably at least 50% higher than the current total then known for the watershed (53). This estimate is supported by the author's subsequent discoveries of 9 additional State-listed plant occurrences and one new State-listed species in the watershed in 2004 and 2005. In considering the implications of this, it is important to realize that the majority of the occurrences discovered by this survey will likely not persist without some form of habitat management/disturbance/manipulation by man. Several of these occurrences (e.g., those of *Scleria triglomerata* Nutrush, *Asclepias purpurascens* Purple Milkweed, *Lespedeza repens* Creeping Bush-clover, *Liparis liliifolia* Lily-leaved Twayblade, *Xyris smalliana* Small's Yellow-eyed grass) may reasonably be viewed as having been discovered just in the nick to time to prevent their imminent loss. Likewise, several priority natural communities were identified which are still intact and of high quality, but are also threatened by one or more of the following: invasives, beaver activity, over-browse by deer, lack of management or less-than-optimal management, and in some cases lack of protection. The timely recognition of these community occurrences' management and protection needs, as well as timely discovery of not-yet-recognized occurrences, makes their continued existence more likely.

Figure 12. State-Special Concern and regionally rare *Asclepias purpurascens* (Purple Milkweed).

Eightmile River watershed in a New England regional context: the NatureServe analysis

There are several ways in which the regional biodiversity significance of the Eightmile river watershed may be assessed. One way is to compare the number of rare species found in the Eightmile to other watersheds of comparable scale in the region. Toward this end, in late 2004, NatureServe.org was commissioned by the Eightmile Watershed Study Committee to create a tally of extant rare species for each of all the HUC12 and HUC10 drainage basins in New England. This analysis was a first of its kind, as it was based upon data shared by state natural heritage programs, and data sharing agreements between the natural heritage programs and NatureServe had only just been finalized by late 2004.

The species used in the analysis were only those currently considered the rarest in each state (species with state ranks of S2S3 or rarer), and all globally rare species (global rarity ranks of G3G4 or rarer). There were several reasons for this restriction, which eliminates from consideration many species that are legally protected in each state, and many other species that have been identified by various organizations as of conservation concern and at-risk. One reason for the restriction was to neutralize as much as possible the geographic scale differences between states that all use the same rarity ranking system, which is based mainly on numbers of known occurrences in the state. Another reason was the supposition that the state heritage programs have a more accurate understanding of true numbers of occurrences for their rarest species than for the less rare species, because the former have been the objects of greater inventory effort.

An additional restriction on the Natureserve analysis is that it counts only species documented in the watershed in the last 25 years. This represents a best attempt to compare, between watersheds, the number of extant rare species, and, by extension, existing habitat conditions (as opposed to historic conditions). The majority of records older than 25 years are problematic to use in this kind of analysis, because locality information is for most records too imprecise to allow assignment to watershed (town is most often the most precise locality information associated with older records).

Given these restrictions, the tally of extant countable rare species for the Eightmile River watershed was 20 species (including 3 globally rare species) before incorporating recent data not available to NatureServe at the time of the analysis, and the tally is 32 species (including 5 globally rare species), after incorporating the occurrence data developed by recent surveys and research in 2003-2005 (which data had not been processed by the state heritage program and transmitted to NatureServe by the time of there analysis). Both tallies are surprisingly small compared with the number of State-listed species (55), and the summary list of "at-risk" species associated with the watershed (160). However, this reduction is understandable, given the focus of this analysis on the rarest species, in a regional, rather than a state, context.

As explained in the introduction, the hierarchical scheme of organization of drainage basins used by the federal government differs from that used by the state of Connecticut, and the other New England states use the federal system. For this reason, it is not possible to directly compare the tally of rare species for the Eightmile River watershed, as it is defined in this report, to the New England HUC12 and HUC10 drainage basins. The majority of New England's HUC10 (i.e., regional) basins are 2X to 9X the area of the Eightmile River watershed, while most HUC12 (subregional) basins are much smaller (median size = ~31 mi^2). Comparisons of species richness among geographic units of very different area are biased toward the larger units, because species richness generally increases with area regardless of relative biodiversity values. However, the Eightmile River watershed is comprised of two federal HUC12 basins, and it was possible to directly compare each of these subsets of the Eightmile River watershed to all other HUC12 basins across New England. The results of this comparison are presented in Table 4. Also, a comparison has been made between the Eightmile watershed, as defined in this report, and all other New England HUC10 watersheds (median size = ~137 mi^2), using density of rare species per unit area, which in some measure equalizes the "advantage" of the larger size watersheds. This comparison is presented in Table 5.

Table 4. Ranking of the two Eightmile River HUC12 basins among all New England and Connecticut HUC12 basins, in terms of extant rare species/basin and extant rare species/unit basin area in New England.

		Eightmile [main stem] HUC12 code: 010802050903 (before updating data)	Eightmile [main stem] HUC12 code: 010802050903 (after updating data)	East Branch Eightmile HUC12 code: 010802050902 (before updating data)	East Branch Eightmile HUC12 code: 010802050902 (after updating data)
Number extant *globally rare species* (G1 thru G2G3) in basin		3	5	0	1
Number extant state-rare and globally rare species (S1 thru S2S3, G1 thru G2G3) in basin		19	25	2	7
New England Context Number of HUC12 basins: 1931 NE HUC12 basin area range: 0.03-265 mi^2 Median HUC12 basin area: 31 mi^2 Extant total rare species/HUC12 basin: Range = 0-60; Median = 1 Extant globally rare species/basin: Range = 0-13; Median = 0	Percentage of New England HUC12 basins hosting MORE extant *globally rare species*	2.1%	0.8%	26.8%	9.3%
	Percentage of New England HUC12 basins hosting FEWER extant *globally rare species*	95.7%	98.9%	n/a	73.2%
	Percentile rank among New England HUC12 basins based on DENSITY of *globally rare species* (i.e., species/unit area of basin)	96th	98th	n/a	90th
	Percentage of New England HUC12 basins hosting MORE extant total rare species (state-rare and globally rare combined)	4.6%	2.7%	36.7%	16.4%
	Percentage of New England HUC12 basins hosting FEWER extant rare species (state-rare and globally rare combined)	95.0%	97.0%	54.4%	81.5%
	Percentile rank among New England HUC12 basins based on DENSITY of MORE extant total rare species (state-rare and globally rare combined) (i.e., species/unit area of basin)	94th	95th	67th	89th

<table>
<tr><th colspan="4">Table 5. Comparison of Eightmile River watershed to HUC10 watersheds in New England and Connecticut, in terms of rare species/unit area.</th></tr>
<tr><td></td><td></td><td>Eightmile River watershed (=Eightmile [main stem]
HUC12 code: 010802050903 + East Branch Eightmile
HUC12 code: 010802050902),
before updating data.</td><td>Eightmile River watershed (=Eightmile [main stem]
HUC12 code: 010802050903 + East Branch Eightmile
HUC12 code: 010802050902),
after updating data.</td></tr>
<tr><td colspan="2">Number extant globally rare species (G1 thru G2G3) in basin</td><td>3</td><td>5</td></tr>
<tr><td colspan="2">Number extant state-rare and globally rare species (S1 thru S2S3, G1 thru G2G3) in basin</td><td>20</td><td>31</td></tr>
<tr><td rowspan="4">New England Context
Number of HUC10 basins: 417
Median HUC10 basin area: ~137 mi^2
Extant total rare species/HUC10 basin:
Range = 0-112; Median = 8
Extant globally rare species/basin:
Range = 0-20; Median = 1</td><td>Percentage of New England HUC10 basins hosting MORE extant globally rare species/square mile</td><td>8.6%</td><td>1.1%</td></tr>
<tr><td>Percentage of New England HUC10 basins hosting FEWER extant globally rare species/square mile</td><td>91.4%</td><td>98.9%</td></tr>
<tr><td>Percentage of New England HUC10 basins hosting MORE extant total rare species (state-rare and globally rare combined)/square mile</td><td>9.4%</td><td>4.6%</td></tr>
<tr><td>Percentage of New England HUC10 basins hosting FEWER extant rare species (state-rare and globally rare combined)/square mile</td><td>90.6%</td><td>95.4%</td></tr>
</table>

To summarize the data presented in Tables 4 and 5, the Eightmile River watershed, as defined for this report, ranks among the New England regional (HUC10) and subregional (HUC12) basins with the highest concentrations of extant rare species, regardless of the several ways in which the comparison may be made. When the Eightmile watershed is ranked among the 417 New England HUC10 basins in terms of number of extant rare species per unit basin area, it ranks in the 96th percentile in terms of extant total rare species/unit basin area, and in the 99th percentile, in terms of extant globally rare species/unit basin area. In an alternative comparison of basins more similar in terms of area, the two component HUC12 basins comprising the Eightmile watershed have been ranked among the 1,931 New England HUC12 basins, in terms of extant rare species/basin. The Eightmile [main stem] basin is exceeded by only 2.7% of New England basins in terms of total extant rare species/basin, and is exceeded by only 0.8% of New England HUC12 basins, in terms of extant globally rare species/basin. The East Branch Eightmile basin is exceeded by 19.2% of New England HUC12 basins, in terms of total rare species per basin, and by 37.4% of New England HUC12 basins, in terms of extant globally rare species per basin.

The evident difference between the rare species richness of Eightmile [main stem] HUC12 basin and the East Branch Eightmile HUC12 basin is in part real, due to the several ecological systems present in the former and not in the latter. However, in part it is an artifact of the much smaller size of the East Branch basin (22.5 mi^2), compared with the Eightmile main stem (39.9 mi^2), the majority of New England HUC12 basins (median size = 31 mi^2). If the one attempts to neutralize the effect of area disparity by using *density* of rare species, the East Branch HUC12 basin ranks in the 90th percentile of New England HUC12 basins, in terms of extant globally rare species/unit basin area, and in the 89th percentile of New England HUC12 basins, in terms of total extant rare species/unit basin area.

Eightmile River watershed in a Connecticut context

In a state context, the biodiversity significance of the Eightmile watershed may be directly compared to the other regional drainage basins, using the CT-DEP organizational scheme, wherein the Eightmile watershed is defined as Regional basin No. 48. In this section, the Eightmile watershed is ranked against other Connecticut regional basins in terms of numbers of globally rare species and numbers of total rare species (i.e., state-rare plus globally rare species). A tally of extant globally rare species for each Connecticut regional drainage basin is presented in Table 6. Extant globally rare species are defined in the same way as in the previous section. Tallies were provided by the CT-DEP-NDDB in May 2005, and thus are more current, by almost one year, than the data used to generate the Natureserve New England tallies in the previous section

Table 6. Comparison of the Eightmile watershed to other Connecticut regional basins, in terms of number of extant1 globally rare and State-rare2 species per basin (regional basins listed in order of highest to lowest density of globally rare species per basin).

CT Regional Basin No.	CT Regional Basin	CT Area (sq mi)	No. of Extant Globally Rare Species	Density extant globally rare species (no. spp./mi2 of basin)	No. of total extant rare species (globally and State-rare combined)	Density total extant rare species (no. spp./mi2 of basin)
n/a	Long Island Sound	n/a	5	n/a		
11	Wood	10.2	2	0.1961	10	0.9851
63	Tenmile	35.7	4	0.1120	53	1.4843
62	Hollenbeck	42.9	4	0.0932	84	1.9580
61	Blackberry	34.4	3	0.0872	56	1.6279
48	Eightmile	62.4	5	0.0801	49	0.7853
41	Stony Brook	35.7	2	0.0560	15	0.4200
36	Pachaug	61.6	3	0.0487	36	0.5843
20	Southeast Shoreline	42.8	2	0.0467	41	0.9887
35	Moosup	48.6	2	0.0412	10	0.2056
34	Fivemile	51.9	2	0.0385	11	0.2119
50	South Central Shoreline	58.5	2	0.0342	36	0.6262
60	Housatonic Main Stem	402.3	13	0.0323	168	0.4176
38	Shetucket	124.9	4	0.0320	20	0.1601
40	Connecticut Main Stem	387.6	12	0.0310	130	0.3354
53	South Central Western Complex	104.8	3	0.0286	32	0.3053
32	Natchaug	175.4	5	0.0285	33	0.1882
66	Still	70.7	2	0.0283	38	0.5373

Table 6. Comparison of the Eightmile watershed to other Connecticut regional basins, in terms of number of extant1 globally rare and State-rare2 species per basin (regional basins listed in order of highest to lowest density of globally rare species per basin).

CT Regional Basin No.	CT Regional Basin	CT Area (sq mi)	No. of Extant Globally Rare Species	Density extant globally rare species (no. spp./mi2 of basin)	No. of total extant rare species (globally and State-rare combined)	Density total extant rare species (no. spp./mi2 of basin)
52	Quinnipiac	165.5	4	0.0242	61	0.3685
70	Southwest Shoreline	41.4	1	0.0242	27	0.7211
72	Saugatuck	89.5	2	0.0223	34	0.3800
47	Salmon	149	3	0.0201	28	0.1879
73	Norwalk	58.3	1	0.0172	10	0.1717
51	South Central Eastern Complex	182.7	3	0.0164	74	0.4050
31	Willimantic	219.1	3	0.0137	24	0.1095
42	Scantic	83.2	1	0.0120	10	0.1203
37	Quinebaug	256.3	3	0.0117	25	0.0975
43	Farmington	451	5	0.0111	109	0.2417
71	Southwest Eastern	98.6	1	0.0101	32	0.3245
30	Thames Main Stem	107.7	1	0.0093	22	0.2045
69	Naugatuck	311.2	1	0.0032	36	0.1157
65	Aspetuck	50.7	0	0.0000	5	0.0985
64	Candlewood	39.0	0	0.0000	7	0.1794
81	Croton	21.1	0	0.0000	5	0.2374
33	French	17.1	0	0.0000	1	0.0586
45	Hockanum	77.1	0	0.0000	12	0.1556

Table 6. Comparison of the Eightmile watershed to other Connecticut regional basins, in terms of number of extant1 globally rare and State-rare2 species per basin (regional basins listed in order of highest to lowest density of globally rare species per basin).

CT Regional Basin No.	CT Regional Basin	CT Area (sq mi)	No. of Extant Globally Rare Species	Density extant globally rare species (no. spp./mi2 of basin)	No. of total extant rare species (globally and State-rare combined)	Density total extant rare species (no. spp./mi2 of basin)
46	Mattabesset	108.9	0	0.0000	38	0.3489
44	Park	77.2	0	0.0000	8	0.1036
10	Pawcatuck Main Stem	47.0	0	0.0000	17	0.3617
68	Pomperaug	89.0	0	0.0000	32	0.3596
67	Shepaug	155.4	0	0.0000	40	0.2573
21	Southeast Eastern Complex	62.4	0	0.0000	27	0.4328
22	Southeast Western Complex	58.2	0	0.0000	11	0.1891
74	Southwest Western Complex	104.3	0	0.0000	13	0.1246
39	Yantic	97.8	0	0.0000	1	0.0102
	Mean	112.9	2.3	0.0275	34.8	0.4133
	Median	77.2	2.0	0.0168	27.5	0.2813
	Maximum	451	13	0.1961	168	1.9580
	Minimum	10.2	0	0.0000	1	0.0102

Source: CT-DEP-NDDB June 2005

1”extant” here means that species has been documented in the basin within the last 25 years, and it is not known to have been extirpated since the last observation

2for this analysis, “State-rare” species are defined as all species listed pursuant to Connecticut’s Endangered Species Act (i.e., “State-listed”), plus any species that are not State-listed that have S-ranks of S2S3 or rarer

The data presented in Table 6 shows that the Eightmile watershed, which hosts populations of five globally rare species, ranks in the top 6 of the 44 regional basins in Connecticut, in terms of number of extant globally rare species per basin. Only two regional basins exceed the Eightmile in the number of extant globally rare species/basin, while four basins have the same number. A straight comparison of species tallies of regional basins in Connecticut means comparing geographic entities of very different area, and such comparisons are potentially biased in favor of the entities with larger area, independent of the biodiversity values of the entities. Thus, a more informative comparison may be that of <u>density</u> of globally rare species per basin. In terms of number of extant globally rare species per unit area of basin, the Eightmile watershed ($0.0801/mi^2$) ranks 5^{th} among the 44 Connecticut regional watersheds. In terms of total extant rare species (globally rare plus State-rare species) per unit area of watershed, the Eightmile watershed ranks 6^{th} in Connecticut. The five watersheds with with higher rare plant densities are all watershes with the highest rare species densities in New England.

V. NATURAL COMMUNITIES

Significant natural community occurrences.

Approximately 100 occurrences of natural communities in the watershed have been identified by the author as "significant" and documented by this survey (summarized in Table 7). Communities were deemed significant on the basis of rarity, uncommonness or restricted occurrence (factoring in threats, and rate and magnitude of decline over last century), high native-species-richness (often including multiple rare and uncommon plant species), and/or exemplary character and/or condition (i.e., especially, low relative prominence of exotic and/or invasive species). Each natural community occurrence was assigned a biodiversity significance rank on a scale of 1 (Very High) to 4 (Moderate) or 5 (Exemplary*) or 6 (Arguable). The following is a breakdown of the 100 natural communities by biodiversity rank:

1. Very High 7 occurrences
2. High 11 occurrences
3. Moderate-High 10 occurrences
4. Moderate 34 occurrences
5. Exemplary* 18 occurrences
6. Arguable 20 occurrences

In the context of global biodiversity, the site of highest recognized significance in the Eightmile River watershed is the concentration of rare entities in the freshwater tidal upper reaches of Hamburg Cove. Three elements of recognized global rarity occur together there: the Freshwater Intertidal Flats/ Parker's Pipewort – Dotted Smartweed (*Eriocaulon parkeri – Polygonum punctatum*) community [Global rank: G2], *Bidens eatonii* [G2], and *Eriocaulon parkeri* [G3]. These entities co-occur near the head-of-tide in close association with nine other State- and/or New England-regional rare plants and several other uncommon/restricted/suspected rare plants, most of which occur in or adjacent to several types of freshwater tidal marsh and wet meadow communities (which may also turn out to be globally rare communities). Consequently, this site

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***** the "Exemplary" rank is applied to high quality occurrences of common types of native communities, and/or to examples of common communities that are in uncommon or rare condition (e.g., a common forest type in old-growth condition), that do not or are deemed unlikely to provide critical habitat for rare plants.

hosts the most intensive concentration (11 species) of extant State-listed plants known in the watershed.

Three other sites in the watershed may have global significance owing to the presence of *potentially* globally rare natural communities: Norwich Pond, Uncas Pond, and Cedar Lake. Occurring at Norwich and Uncas Ponds are the [sandy] Acidic Pond Shore/Seven-angle Pipewort – Dortmann's Cardinalflower (*Eriocaulon aquaticum – Lobelia dortmanna*) Intermittently Exposed Forb Vegetation (global rank: G?). It is suspected that this community may be a global rarity (depending on the outcome of more range-wide inventory and classification work). Additionally, Uncas Pond hosts the second highest concentration of multiple State-listed plants in the watershed (5 species, including one New England regional rarity).

Cedar Lake hosts what the author suspects may be a globally rare community that occupies a floating peat flat that occurs along the pond shoreline where it is adjacent to shrub-swamp and Atlantic White Cedar basin swamp. This community is apparently not yet represented in International Vegetation Classification (Grossman et al. 1998), but based on its strong floristic similarity to the above-mentioned sandy pond shore community (Grank: G?) at Uncas Pond, may likewise be suspected to be a globally rare community. This community supports very robust populations of 3 of the same State-listed rare plant species that occur at Uncas Pond, including one regionally rare species, and the author strongly suspects that additional survey at this site would reveal more rare plants.

Figure 13. Freshwater intertidal sand and gravel flat supporting the globally rare (G2) Parker's pipewort – Dotted smartweed (*Eriocaulon parkeri – Polygonum punctatum*) community. The two globally rare plants *Eriocaulon parkeri* (Parker's Pipewort) [the plant with the star-like habit and small round white flowers] and *Bidens eatonii* (Eaton's Begger-tick) [the plant appearing to have toothed leaves in whorls of four, in the right half and near the bottom of the picture] grow together in this community.

In a New England regional biodiversity context, several other sites in the Eightmile River watershed have special prominence: two sections of the electrical transmission right-of-way Lyme; the meta-occurrence of meadow habitats in the vicinity of Salem Four Corners; the Pleasant Valley Preserve, in Lyme; and the meta-occurrence of acidic cliff habitat in the vicinity of Devil's Hopyard State Park, in East Haddam. All of these sites host one or more regional stronghold populations of New England-regionally rare plant species (the first three sites each host at least 3-4 State-listed species each), in association with natural communities of conservation significance, at least in a state context.

Among the potentially most important biodiversity features of Eightmile River watershed is the extensive meta-occurrence of so-called "warm-season" grasslands, which include, more frequently, little bluestem (*Schizachyrium scoparium*)- and/or *Carex pensylvanica*-dominated grasslands, and, less frequently, big bluestem (*Andropogon gerardii*)-dominated "prairies". These dry to seasonally wet/dry grasslands, which require periodic anthropogenic disturbance (fire or mowing) to persist as open-canopy communities, represent among other things an important reservoir of native genotypes of grass species whose seeds of non-local origin are purchased and planted at considerable expense by land managers in efforts to create warm-season grassland habitat by around New England. There appears to be a strong correlation between the occurrence and prominence of the tall-grass prairie species (i.e., *Andropogon gerardii*, *Sorghastrum nutans*, *Tridens flavus*, etc.) and the occurrence of rare and uncommon herbaceous species, and a similar, but somewhat weaker, correlation between Little Bluestem-(*Schizachyrium scoparium*)-dominated grasslands and the occurrence of rare and uncommon herbaceous species.

Figure 14. Sevenangle pipewort – Dortmann's cardinalflower (*Eriocaulon aquaticum – Lobelia dortmanna*) Intermittently Exposed Forb Vegetation (global rank : G?), along shoreline of Uncas Pond.

Table 7. Summary of significant natural communities documented to-date in the Eightmile River watershed.				
Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Freshwater Intertidal Flats	2	1-2	Recognized globally rare (G2) vegetation alliance	Actual (including 2 globally rare species [G2, G3]) and potential
Freshwater Tidal Marsh	3	1-4	Uncommon/restricted to rare community (one or more may be globally rare)	Actual (including 1 globally rare species [G2]) and potential
Dry rich cedar-dogwood forb/Carex pensylvanica savannas	1 meta-occurrence	1	Rare or uncommon community; host concentrations of rare and uncommon plants with robust populations	Actual and potential
Floating seasonally flooded peat flat community	1 meta-occurrence	1	Rare (possibly globally rare) community; hosts multiple rare plants with robust populations	Actual and potential
Acidic Pond Shore community	2	1	Rare (possibly globally rare) community; hosts multiple rare plants with robust populations	Actual and potential
Fresh-spring-tidal wet meadow/acidic, sandy seasonally saturated meadow	1	1	Rare (possibly globally rare) community; hosts two regionally rare plants and several uncommon species	Actual
Big Bluestem prairies	3	2	Uncommon or rare community	Actual and Potential

Table 7. Summary of significant natural communities documented to-date in the Eightmile River watershed.				
Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Sandy, acidic, seasonally saturated and/or inundated meadows	7	2-4	Rare or uncommon community, threatened without management	Potential
Wet meadows and scrubby seasonally wet meadows of Thick Till landscape in Salem	2	2	High native plant diversity including multiple rare and uncommon species; rarity?	Actual
Sand barrens, dry grasslands, dry acid cedar savannas, and acid oak woodlands	34	2-6	Uncommon community, at least as large meta-occurrence, threatened without management	Actual and potential (global rarities among potentials)
Medium and Poor Fens	6	3-6	Rare or uncommon community	Actual and potential
Ice talus forest	1	3	Rare or uncommon community	Potential
Acidic cliffs	1 large meta-occurrence	3	Exemplary meta-occurrence	Actual and potential
Open and semi-open Acidic Rocky Summit/Outcrop communities	2	3-4	Rare or uncommon community	Potential
Acidic Atlantic White Cedar Basin Swamp	1	4	Uncommon/restricted community	Actual and potential
Acidic Spring Fen	3	4	Uncommon/restricted community	Potential
Subacidic Rocky Summit/Outcrop communities	1	4	Rare or uncommon community	Potential (global rarities among potentials)
Dry Subacidic Forests	4	3-4	Rare or uncommon community	Actual and potential (global rarities among potentials)

Table 7. Summary of significant natural communities documented to-date in the Eightmile River watershed.				
Natural Community/Natural Community group/other designation	No. Occur-rences	Biodiversity Significance Rank[s] (1=highest, 6 lowest)	Rationale for Assigning Significance	Rare Plant Habitat (Actual/Potential/Negligible)
Old-age ravine hemlock forest	1	5	Exemplary	Probably negligible
Mature swamp white oak forest swamp	1	5	Arguably exemplary (large, with many large oaks)	Potential
Vernal pool communities and related draw-down swamp forests and woodlands	9	5	Exemplary	Potential for some, negligible in others
Basin Marsh	2	5	Exemplary	Potential
Riverside Seep/Riverbank Beach/Shore Community	1 meta-occurrence	5	Exemplary	Potential
Acidic Seepage Forests and Swamps	3	5-6	Exemplary	Potential
Assorted other common types of wet/seasonally wet meadows, fens, marshes and shrub swamps	7	5-6	Exemplary	Actual and potential
Acer-Fraxinus-Hepatica forests	2	2-4	Host rare and uncommon plants; may be uncommon or rare community	Actual and potential

VI. ANADROMOUS AND RESIDENT FISH

Fish Species of Special Conservation Concern

The Eightmile watershed hosts at least 7 fish species that have been identified as being of special conservation concern/significance (see Table 2). These include one State-listed species, *Enneacanthus obesus* Banded Sunfish (State-Special Concern; G5S3), which was documented for the first time in the watershed by a survey in the late 1990s, at one of the impoundments along the Eightmile River (CT-DEP-NDDB 2004; Gephardt, pers. comm.). The University of Massachusetts' Northeast Instream Habitat Program (NEIHP) conducted a summer 2004 survey of Eightmile River and it's tributaries for fish and mussels, which was restricted to lotic habitats (i.e., not including impoundments). This survey documented the presence of 3 anadromous fish species that the Connecticut Comprehensive Wildlife Conservation Strategy (CWCS) has identified as "Most Important" or "Very Important": *Anguilla rostrata* American Eel (Most Important), *Salmo salar* Atlantic Salmon (Very Important), and *Petromyzon marinus* Sea Lamprey (Very Important). In addition, the NEIHP survey documented the presence of 3 resident fish species listed in the CWCS as "Very Important": *Esox niger* Chain Pickerel, *Erimyzon oblongus* Creek Chubsucker, *Esox americanus* Redfin Pickerel. Finally, "wild" (i.e., not introduced from hatchery stock) *Salvelinus fontinalis* Brook Trout (CWCS: "Most Important"), is suspected to occur in the Eightmile River (Bingham 2005) and/or its tributaries (Walden and Parasiewicz 2004; Bingham 2005), but this has not yet been confirmed.

Figure 15. Chapman's Falls, at Devil's Hopyard State Park: this is the natural limit to upstream fish movement in the Eightmile River [mainstem].

Diadromous Fish of the Eightmile watershed

Three diadromous (i.e. migrating between freshwater and saltwater) fish species were detected in the Eightmile watershed by the 2004 NEIHP fish survey, and an additional five diadromous species have been documented by historic surveys (researched and compiled by NEIHP). These include anadromous species (which live most of their lives in saltwater, but return to freshwater to spawn), a catadromous species (living most of its life in freshwater, returning to saltwater to spawn), and amphidromous species (migrating between salt- and freshwater for purposes other than to spawn, such as to feed).

The 2004 NEIHP survey documented the presence of juvenile Atlantic Salmon (*Salmo salar*), an anadromous species, at most sampling sites in the Eightmile River [main stem] as far upstream as Chapman's Falls, which is a natural and historic limit to upstream movement of anadromous fish returning upstream to spawn. In the East Branch Eightmile River, Atlantic Salmon were detected at all sample sites downstream of, and none above, Hales Pond, where the pond dam is currently a barrier to upstream movement (this dam is scheduled to be removed in 2005). The juvenile salmon detected by the NEIHP survey were almost certainly fish that have been released as fingerlings into the Eightmile, as part of the Atlantic Salmon restoration program that has been underway in Connecticut for several years. The restoration program has used for stocking salmon native to several rivers in Maine, our native Connecticut stock having been extirpated by the 1800s. Though there have been some reports of adult salmon (30+ inches) in the Eightmile watershed streams, no returns of adult salmon have been substantiated. However, confirmation of adult returns to the Eightmile watershed may be expected lag behind the first occurrence, since there are no monitoring traps installed on the Eightmile, as there are on the other two rivers (Salmon River and Farmington River) in which salmon restoration is being attempted (Gephart pers. comm.).

American Eel (*Anguilla rostrata*), our only catadromous species, was detected at all sample sites on the Eightmile River and its tributaries, including those upstream of Chapman's Falls and Hales Pond.

The anadromous Sea Lamprey (*Petromyzon marinus*) was detected by the NEIHP survey at one sample site on the Eightmile River [main stem].

The five additional diadromous species documented by historic surveys are the amphidromous or anadromous White Perch (*Morone Americana*) and Striped Bass (*Morone saxatilis*), and the anadromous Blueback herring, Alewife (*Alosa pseudoharengus*), and State-Threatened Rainbow Smelt (*Osmerus mordax*). All of these species except the last were detected in Hamburg Cove during recent (1989, 1990, and/or 2003) CT-DEP surveys, but there is apparently no evidence of their presence, historic or current, upstream of the Cove (Walden and Parasiewicz 2005). The Rainbow Smelt records are from 1942 and 1959 publications; it is not clear if the record locations were definitely in Hamburg Cove, or from the Connecticut River close to the mouth of the Cove (Walden and Parasiewicz 2005; Whitworth et al. 1968).

Regarding the above-listed diadramous fish, the importance of Hamburg Cove, as a White Perch fishery and a staging area for their fall migration, has been emphasized by the CT-DEP. In the fall, White Perch crowd into Hamburg Cove to feed in very large numbers, as they migrate up the Connecticut River. White Perch is a relatively abundant native fish in Connecticut, and thus has not been flagged by agencies or conservation entities as a species of special conservation concern, but the numbers supported by Hamburg Cove are considered exemplary and a bulwark of the currently healthy state population (Gephart pers. comm.)

VII. River/Watershed Ecosystem Quality: Indicators of an Exemplary and Unique, Intact and Functioning Watershed Ecosystem

Biological Indicators

Cerulean warbler

This forest-interior warbler is the most area-sensitive North American bird species (Askins pers. comm.). The Eightmile River watershed, which comprises the greater part of a localized southern New England concentration area for this species, has a relatively high proportion of large, unfragmented blocks of forested habitat. The Eightmile watershed appears to have the largest blocks of Appalachian-affinity forests that still exist this far south in New England (i.e., similarly large forested blocks farther to the southeast in Connecticut and southwestern RI, support either lower Cerulean densities or no Ceruleans, and are Coastal Plain forests of different types (Askins pers. comm.). The robust Cerulean Wabler populations in and about the Eightmile watershed are an indication that the Eightmile River watershed has a unique combination of forest size, type, and geographic position.

Spotted Salamander

Based on the author's field observations and reports of others, the Spotted Salamander is evidently abundant throughout all or much of the watershed. This is an indication of an abundance of functioning vernal pool breeding habitat, and especially of an abundance of functioning forested foraging habitat for adults (Gruner pers. comm.).

Wood Frog

Based on the author's field observations and reports of others, the Wood Frog is very abundant throughout all or most of the watershed. Research elsewhere in Connecticut has shown that this vernal-pool-dependent amphibian is sensitive to fragmentation of upland habitat blocks surrounding its vernal pool breeding sites (Klemens 2000). The robust population in the Eightmile watershed is an indication that such fragmentation has not occurred in the watershed.

Stream Macrobenthos

Assemblages of benthic macroinvertebrates have been sampled and monitored by the CT-DEP in many streams across Connecticut for more than 25 years. As part of this statewide biomonitoring program, macroinvertebrate data was collected for the Eightmile River [mainstem] and East Branch Eightmile River in 1998 and 1999. Macroinvertebrate community structures in these streams indicated that the Eightmile River [mainstem] was "un-impaired", while the East Branch was "slightly impaired", compared to a nearby "reference" stream (i.e., a site selected because it is believed to represent essentially pristine conditions). The CT-DEP concluded that the Eightmile River [mainstem] could itself be used as a reference stream, while the East Branch Eighmile River ranks in the upper half of sampling sites statewide (Beauchene 2003).

Umbrella Species

Cerulean warbler

The term "umbrella species" has been applied to species whose habitat requirements are such that they may be considered surrogates for the ecosystem that they inhabit. In other words, if an ecosystem is managed in such a way that the "umbrella species" naturally prospers, then we may be confident that the rest of the ecosystem and the species associated with it have been secured as. Since the Cerulean Warbler is the species in the watershed most sensitive to forest fragmentation, it may be considered an umbrella species for this system. Management for its success will undoubtedly ensure the success of many other species in the watershed known or suspected to be sensitive to forest fragmentation.

Habitat Intactness

One indicator of habitat intactness is the ratio of cumulative road length per unit area of watershed. For this investigation, road miles per square mile of total watershed area (road mi/mi^2) in Connecticut has been calculated from GIS data available from CT-DEP-EGIC. Based on this data, the Eightmile watershed, with 2.65 road mi/mi^2, has the third lowest road mi/ mi^2 of the 44 regional watersheds in CT (range: 1.57 to 16.5 road mi/mi^2). The two watersheds in Connecticut that have fewer road mi/mi^2 than the Eightmile, the Hollenbeck and the Wood, are parts of systems that have the highest numbers of rare species in New England.

Another indicator of habitat intactness is the proportion of a watershed that is occupied by large roadless blocks. The Nature Conservancy has developed a GIS map of roadless blocks in Connecticut and neighboring portions of Massachusetts and Rhode Island. From this coverage, a breakdown was developed for the 44 regional watersheds in Connecticut wherein total areas were calculated in each watershed falling into different size ranges of roadless blocks (e.g., 0-50 ac, 50-100 ac, 100-250 ac, and so on up to 10,000+ ac). Based on this analysis, the Eightmile watershed ranks 2nd from the top in terms of percentage of watershed occupied by roadless blocks of 1000 ac or greater (72.2% for the Eightmile watershed). The only Connecticut regional watershed with a higher percentage occupied by roadless blocks ≥1000 ac is the Hollenbeck, in northwestern Connecticut.

The University of Connecticut Center for Land Use Education and Research (CLEAR) has developed several GIS land use coverages for Connecticut, using satellite imagery as recent as 2002. The CLEAR coverage potentially allows a comparison of the Eightmile watershed to the other regional watersheds in Connecticut, in terms of percentages of various broad habitat types (e.g., percentages of deciduous forest). However, there has been only very limited field verification/testing of the CLEAR data to-date (Wilson, pers comm.). During the generation of this report, the author developed a vegetation/habitat coverage for the Eightmile watershed, using a combination of low altitude aerial photo analysis, ground-truthing, and fixed-wing airplane reconnaissance. The habitat coverage developed for this investigation was developed independently of the CLEAR data, and was thus effectively a test of the accuracy of the CLEAR data, for the Eightmile watershed. Total areal percentages for certain important habitat/land cover units developed by the author for the Eightmile watershed have been compared to comparable units in the CLEAR coverage. For example, the percentage of total forested habitat derived from the author's work is 75.5%, which compares to 81% based on CLEAR data. The percentage of developed land in the watershed, based on the author's work, is 8.9%, which compares with 6.7% based on CLEAR data. These differences are smaller than differences derived from CLEAR data between the Eightmile watershed and most other regional watersheds. This supports using the CLEAR data to compare certain paramenters of the Eightmile watershed to other watersheds.

In Table 8, the Eightmile River watershed is compared to other regional watersheds in Connecticut, with respect to percent of each watershed occupied by developed area and forested area, based on the 2002 CLEAR GIS land cover data. Watersheds highlighted in blue are the other near-coastal watersheds in Connecticut (i.e., those the greater part of which are within the same distance from the coast as the Eightmile watershed). The regional watersheds are listed in order of increasing percentage of developed area. From Table 8, it is evident the Eightmile watershed, with 6.74% developed land, has a lower percentage of developed area than all except four of Connecticut's 44 regional watersheds, and a lower percentage of developed land than all 15 other near-coastal watersheds. For all except one of these other near-coastal watershed, this difference is greater than the above-mentioned difference between the author's habitat-map-derived developed area percentage and the CLEAR data for the Eightmile watershed. In terms of forested area, Table 8 shows that only two of Connecticut's 44 regional watersheds have a greater percentage of forested area than the Eightmile watershed. It exceeds all other near-coastal watersheds in percentage forested area, by 9 to 81 percentage points. In this case, all differences are greater than the disparity between the author's habitat-map-derived forested area percentage and the CLEAR data percentage.

Table 8. Comparison of Eightmile River watershed to other Connecticut regional drainage basins, in terms of percentages of developed land and forested land, using University of Connecticut CLEAR data (other near-coastal watersheds are highlighted in blue).

Regional Drainage Basin/watershed (per CT-DEP hierarchy)	Total area of regional basin (sq mi)	Total sq mi covered by CLEAR	developed % of basin (covered by CLEAR 2002)	forested % of basin (covered by CLEAR 2002)	Total acres covered by CLEAR
Hollenbeck	42.896	42.896	3.54%	84.5%	27453.627
Wood	34.189	11.764	5.17%	81.3%	7528.926
Tenmile	206.506	64.756	5.50%	56.3%	41443.985
Blackberry	46.573	46.515	6.68%	73.8%	29769.284
Eightmile	62.400	62.400	6.74%	80.5%	39935.721
Shepaug	155.438	155.438	7.71%	69.0%	99480.487
Pachaug	63.009	63.007	8.68%	71.6%	40324.610
Natchaug	175.840	175.840	8.91%	76.1%	112537.420
Aspetuck	50.740	50.740	8.93%	69.0%	32473.600
Fivemile	76.386	76.372	9.24%	75.0%	48878.329
Moosup	71.414	58.570	9.63%	73.6%	37484.848
Shetucket	124.957	124.957	10.20%	68.2%	79972.222
Quinebaug	398.538	398.538	10.34%	67.8%	255064.509
Yantic	97.809	97.809	10.84%	62.2%	62597.567
Pomperaug	88.999	88.999	11.37%	62.5%	56959.596
Willimantic	225.494	225.494	11.43%	72.1%	144315.886
Scantic	113.743	113.635	11.91%	52.6%	72726.584
Stony Brook	44.597	44.558	12.49%	42.7%	28516.988
Salmon	148.983	148.983	12.83%	70.6%	95349.174
Croton	95.043	44.923	13.64%	65.7%	28750.459
Farmington	607.173	478.437	13.95%	69.0%	306199.495
Candlewood	40.517	40.486	14.10%	56.0%	25910.927
Pawcatuck Main Stem	81.616	61.038	14.35%	62.8%	39064.279
Housatonic Main Stem	689.167	417.973	14.40%	65.1%	267502.525
Southeast Eastern Complex	62.404	62.404	15.27%	63.4%	39938.705
Southeast Western Complex	58.204	58.204	16.19%	63.2%	37250.459

Table 8. Comparison of Eightmile River watershed to other Connecticut regional drainage basins, in terms of percentages of developed land and forested land, using University of Connecticut CLEAR data (other near-coastal watersheds are highlighted in blue).

Regional Drainage Basin/watershed (per CT-DEP hierarchy)	Total area of regional basin (sq mi)	Total sq mi covered by CLEAR	developed % of basin (covered by CLEAR 2002)	forested % of basin (covered by CLEAR 2002)	Total acres covered by CLEAR
French	112.079	112.076	16.59%	61.0%	71728.880
Saugatuck	89.479	89.479	17.42%	67.7%	57266.299
South Central Eastern Complex	182.742	182.742	17.45%	65.1%	116954.775
Thames Main Stem	107.697	107.697	19.88%	60.4%	68926.309
Naugatuck	311.166	311.166	21.23%	61.1%	199146.006
Connecticut Main Stem	423.747	401.482	22.67%	48.4%	256948.577
Mattabesset	108.920	108.920	25.13%	44.0%	69708.907
Southeast Shoreline	42.788	42.788	28.53%	46.3%	27384.068
Southwest Western Complex	157.467	157.215	30.02%	44.3%	100617.769
Still	71.337	71.313	31.36%	46.9%	45640.496
Norwalk	62.407	62.407	31.62%	51.8%	39940.312
Hockanum	77.131	77.131	32.90%	42.3%	49364.096
South Central Western Complex	105.066	105.066	33.03%	45.5%	67241.965
Quinnipiac	165.548	165.548	34.48%	37.5%	105950.872
Southwest Eastern	98.619	98.619	42.48%	34.7%	63116.391
Park	77.221	77.221	46.38%	27.8%	49421.488
South Central Shoreline	58.978	58.978	48.75%	23.9%	37746.097
Southwest Shoreline	41.412	41.402	63.91%	9.4%	26497.245

Naturally functioning hydrologic system. One over-arching component of a functioning watershed ecosystem is a naturally functioning hydrologic cycle. Un-natural perturbations of a watershed's hydrology include dams, water diversions, stream channel encroachment and channelization, point source and non-point source discharges, and many other human actions. The Eightmile River watershed has determined to have an essentially natural intact flow, few and minor impediments, and a single known consumptive water diversion, the impact of which is considered insignificant (CT DEP diversion permit DIV 97-20). In the Eightmile watershed, there is a low cumulative percentage of impervious surfaces (2.97%), a low percentage of developed area (8.9%), and a high percentage of forested land (75.5%). These values for these parameters are in the ranges that are correlated empirically with high ground and surface water quality. Available chemical and biotic data indicate that surface water quality is high in streams in the watershed. Biotic data collected by the CT-DEP 1998-1999 indicate "exemplary ecological conditions" for the Eightmile River [mainstem] and very good conditions for the East Branch Eightmile River (Beauchene 2003). In the context of Connecticut, and especially in the context of coastal Connecticut, a high percentage of the watershed, 75.5%, is forested. This is doubtless the primary reason for the high surface water quality and high ecological integrity of these rivers.

Presence of large unfragmented forest blocks. The high percentage of forested habitat in the Eightmile River (75.5%) is comparable in Connecticut only to watersheds in the northwest corner of Connecticut and the southeast border of Connecticut with Rhode Island, both areas that are recognized as having the highest known biodiversity in New England (as indicated by these areas having the highest numbers of extant rare species in New England [NatureServe 2004]). Similarly, in a Connecticut context, a low percentage of Eightmile watershed is developed (8.8%), and it has a low density of roads (2.65 road mi/mi^2), and percentage of watershed occupied by large roadless blocks (72% occupied by roadless blocks greater than 1000 ac). All three parameters are strong indicators of the level of habitat connectivity and intactness, and the Eightmile watersheds values are in Connecticut comparable to, and exceeded only by, watersheds in the two areas of highest biodiversity in New England.

A large portion of the Eightmile watershed's forested portion occurs as large, unfragmented blocks (e.g., 33% in blocks greater than 1000 ac, 17% in blocks greater than 500 ac). The Eightmile watershed also comprises the greatest part of a major New England concentration of the Cerulean Warbler, a forest interior species that is considered to be the most area-sensitive bird in North America, and which is experiencing a rapid rangewide decline. The high densities of the Cerulean Warbler centered in the Eightmile watershed are attributed to the combination of the Eightmile watershed's near-coastal position (and therefore warmer climate), its high proportion of large forest blocks, and the type and maturity of its forests. The Cerulean Warbler, besides being identified by multiple conservation organizations as a continental conservation priority, is both an indicator species and an umbrella species in the Eightmile watershed ecosystem. Its high densities indicate that the system has adequate resources, in this case forest blocks of adequate quantity and quality, to support a species with high sensitivity to both parameters. The Cerulean Warbler is an umbrella species in this system, because if habitat quality is such that there are high densities of Cerulean Warblers, we can expect that a large number of other area-sensitive forest species should thrive as well.

Relatively high proportion of watershed protected as conservation land. As of May 2005, based on research done by The Nature Conservancy, approximately 11,000 acres, or ~28%, of the Eightmile River watershed was protected by conservation ownership or easement (Geisler and Frohling 2005). The largest portion of this protected portion (nearly ¾) is CT-DEP-owned State Forest, State Park, and other types of conservation land. The remainder (~¼) of protected parcels is owned, or easements held, by such entities as The Nature Conservancy, local land trusts, and towns (Geisler and Frohling 2005). Existing state-wide data does not allow a precise or up-to-date comparison of the Eightmile River watershed to other regional watersheds in the state, but available data suggests that the Eightmile watershed ranks very high. Digital GIS data, available from CT-DEP-EGIC, provides a coverage of parcels classified as "open space", which includes such entities as golf courses, campgrounds, and schools, and is 10 years or more out of date, especially with respect to conservation acquisitions by non-governmental organizations. Based on this coverage, 21% of the Eightmile River watershed is open space, and in this percentage is exceeded by only 4 of the 44 Connecticut regional watersheds (these being the Hollenbeck, Pachaug, Wood, and Natchaug). Another comparison, which may reasonably be said to be in a southern New England regional context, is possible using state-wide Massachusetts GIS data that was last updated in February 2006 (MassGIS 2006), and strictly represents permanently protected open space parcels (i.e., the same kind of entities that comprise the 28% figure for the Eightmile watershed). Using the Massachusetts data, the author calculated percentages for the 27 so-called "major drainage basins" in Massachusetts (MassGIS 2003). Percentages of permanently protected open space in the major Massachusetts drainage basins range from 6.4% to 33.4%, with the median being 18.8%. In this comparison, the Eightmile River watershed's 28% represents a relatively high percentage of protected land, compared with most watersheds.

Permanent protection of a relatively large portion of the Eightmile River watershed secures the sustainability of a significant portion of the existing ecological and biodiversity values that have been identified in the watershed. In addition, there exists a great deal of undeveloped open space with high natural value that may still be protected. For example, protected parcels in the Eightmile watershed have to-date "captured" only about 36% of the total acreage (~17,400 ac) of forest that occurs in large unbroken blocks (i.e., greater than 300 ac).

Nutrient cycling. Excessive leaching of nutrients in terrestrial ecosystems and excessive loading of nutrients in aquatic ecosystems are widely accepted as among the indicators of "ecosystem disease", and intact, well functioning nutrient cycling processes are essential to preventing these types of disfunction and maintaining ecosystem health (Gallicott et al. 1999). The conditions of nutrient cycling processes are difficult to measure directly for an area the size of the Eightmile River watershed, but surface water quality is a strong indicator of well-functioning nutrient cycling processes in an ecosystem. The author has not been able to find stream water chemistry data more recent than several decades old, but recent (1998-2003) bio-assays of water quality, using sampling and analysis of benthic macro-invertebrate communities, have been conducted in the Eightmile River [mainstem], East Branch Eightmile River, their two largest tributaries, Beaver Brook and Harris Brook, and two lesser tributaries, Burnham Brook and Pleasant Valley Brook. Benthic macro-invertebrate community parameters are widely used as indictors of nutrient enrichment in streams.

Macroinvertebrates in the Eightmile River [mainstem] and East Branch Eightmile River was sampled by professional biologists with the CT-DEP as recently as 1998 and 1999. These data indicated that the Eightmile River [mainstem] was “un-impaired”, while the East Branch was “slightly impaired”, compared to a nearby “reference” stream (i.e., a site selected because it is believed to represent essentially pristine conditions). The CT-DEP concluded that the Eightmile River [mainstem] could itself be used as a reference stream, while the East Branch Eighmile River ranks in the upper half of sampling sites statewide (Beauchene 2003).

The most recent macro-invertebrate data for the Eightmile River [mainstem] and East Branch Eightmile River was collected in 2001 and 2002 by trained non-professional Connecticut River Watch Program volunteers, and the program volunteers sampled the one major tributary to the East Branch Eightmile River (Harris Brook) and three tributaries (including the largest, Beaver Brook) to the Eightmile River [mainstem]. In these studies, volunteers assessed representation in macro-invertebrate samples of easily recognized invertebrate organisms that are least pollution-tolerant versus organisms that are more pollution-tolerant. The studies found good representation of the least pollution-tolerant organisms and low representation of the most pollution-tolerant organisms in all streams sampled, with the possible exception of Harris Brook. The studies concluded from these data the water quality was very good in all streams sampled, with the possible exception of Harris Brook. According to the study report, it is not clear whether this reflects actual lower water quality in Harris Brook or sampling error (Brawerman 2002; 2003; 2004).

Another important component of surface water quality in the watershed is that of lentic habitats. Water quality data sets exists for the three largest ponds/lakes in the watershed: Lake Hayward, Uncas Pond, and Norwich Pond. Lake Hayward has a highly developed shoreline, and its watershed is 25% developed (nearly all residential) and 56% forested. Uncas Pond and Norwich Pond both have lightly developed shorelines, mostly forested shorelines, and very lightly developed (3% and 2%, respectively) and highly forested (91% and 82%, respectively) watersheds (Moorhead vegetation/habitat map 2006). The most comprehensive water quality data on these lakes was collected in 1979-1980, and this study classified Lake Hayward and Norwich Pond as mesotrophic, and Uncas Pond as oligotrophic (Frink and Norvell 1984). Less comprehensive water quality surveys of all three waterbodies were conducted in the early 1990s, and based on these data all three waterbodies were classified as mesotrophic (Canavan and Siver 1995). There are unpublished water quality survey data sets for Lake Hayward in 2003 and 2005, and for Uncus Pond in 2006 (CT-DEP 2006). Though there are some problems in comparing the 1979-1980 data sets with the more recent data sets (not all parameters were measured in the same way in each survey), it may reasonably be concluded that water quality in the three lakes has remained stable between 1979-1980 and the present (Lee, pers. comm.; Wahle, pers. comm.). The apparent change of Uncas Pond from oligo- to mesotrophic is not real, because the pond would have been classified as mesotrophic, by modern standards, based on Frink and Norvell's actual data (Frink and Norvell 1984; Lee pers. comm., Wahle pers. comm.). Based on existing direct measurement data sets, there is no evidence of significant nutrient level increases in the three largest waterbodies in the watershed over the last 26 years. Consistent with this, there are associated with all three waterbodies robust occurrences of rare plant species and/or plant communities that occur only in low nutrient environments (Moorhead 2003).

These studies and observations demonstrate very good to excellent surface water quality throughout all, or at least most, of the watershed (see above discussions of Harris Brook and East Branch Eightmile River), and this is a strong indication of intact, well functioning nutrient cycling processes throughout all or most of the Eightmile watershed.

Level of impairment due to invasives species. One parameter often used to assess ecosystem integrity, function, and stress is the relative abundance of non-native and/or invasive species. Extensive displacement of native species by invasive species, and loss especially of the rarer, more sensitive native species are considered indicators of an impaired, stressed ecosystem. Regarding the relative importance of invasive species in the Eightmile watershed, inadequate scientific data precludes a rigorous comparison of this watershed to others, but in the opinion of many naturalists and scientists familiar with this region, the Eightmile watershed has relatively low levels of invasive species. This author's field observations (2003-2005) support this view, especially considering the vast acreage of dry to mesic, relatively acidic forest in the watershed, which is invasive-free or nearly so, and naturally inhospitable to all or most invasive plants. If one uses the presence/abundance of extant rare species as an indicator of ecosystem impairment due to invasives, the Eightmile watershed ecosystem's integrity appears rather high. The density of extant rare species in the Eightmile watershed (.08 spp./mi^2) is substantially higher than all other regional watersheds in Connecticut except for those in the northwest corner and along the Rhode Island border that have the highest numbers of extant rare species in New England. Thus, both subjective professional impressions and data on extant rare species indicate that the Eightmile watershed ecosystem is currently relatively unimpaired by invasives. However, a number of invasive plant species are established in the watershed, and a number of these are perceptibly increasing (See Table 9). They may be expected to increasing stress on at least certain elements of the Eightmile ecosystem. Among these in particular are the less common and rare habitats and species that occupy a relatively small portion of the watershed, but represent a large portion of the biodiversity.

Disturbance regimes. Among the many important intact natural disturbance regimes in the Eightmile watershed is the seasonal high flow-low flow cycle, overlaid by the lower frequency very high flows associated with catastrophic storms, of the larger streams in the system. In the opinion of CT-DEP Inland Fisheries biologist Peter Aarrestad, the Eightmile streams are relatively free of flood control structures, and the larger streams, especially, have relatively little bank stabilization. Thus, there exist in abundance along the streams various riparian communities that are maintained by and dependent upon periodic flooding and mechanical scouring, and natural changes in channel configuration. In Aarrestad's opinion, the Eightmile River system is exceptional in the extent to which riparian landowners have generally "allowed the river to misbehave", and this has led to an exceptionally natural system in which natural disturbance regimes are prevalent at a watershed scale (Aarrestad pers. comm.)

VIII. MANAGEMENT ISSUES

Large unfragmented Forest blocks and the Cerulean Warbler

Though it is not the rarest species known to occur in the Eightmile watershed, the Cerulean Warbler is the arguably the highest-profile management issue for the Eightmile watershed. The Eightmile watershed appears to have among the highest breeding-seeding densities of this bird in New England. It is perhaps the most area-sensitive of all North American birds, and is experiencing rapid range-wide decline. It has been listed as a species of high global conservation concern by several international bird conservation organizations. Research on Cerulean Warblers suggests that they require continuous forest blocks of at least 1000 ac if they are to maintain stable populations (Askins pers. comm.). As shown in Figure 8, the Eightmile River watershed has a number of unbroken forest blocks that exceed that size, but not by much. Maintenance of the watersheds robust Cerulean Warbler population likely depends on the successful preservation of these large forest blocks as intact.

Deer management

High densities of deer and consequent impacts on biodiversity have been well documented in at least one part of the Eightmile watershed (Goodwin 1991b; Kilpatrick pers. comm.), though the author is not aware of any systematic evaluation of the entire watershed. During the author's 2003-2005 rare plant and natural community survey work, he developed a subjective impression that levels of deer herbivory impacts vary widely throughout the watershed. In the Burnham Brook area, in particular, long term monitoring has documented the link between loss of plant species and high deer densities (Goodwin 1991b). Monitoring and control of deer densities in the watershed is essential to maintenance and enhancement of the watershed's biodiversity.

Biological and ecological inventory

This study has for the most part drawn on existing information on the occurrence and distribution of animal and plant species (including rare species) and natural communities in the Eightmile watershed. None of the studies that generated these data can be said to be comprehensive for the Eightmile watershed. The author's limited-scope 2003 survey for rare plants and natural communities resulted in the discoveries of a rather high number of previously unknown rare plant and natural community occurrences, and he continued to stumble upon new rare plant occurrences during 2004 and 2005 field work whose focus was not rare plant and natural community inventory. During the same period, a number of previously unknown occurrences of rare animals have been discovered by both professional and amateur scientists during various limited scope surveys and recreational activities. Such a high rate of discovery of new rare species populations strongly suggests that we are not yet approaching comprehensive knowledge of the Eightmile watershed's complement of rare species.

It is also true that relatively few of the known rare species and natural community occurrences in the Eightmile watershed have been judged to be secure and unthreatened, without some form of active protection and/or focused management. It is reasonable to expect that what is true for most of the known occurrences is also like true for the undiscovered occurrences. Continuing inventory is required if we are to approach comprehensive knowledge of Eightmile watershed's rarest and most vulnerable species, and thus be able to wisely allocate resources to manage them.

Minimally managed open and semi-open habitats

The majority of extant State-listed Endangered, Threatened, and Special Concern species of plants and animals known in the Eightmile watershed occur in, or are in some measure dependent on, non-forested open and semi-open habitats that with few exceptions cannot exist without certain some form of periodic disturbance by man that prevents development of closed-canopy forest and/or shrub thicket. Such habitats include former agricultural row-crop fields, hayfields, and pastures on various soil types, power line and highway rights-of-way, roadsides, old sand and gravel pits, forest clearings, and cemeteries, potentially (the author is unaware of rare species having yet been found in any cemeteries in the Eightmile watershed, but a number of other cemeteries in southeastern New England support State-, regionally, and globally rare plant species, and several of the Eightmile watershed's cemeteries support native-species-dominated grassland communities of high integrity). Rare species and natural community occurrences in these habitats are among the most imminently threatened elements of biodiversity in the Eightmile watershed. They are threatened both by a lack of protection and by a lack of management, or the wrong kind of management. The greatest number of these threatened elements are associated with glaciofluvial sand and gravel deposits that are either xeric or have a seasonally fluctuating water table. A lesser but significant number occur on so-called Thick Till (i.e., basal till) deposits.

There are a very large number of these minimally managed open and semi-open habitats in the Eightmile watershed, and only a small fraction were field- surveyed by the author during his 2003 rare plant and natural community survey. Additional survey is needed to identify those with the highest biodiversity values. For those that are already known to be of higher biodiversity significance, management needs and threats should be assessed within the next 5 years (in some cases, more urgency is required), resources allocated, and management actions begun.

A special and very significant case is the Northeast Utilities (NU) transmission right-of-way that transects the Eightmile watershed at about its “waist”. This right-of-way is both habitat for some of the rarest and significant species in the watershed, due to past ROW management practices that have maintained open-canopy conditions juxtaposed with certain bedrock formations and surficial deposit types. The ROW is also an area with some of the largest infestations of invasive species such as *Phragmites australis* subsp. *australis* and *Elaeagnus umbellata*. The ROW is subject to periodic ROW management practices, which include the use of herbicides and heavy equipment, whose purpose is to maintain electric power delivery infrastructure, rather than biodiversity values. These management actions in certain instances can be inferred to have clearly been beneficial to rare plant populations and habitats in ROWs, but in other instances have just as clearly been harmful. One of the latter instances occurred recently at one site in the Eightmile watershed, where in 2004 and 2005 a regional stronghold population of a regionally rare plant was impacted and may have been in largest part destroyed by a combination of management actions, involving both herbicide applications and earth-moving. This incident occurred in spite of an existing review process in which NU’s planned ROW maintenance actions state-wide are reviewed by CT-DEP and potential impacts to rare species populations already in the CT-DEP-NDDB’s database are identified and resolved. The obvious weakness in this system are that it involves no active *de novo* rare species survey by either NU or the CT-DEP-NDDB, and it thus affords no protection to rare species populations not yet databased by the CT-DEP-NDDB (both because the populations have not been found and reported to the state, and because recently found and reported populations require processing time).

Little scientific data is available from which to judge what proportion of NU’s ROW management actions have harmed versus benefited rare species populations. The author and other naturalists have in recent years observed numerous instances of at least short term impacts to known rare species populations and natural communities, throughout Connecticut. However, there is little if any adequate long-term monitoring data by which to judge long-term impacts, and especially whether short term impacts to populations are followed by recovery and perhaps expansion because of habitat enhancement caused by the management actions. In the absence of strong evidence to the contrary, however, it is at least a reasonable conclusion that the higher intensity and frequency of ROW management actions in recent years may result in more destruction of rare species populations than did the lower intensity maintenance practices of the 1970s and 1980s (Johnson pers. comm.).

In light of this, it is clear that the NU transmission ROW in the Eightmile watershed hosts multiple recently discovered populations of important rare species, and there has been at least one significant failure in the existing system by which the CT-DEP and NU resolved conflicts between ROW maintenance needs and protection of the rare species. Several reasons for this failing have been cited. According to NU, a heavy herbicide application by a vegetation management subcontractor that heavily impacted the herbaceous vegetation, including the rare plant, was not within NU's performance specifications for the work, and was the fault of subcontractor. In addition, NU was not informed of the existence of any rare species in the area (4 rare species occur in the area) during the review which occurred in advance of the herbicide treatment (this was likely due to the timing of the review in relation to the first reports CT-DEP-NDDB received on the 4 rare species populations – all were reported in early 2004, and the herbicide work was likely reviewed before they were reported or databased). After the herbiciding in 2004, a local naturalist contacted NU's vegetation management section and CT-DEP to alert them both to the impacts to the rare species. And finally, while coordination of the NU ROW vegetation management division with CT-DEP-NDDB was being practiced, the NU ROW *infrastructure* maintenance division was not, as of summer 2005, coordinating with CT-DEP-NDDB (Johnson pers. comm.). Significant avoidable impacts to rare plants and rare plant habitat occurred as a result of ROW infrastructure maintenance actions, such as service road widening and cut-and-fill.

Given the recently demonstrated biodiversity significance of the NU transmission ROW and the evident potential and actual impacts of ROW maintenance that may occur/have occurred in the absence of adequate coordination between NU, CT-DEP, and other stake-holders, one or more of the following actions are recommended. Existing information on known occurrences of rare species and natural communities in the ROW should be conveyed as soon as possible to NU and the CT-DEP-NDDB. The two most important reasons for the recent impacts to known rare species populations in the NU ROW are 1) the lag time between discovery of new populations and their being revealed to NU during their annual review process with CT-DEP-NDDB, and 2) absence of a system of review of proposed ROW infrastructure maintenance actions by the CT-DEP-NDDB. Obviously, this underscores the importance of reporting of rare species discoveries to the CT-DEP-NDDB as soon as possible, but given limitations of state government staff and time, the author suggests that there should also be a frequent direct dialogue between NU and local knowledgeable naturalists, consulting scientists, and others developing new information on rare species in the Eightmile watershed. Most importantly, however, NU should also recognize the necessity for, and take on the responsibility for, systematic rare species inventories in sections of ROW in which vegetation and infrastructure maintenance actions are planned, given the abundant evidence that there rare species occurrences in powerline ROWs not yet known to the CT-DEP-NDDB.

Obviously, the above measure would provide protection only to known populations of rare species, and to the author's knowledge only a relatively small proportion of the NU transmission ROW in the Eightmile watershed has been comprehensively surveyed for rare species. Given the need for on-going maintenance activities, the need for *de novo* inventory of the entire ROW within the Eightmile watershed as soon as possible is a critical first step to providing a reasonable high level of protection to the many of the most vulnerable elements of biodiversity on the watershed.

A review and assessment of current NU ROW maintenance practices, and maintenance contracting practices, should be initiated by a multidisciplinary panel of experts on rare species plant and animal groups. The committees charge should be determine if there are ways in which overall risk to rare species could be reduced by standard procedure (i.e., ways in which risks might be reduced by NU standard protocol, regardless of whether the rare species population is known). This process would culminate with a presentation of recommendations to NU, and NU should be invited to participate from the outset.

It has been recognized for some time that both purposes may be achieved, with certain modifications of practices (William Niering of nearby Connecticut College was among the first to effectively campaign for this, in the late 1950s and 1960s).

Inventory, Monitoring, and Control of Invasive Species.

A comprehensive inventory of invasive species in the Eightmile watershed has not yet been performed, to the author's knowledge. The following comments on invasive plants in the Eightmile watershed draw in largest part upon author's incidental observations collected during 2003-2005 field work during the rare plant/ natural community survey, and field verification during the development of the habitat map of the watershed. Also, The Nature Conservancy commissioned a 2002 survey of invasive plants in the watershed, which involed the collection of plot data from ca. 200 sites in the watershed, using IPANE sampling methodology in 2002 (Horning & Pfeiffer 2002) (. Invasive plants documented in the watershed to-date by the author and/or Horning and Pfeiffer are presented in Table 9. Also presented in the table are non-native species whose status as invasives is, or has been, under consideration.

Though at least 23 invasive plant species are have been documented by the author's field work and others in the Eightmile watershed, invasives are probably either absent or occur in very low abundance throughout the greater part of the forested portion of the watershed (~75.5%). This is because the greater part of the existing forest are oak-dominated types occupying acidic, lower-fertility sites, and these communities are evidently naturally inhospitable to the majority of invasive species.

However, many natural communities and habitats in the Eightmile watershed are threatened, sooner or later, by invasive plants species (See Table 9). Some of these, like *Froelichia gracilis* (Slender Snake Cotton), *Cynanchum rossicum* (Pale Swallow-wort), and *Euphorbea esula* (Leafy Spurge), appear to be barely established and occasional on roadsides. Others, such as

Phragmites australis subsp. *australis* (introduced Common Reed), *Berberis thunbergii* (Japanese Barberry), *Elaeagnus umbellata* (Autumn Olive), *Celastrus orbiculatus* (Oriental Bittersweet), *Rosa multiflora* (Multiflora Rose), *Microstegium vimineum* (Japanese Stilt Grass), and *Robinia pseudo-acacia* (Black Locust), are well-established and locally abundant in certain habitats.

It is the author's subjective impression, based on his 2003-2005 field work in the Eightmile watershed, that the invasive species experiencing the most rapid increase in the Eightmile watershed are *Microstegium vimineum* (Japanese Stiltgrass) and *Elaeagnus umbellatus* (Autumn Olive). Both species are threatening existing rare species and their associated special natural communities.

Effective, on-going control of invasive species in the Eightmile watershed is essential to the preservation and enhancement of the Eightmile watershed's existing biodiversity. The most evident and immediate threat is to open-canopy and semi-open-canopy habitats and their associated rare and uncommon species. In most cases, these communities and species are also threatened by succession to forest or scrub, and a similar approach will control both threats.

Table 9. Invasive plant species (including both those species already accepted as invasives and non-natives that may be suspected of being invasive, at least in this system) documented in the Eightmile River watershed, with comments on status.

Taxon	Common name	CT status, acc. to Mehrhoff et al. 2003	CT legal status (Public Acts 03-136 and 04-203)	Comments
Acorus calamus	Sweetflag	not listed	none	This non-native species has not been identified as an invasive species in Connecticut, in part because only recently has it been recognized that we have two similar species of *Acorus*, the native *A. americanus* and the non-native *A. calamus*. The author's survey work in the Eightmile watershed has documented freshwater intertidal marshes in Hamburg Cove dominated by *A. calamus*. The ecological and management implications of these stands require study.
Ailanthus altissima	Tree-of-heaven	Widespread and invasive	Banned	
Alliaria petiolata	Garlic Mustard	Widespread and invasive	Banned	Observed primarily along roadsides
Amorpha fruticosa	False Indigo	Potentially invasive	Banned	Restricted to intertidal wetlands and intertidal shores
Berberis thunbergii	Japanese Barberry	Widespread and invasive	none	Serious and occasionally large-scale infestations occur locally in the Eightmile watershed, most often associated with mesic to seasonally wet soils and land relatively recently in agricultural use. Most widespread invasive species in watershed, according to Horning & Pfeiffer (2002)
Celastrus orbiculatus	Oriental Bittersweet	Widespread and	Banned	Among the three most widely distributed invasive

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Taxon	Common name	CT status, acc. to Mehrhoff et al. 2003	CT legal status (Public Acts 03-136 and 04-203)	Comments
		invasive		species in the watershed (Horning & Pfeiffer 2002)
Centaurea bierbersteinii	Spotted Knapweed	Widespread and invasive	Banned	Noted by the author in several sandy open habitats in the Salem area
Clematis terniflora	Yam-leaved Clematis	not listed		Frequent as showing low-climbing vine at forest and shrubland edge along north shore of Hamburg Cove
Cynanchum rossicum	Pale Swallow-wort	Widespread and invasive	Banned	At least one small population along Rte. 82 in Salem
Elaeagnus umbellata	Autumn Olive	Widespread and invasive	Banned	Locally abundant, and fifth most widespread invasive species in the watershed, according to Horning & Pfeiffer (2002). Vigorous invader of old fields, sand barrens, highway and transmission ROW habitat. Several extensive infestations in the watershed. Probably most serious of invasive threats to dry grasslands and barrens.
Euonymus alatus	Winged Euonymus	Widespread and invasive	none	Author has noted several moderate established infestations in mesic, higher-fertility forests, near roads and development. Fourth most widespread invasive species in the watershed, according to Horning & Pfeiffer (2002).
Euphorbia esula	Leafy Spurge		Banned	Author has observed the occasional roadside colony

Table 9. Invasive plant species (including both those species already accepted as invasives and non-natives that may be suspected of being invasive, at least in this system) documented in the Eightmile River watershed, with comments on status.

Taxon	Common name	CT status, acc. to Mehrhoff et al. 2003	CT legal status (Public Acts 03-136 and 04-203)	Comments
Fallopia japonica	Japanese Knotweed	Widespread and invasive	Banned	
Froelichia gracilis	Slender Snake Cotton	Widespread and invasive	Banned	Author has observed a single colony along Route 11. This route appears to be a corridor of southward dispersal into the watershed. This species is a potential threat especially to sand barren communities.
Glossostigma cleistanthum	Mud Mat	not listed	none	Vast numbers of this tiny plant occupying fresh [and perhaps oligohaline] intertidal flat habitat. It is not clear whether it is impacting the co-occurring native species, which include globally rare species.
Iris pseudacorus	Yellow Iris	Widespread and invasive	Banned	
Lonicera japonica	Japanese Honeysuckle	Widespread and invasive	Banned	
Lonicera morrowii	Morrow Honeysuckle	Widespread and invasive	Banned	
Lythrum salicaria	Purple Loosestrife	Widespread and invasive	Banned	
Microstegium vimineum	Japanese Stilt-grass	Widespread and invasive	Banned	Particularly abundant in the Hamburg Cove area, where it occurs immediately adjacent to, and just

Table 9. Invasive plant species (including both those species already accepted as invasives and non-natives that may be suspected of being invasive, at least in this system) documented in the Eightmile River watershed, with comments on status.

Taxon	Common name	CT status, acc. to Mehrhoff et al. 2003	CT legal status (Public Acts 03-136 and 04-203)	Comments
				above, the intertidal zone. Common along roadsides in the same vicinity, and by all appearances rapidly increasing.
Myriophyllum spicatum	European Water-milfoil	Restricted and invasive	Banned	Abundant in parts of Hamburg Cove
Phalaris arundinacea	Reed Canary-grass	Potentially invasive	none	Extensive in stands in open-canopy wetlands along East Branch in Salem, and Eightmile [main stem] at Pleasant Valley, and in some hay fields. Doubtless originally planted for hay in some, perhaps all, locations.
Phragmites australis var. *australis*	Common Reed (non-native var.)	Widespread and invasive	Banned	Occurring in wetlands at scattered locations in the watershed. Most patches are of modest size, but a few large/multi-acre stands are known. Perhaps most frequent in the electrical transmission ROW.
Poa compressa	Canada Blue-grass	Potentially invasive	Banned	Occurring especially in dry grasslands, sand barrens, and rocky outcrops
Robinia pseudoacacia	Black Locust	Widespread and invasive	none	Frequent along the shores of Hamburg Cove. Encountered at relatively few sites by Horning & Pfeiffer (2002).
Rosa multiflora	Multiflora Rose	Widespread and invasive	Banned	Second most widespread and abundant invasive species in watershed, according to Horning & Pfeiffer (2002)

Table 9. Invasive plant species (including both those species already accepted as invasives and non-natives that may be suspected of being invasive, at least in this system) documented in the Eightmile River watershed, with comments on status.

Taxon	Common name	CT status, acc. to Mehrhoff et al. 2003	CT legal status (Public Acts 03-136 and 04-203)	Comments
Rumex acetosella	Sheep Sorrel	Potentially invasive	Banned	
Solanum dulcamara	Climbing Nightshade	Potentially invasive	Banned	
Trapa natans	Water chestnut	Restricted and invasive	Banned	Discovered in Hamburg Covein 2004, by the author. Population evidently consisting of a single individual (which was removed).

Beaver management.

Beaver, whose activities determine the hydrology, structure, and plant composition of at least several hundred acres of the Eightmile watershed's wetlands and watercourses, are one of the three "keystone species" of the watershed (the other two being deer and humans). The cyclic disturbances of wetlands, watercourses, and surrounding habitat is a natural ecological process in North America, and such disturbances create much diversity of habitat upon which many other species depend. Thus, widespread beaver activity in the watershed is an intact native ecological process.

In certain habitats, however, the activity of beaver may threaten the existence of certain of the rare plants and associated communities on which they depend. One such instance is an occurrence of a floating lake-shore peat flat community which supports a major concentration of rare plants. Beaver in this case may be destroying the peat flat habitat by burrowing in the peat, perhaps for food. At the same lake, recent raising of water levels by the beaver have caused high mortality of trees in an adjacent *Chamaecyparis thyoides* Atlantic White Cedar swamp. Other significant communities that exist in the Eightmile watershed that could be threatened by beaver include freshwater intertidal communities and medium fens (these communities have been degraded by beaver activity elsewhere in Connecticut, but not yet in the Eightmile watershed, to the author's knowledge).

Beaver control is often controversial, because they are charismatic and their activities are considered "natural". However, in the rare cases when populations of rare species and natural communities are evidently threatened by beaver activities, and that threat can be removed with no significant impact to the greater beaver population, the cause of biodiversity conservation should take precedence. To this end, those habitats and rare species occurrences that are vulnerable to beaver impacts should be identified and monitored, and the appropriate measures taken when beaver activity is reasonably concluded to be a threat.

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APPENDIX A

Explanation of global and state conservation ranks (NatureServe 2006)

NatureServe Global Conservation Status Ranks	
GX	Presumed Extinct (species)— Not located despite intensive searches and virtually no likelihood of rediscovery. Eliminated (ecological communities)—Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
GH	Possibly Extinct (species)— Missing; known from only historical occurrences but still some hope of rediscovery. Presumed Eliminated— (Historic, ecological communities)-Presumed eliminated throughout its range, with no or virtually no likelihood that it will be rediscovered, but with the potential for restoration, for example, American Chestnut Forest.
G1	Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
G2	Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
G3	Vulnerable—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
G4	Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5	Secure—Common; widespread and abundant.
G#G#	Range Rank—A numeric range rank (e.g., G2G3) is used to indicate the range of uncertainty in the status of a species or community. A G2G3 rank would indicate that there is a roughly equal chance of G2 or G3 and other ranks are much less likely. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).
GU	Unrankable—-Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. Whenever possible, the most likely rank is assigned and a question mark qualifier may be added (e.g., G2?) to express minor uncertainty, or a range rank (e.g., G2G3) may be used to delineate the limits (range) of uncertainty.
GNR	Unranked—Global rank not yet assessed.
GNA	Not Applicable—A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

NatureServe State Conservation Status Ranks	
SX	Presumed Extirpated—Species or community is believed to be extirpated from the nation or state/province. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
SH	Possibly Extirpated (Historical)—Species or community occurred historically in the nation or state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. A species or community could become NH or SH without such a 20-40 year delay if the only known occurrences in a nation or state/province were destroyed or if it had been extensively and unsuccessfully looked for. The NH or SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences.
S1	Critically Imperiled—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
S2	Imperiled—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
S3	Vulnerable—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
S4	Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5	Secure—Common, widespread, and abundant in the state/province.
S#S#	Range Rank —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4).
SNR	Unranked—Nation or state/province conservation status not yet assessed.
SU	Unrankable—Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
SNA	Not Applicable —A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

NatureServe Rank Qualifiers	
?	Inexact Numeric Rank—Denotes some uncertainty about the numeric rank (e.g. G3? - Believed most likely a G3, but some chance of either G2 or G4).

Q	Questionable taxonomy—Taxonomic distinctiveness of this entity at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or the inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority conservation priority.
C	Captive or Cultivated Only—At present extant only in captivity or cultivation, or as a reintroduced population not yet established.
T#	Infraspecific Taxon (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above for global conservation status ranks. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T-rank cannot imply the subspecies or variety is more abundant than the species as a whole-for example, a G1T2 cannot occur. A vertebrate animal population, such as those listed as distinct population segments under under the U.S. Endangered Species Act, may be considered an infraspecific taxon and assigned a T-rank; in such cases a Q is used after the T-rank to denote the taxon's informal taxonomic status.
B	Breeding—Conservation status refers to the breeding population of the species in the state/province (not applicable to global ranks).
N	Nonbreeding—Conservation status refers to the non-breeding population of the species in the state/province (not applicable to global ranks).
M	Migrant—Migrant species occurring regularly on migration at particular staging areas or concentration spots where the species might warrant conservation attention. Conservation status refers to the aggregating transient population of the species in the nation or state/province.

Appendix 7

Analysis of Existing Protections and Potential Gaps in Protection

Eightmile River Watershed Management Plan

Gap Analysis: Summary of Current Protections

Threat = Development—Habitat Fragmentation Mean Rank Score = 1

Municipal

There are no specific regulations at the town level that address habitat fragmentation issues as a result of new development proposals. However, open space set aside requirements for each town encourage set asides that protect wildlife resources or connections to other existing or planned open space resources.

East Haddam—Requires development of a “Conservation Subdivision” plan that requires identification of conservation areas, including land that protects NDDB areas as defined by DEP, and wildlife habitats. House sites are to be located on suitable soils outside of the conservation areas.

Local wetland regulations provide for the protection of habitat functions within wetlands and watercourses, although cannot address habitat functions of adjacent uplands.

East Haddam Inland Wetland regulations include a 400 foot review area around vernal pools which allows for a more comprehensive look at habitat conditions and needs, although municipal wetland decisions cannot be based on upland habitat issues.

Lyme—Requires open space set aside in each subdivision, The set aside may include wildlife habitat and unusual ecological features. (subdiv. Reg. Sec. 4.9) Local wetland regulations same as East Haddam, except no vernal pool upland review area.

Salem—May require open space set aside as part of subdivision. Open space includes important natural resources such as wildlife corridors. Local wetland regulations same as East Haddam, except no vernal pool upland review area.

No towns currently have significant habitat information available to assist in such decisions beyond the state Natural Diversity Database and what the applicant provides.

State

There are no state regulations directly addressing habitat fragmentation related to local development issues.

Section 26-310 of the Connecticut General Statutes provides that any activity authorized by a state agency must not threaten the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat designated as essential to such species.

Federal

There are no federal regulations directly addressing habitat fragmentation related to local development issues.

Section 7 of the Federal Endangered Species Act requires all federal agencies ensure that any action authorized, funded or carried out by the agency is not likely to jeopardize the continued existence of an endangered or threatened species, or result in destruction or adverse modification of a critical habitat of a species.

Gap Analysis: Summary of Current Protections

Threat = **Nonnative Invasive Species** Mean Rank Score = 2

Municipal

There are no municipal regulations in place that address invasive species. As well, there is no comprehensive assessment at the town level of existing invasive species, their location or quantity.

State

Public Act 03-136 established the Invasives Plants Council responsible for among other things making recommendations to control and abate the spread of invasive plants and publish annually a list of invasive or potentially invasive plants.

The state has established that no person shall import, move, sell, purchase, transplant, cultivate or distribute any invasive plants as identified in the list provided in CGS 22a-381d. In addition no state agencies can use such plants.

The Invasive Plant Atlas of New England is working to set up “Rapid Responders” who are teams of experts who can quickly assess a situation and devise an actions plan for a specific location.

Federal

In 1999 Executive Order 13112 was issued that established The National Invasive Species Council (Council) to help coordinate and ensure complementary, cost-efficient and effective Federal activities regarding invasive species.

As a part of the Executive Order all federal agencies are required to prevent the introduction of invasives species, and not authorize or fund actions that would advance invasives. In addition the Council was required to come up with a National Invasive Species Management Plan.

Gap Analysis: Summary of Current Protections

Threat = **Development—Impervious Surfaces** Mean Rank Score = 3

Municipal

East Haddam does require the disclosure of the amount of impervious cover to be created in a new development and P&Z reserves the right to establish restrictions on one or more lots where it cannot be accurately predicted or enforced in advance.

Lyme does not regulate impervious cover in any way.

Salem limits impervious surfaces in the Golf Course Planned Residential Development zone at 13% and the Adult Age Restricted Floating Zone at 15%.

State

The state has no direct regulations over levels of impervious cover.

The State Water Quality Anti-Degradation Policy does require that existing water uses are protected and maintained in all cases. As well in waters considered "high quality" the protection of water quality is required.

General permits are required for the discharge of stormwater from small municipal separate storm sewer systems. East Haddam, Lyme and Salem are all exempt from this program.

CT River Gateway Commission—

The Commission created through CGS Sec. 25-102d that is responsible for the scenic and ecological preservation of the Gateway Area. The Gateway area is from ridgeline to ridgeline of the eight communities at the mouth of the CT River, extending upstream 30 miles and encompassing 30,000 acres. It includes East Haddam and Lyme. The Eightmile River Watershed is not in the Gateway area in East Haddam, but is in the Gateway area in Lyme. The Commission accomplishes its mission through land protection and the creation of zoning standards to be adopted and enforced by the participating towns. The Commission must approve any amendments, adoptions, or repeals of zoning, subdivision or planning regulations, review zoning board of appeals applications for compatibility and work with DEP on recommending and approving state land acquisition projects in the Gateway Zone.

The Gateway Zone standards provide guidance on maximum building coverage per lot. Coverage ranges from 10-25% in residential areas depending on lot size, 25% in industrial areas and 40% in commercial areas.

Federal

The federal government has no direct regulatory control over levels of impervious cover.

The Clean Water Act does have certain tools related to maintaining water quality that are relegated to the state to implement.

Gap Analysis: Summary of Current Protections

Threat = **Development— Poor Stormwater Management** Mean Rank Score = 4

Municipal

East Haddam closely follows the State Stormwater Design Manual for development of new stormwater systems. Some of their general performance criteria includes reducing peak flow and the generation of stormwater, utilizing pervious surfaces and promoting infiltration.

Waivers to stormwater management requirements can be granted if the applicant can prove no deterioration of biological function or habitat among other things.

Lyme has no stormwater system design guidance in place.

Salem has no stormwater system design guidance in place. The P&Z commission "may require the installation of various storm drainage improvements for the whole or any part of a subdivision ".

All towns require state erosion and sediment control standards.

State

General permits "Phase II" are required for the discharge of stormwater from small municipal separate storm sewer systems. Colchester, East Haddam, Lyme and Salem are all exempt from this program.

The State Water Quality Anti-Degradation Policy does require that existing water uses are protected and maintained in all cases. As well in waters considered "high quality" the protection of water quality is required.

Federal

The Clean Water Act does have certain tools related to maintaining water quality that are relegated to the state to implement, e.g. the "Phase II" program.

Gap Analysis: Summary of Current Protections

Threat = **Roads — Habitat Fragmentation** Mean Rank Score = 5

Municipal

East Haddam, Lyme & Salem

There are no specific municipal regulations that address habitat fragmentation issues as a result of new road development. However, open space set aside requirements for each town encourage set asides that protect wildlife resources or connections to other existing or planned open space resources.

There is no significant habitat information available to assist in such decisions beyond the state Natural Diversity Database and what the applicant provides.

Local wetland regulations provide for the protection of habitat functions within wetlands and watercourses, although cannot address habitat functions of adjacent uplands.

No town requires cape cod curbs or other specific wildlife friendly features to new roads.

Additional East Haddam — Inland Wetland regulations include a 400 foot review area around vernal pools which allows for a more comprehensive look at habitat conditions and needs, although municipal wetland decisions cannot be based on upland habitat issues.

State

There are no state regulations directly addressing habitat fragmentation related to state roads.

Section 26-310 of the Connecticut General Statutes provides that any activity authorized by a state agency must not threaten the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat designated as essential to such species.

For state roads designated as “Scenic Roads” the state Scenic Road Advisory Committee must review and determine whether any proposed changes to the designated road would alter the characteristic that made the road eligible for “Scenic” status, including natural features. As well, drainage and curbing will be accomplished with consideration given to the characteristics of the scenic road.

If significant adverse effects are identified, the Advisory Committee can recommend alternatives to the Commissioner of DOT who makes the final decision.

One of the characteristics that made Rt. 156 eligible for scenic road status is the scenic quality of the Eightmile River along the roadway.

Federal

There are no federal regulations directly addressing habitat fragmentation related to roads.

Section 7 of the Federal Endangered Species Act requires all federal agencies ensure that any action authorized, funded or carried out by the agency is not likely to jeopardize the continued existence of an endangered or threatened species, or result in destruction or adverse modification of a critical habitat of a species.

Gap Analysis: Summary of Current Protections

Threat = **Roads — Poor Stormwater Management** Mean Rank Score = 6

Municipal

East Haddam closely follows the State Stormwater Design Manual for development of new stormwater systems. Some of their general performance criteria includes reducing peak flow and the generation of stormwater, utilizing pervious surfaces and promoting infiltration.

Waivers to stormwater management requirements can be granted if the applicant can prove no deterioration of biological function or habitat among other things.

Lyme has no stormwater system design guidance in place.

Salem has no stormwater system design guidance in place. The P&Z commission "may require the installation of various storm drainage improvements for the whole or any part of a subdivision ".

State

"Phase II" general permits are required for the discharge of stormwater from small municipal separate storm sewer systems. Colchester, East Haddam, Lyme and Salem are all exempt from this program.

The State Water Quality Anti-Degradation Policy does require that existing water uses are protected and maintained in all cases. As a result no state level actions should be approved that would degrade a water bodies ability to support existing and designated uses.

For state roads designated as "Scenic Roads" the state Scenic Road Advisory Committee must review and determine whether any proposed changes to the designated road would alter the characteristic that made the road eligible for "Scenic" status, including natural features. As well, drainage and curbing will be accomplished with consideration given to the characteristics of the scenic road.

If significant adverse effects are identified, the Advisory Committee can recommend alternatives to the Commissioner of DOT who makes the final decision.

Federal

The Clean Water Act does have certain tools related to maintaining water quality that are relegated to the state to implement, e.g. the "Phase II" program and the anti-degradation policy.

Gap Analysis: Summary of Current Protections

Threat = **Riparian Corridor — Cutting, Excavation, Filling, Cultivation**

Mean Rank Score = 7, 11, 24

Municipal

East Haddam — Has 100 foot regulated upland review area along wetlands and watercourses, providing an opportunity for the IWC to review activities within 100 feet of the corridor to determine if impacts would result to the wetland or watercourse itself. Grazing, farming, clear cutting for the expansion of crop land, and landscaping on residential property is considered "as of right" and permitted in inland wetlands and watercourses. They defer to CT DEP to address construction of dams, reservoirs, and other facilities necessary for public water supply.

Subdivision reg 3:02,b,I notes land subject to flooding shall not be subdivided for residential or any other use that would increase the hazard.

Salem — Any clearing, grubbing, filling, grading, excavating, or removal or deposition of material within 75 feet of a wetland or watercourse, is a regulated activity. As well, any similar activity in any other non-wetland or non-watercourse area outside the 75 foot area that is likely to likely to impact or affect wetlands or watercourses is regulated. "As of right" uses and deferrals to CT DEP are consistent with East Haddam. Net buildable calculations do not allow inclusion of upland review area in determining buildable area of a lot.

Lyme — Areas within 100 feet of all wetlands and watercourses are considered regulated. The location of a septic within 150 feet of all wetlands and small watercourses, and within 200 feet of larger water bodies and water courses is regulated. "As of right" uses and deferrals to CT DEP are consistent with East Haddam. Criteria for decisions by IWC include assessing a proposed activity as it relates to chemical & biological properties, state water quality classifications, and natural habitat among other things.

State

DEP has exclusive jurisdiction for regulating activities in or affecting wetlands or watercourses done by state agencies. An advisory decision can be provided to DEP by the local IWC. As well DEP has jurisdiction over tidal wetlands and navigable waters.

Activities in upland areas are not considered regulated activities. Activities within 1,000 of a tidal wetland or navigable river in coastal areas requires a coastal site plan review by DEP, although any comments or recommendations are only advisory in nature.

Sec. 3c of the revised CT River Gateway Commission Standards call for no building or other structure shall be constructed, reconstructed, enlarged, extended, moved or structurally altered within one hundred (100) feet of the high tide line, as defined in the Connecticut General Statutes, of the Connecticut River or any of its tributaries or associated wetlands.

In relationship to timber cutting the new Gateway Standards (Sec. III, F. 1.) call for no cutting of vegetation within a strip of land extending fifty(50) feet in horizontal distance inland from the high tide line, as defined in the Connecticut General Statutes, of the Connecticut River or any of its tributaries or associated wetlands, except as provided in this section.

Federal

Federal jurisdiction, through Sec. 404 of the Clean Water Act, is through the Army Corps of Engineers for dredge and fill activities in wetlands and watercourses that meet federal definitions.

Activities in upland areas are not considered regulated activities in these instances. If something triggers Army Corps jurisdiction they can then consider secondary impacts to related upland resources.

Gap Analysis: Summary of Current Protections

Threat = **Development — Suburban Lawns** Mean Rank Score = 8

Municipal

East Haddam — No regulations specifically address impacts from suburban lawns. Residential landscaping is allowed “As of right” in wetlands and watercourses.

Salem — No regulations specifically address impacts from suburban lawns. Residential landscaping is allowed “As of right” in wetlands and watercourses.

Lyme — No regulations specifically address impacts from suburban lawns. Residential landscaping is allowed “As of right” in wetlands and watercourses.

State

The DEP Pesticide Management Program has a main goal prevent adverse human health or environmental effects from the misuse of pesticides. They license pesticide applicators and enforce proper use of pesticides, among other things. They do not directly regulate the use pesticides on suburban lawns.

Federal

EPA has overall responsibility for registering or licensing pesticides for use in the U.S. They relegate responsibility for this program to CT. They do not directly regulate the use pesticides on suburban lawns.

Gap Analysis: Summary of Current Protections

Threat = **Lack of Information/Analysis on of Resource Location, Quality and Vulnerability**

Mean Rank Score = 9

Municipal

All towns have available to them the state Natural Diversity Database, the NRCS soils data, geology data, floodplain data, potential vernal pool mapping, and information provided to them by applicants or consultants the town hires in response to an application. East Haddam and Lyme also have archaeological survey information from a state survey effort. Also, information from Audubon, the CT Butterfly Atlas, The Center for Plant Conservation, and the New England Wildflower Society, among others is available.

Towns do not have detailed habitat or species information, instream flow or hydrologic information, specific water quality information, wetland functions and values information, detailed vernal pool surveys, information conveying the key aspects of the cultural landscape in their community, or detailed knowledge of important archaeological sites.

Importantly, towns do not have the staff time or specific expertise to take advantage of some of the information they have and little resources to collect new information on their own.

As well, staff and commission time and expertise available to learn and implement new planning, zoning, and inland wetland approaches and strategies is limited.

State

The state offers the towns a substantial amount of GIS data including NDDB, soils, geology, water bodies, along with other data, however little technical expertise to implement.

The state also publishes a bi-annual water quality report to congress that includes a listing of impaired waters and the potential causes of impairment. Chemical, physical and biological water quality data is available for certain water bodies.

Fisheries data may be available from DEP efforts to sample the Eightmile River system on a regular basis.

Training seminars are available to planning, zoning and inland wetland commission members at different times. The wetlands training includes information on understanding the law and regulations, wetland identification, wetland functions and values, reading development site plans, alternatives evaluation, construction practices including controlling erosion and sedimentation, and related areas. Also part of this basic program and in cooperation with Connecticut's Office of the Attorney General, a "legal issues" workshop is presented.

At least one member of staff of the IWC must have completed the comprehensive training program and it must be offered to at least one members or staff annually.

Federal

Information that may be of interest to local commissions and staff typically includes USGS stream flow data and water quality studies, FEMA floodplain maps, and US Fish & Wildlife species and habitat information.

Gap Analysis: Summary of Current Protections

Threat = **Development - Wetland/Vernal Pool Filling & Alteration**

Mean Rank Score = 10, 12

Municipal

East Haddam — Wetland and watercourse definition consistent with state statute. Separate definition included for vernal pools. Decision criteria for determining whether a regulated activity will be permitted includes: the environmental impact to the wetland or watercourse; review of prudent and feasible alternatives; the relationship of the short and long term impacts of the proposed activity on the long-term productivity of the wetland or watercourse; irretrievable loss of resources that would be caused and the ability to mitigate such losses; effect on wetlands or watercourses outside the area of proposed activity; assessing suitability of activity based on balancing environmental protection and need for economic growth; and others.

Salem — Wetland and watercourse definition consistent with state statute.

Decision criteria is similar to East Haddam.

Lyme — Wetland and watercourse definition consistent with state statute, except intermittent watercourses are not defined. Lyme decision criteria is similar to East Haddam, although they provide 9 specific measures of environmental impact to consider, they also specifically raise the issue of characterizing and assessing the degree of injury to unique habitat and habitat loss, and they have an additional criteria to assess any proposed actions by the applicant to put deed restrictions or easements on their property that would be beneficial to the wetlands and watercourses associated with the proposed activity.

State

State statutes (CGS § 22a-38)provide definitions for local municipalities to follow in defining wetlands and water courses.

DEP has exclusive jurisdiction for regulating activities in or affecting wetlands or watercourses done by state agencies. An advisory decision can be provided to DEP by the local IWC. As well DEP has jurisdiction over tidal wetlands and navigable waters.

No direct regulatory guidance to municipalities is offered for vernal pools, other than they can be regulated just as wetlands.

Federal

The Clean Water Act "Section 404" program is the principal way by which the federal government protects wetlands and other aquatic environments. Federally regulated wetlands are defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

The Corps of Engineers regulates construction and other work in navigable waterways under Section 10 of the Rivers and Harbors Act of 1899 and the discharge of dredged or fill material into "waters of the United States" under Section 404 of the Clean Water Act. "Waters of the United States" are navigable waters, tributaries to navigable waters, wetlands adjacent to those waters and/or isolated wetlands that have a demonstrated interstate commerce connection. The Corps regulatory program goal is to ensure protection of the aquatic environment, while allowing for necessary economic development.

Any activity that occurs in a component of, or within 0.25 miles up or downstream of the main stem or tributaries of a river segment of, the National Wild and Scenic River System, must be reviewed by the Corps under the procedures of Category II, regardless if it meets the Category I size of impact thresholds. This condition applies to both designated Wild and Scenic rivers and rivers designated by Congress as study rivers for possible inclusion while such rivers are in an official study status. The Corps will consult with the National Park Service (NPS) with regard to potential impacts of the proposed activity on the resource values of the Wild and Scenic river. The culmination of this coordination will be a determination by the NPS and the Corps that the work:

1) may proceed as proposed;

2) may proceed with recommended conditions; or could pose a direct and adverse effect on the resource values of the river, and an individual permit is required.

Gap Analysis: Summary of Current Protections

Threat = **Groundwater/Surface Water Diversions & Impoundments**

Mean Rank Score = 13

Municipal

East Haddam — The IWC regulations do not directly address the withdrawal or diversion of water.

However, the regulations identify regulated activities to include the alteration of a watercourse if the alteration was not specifically recognized "as of right". As such, it appears the IWC could regulate a diversion or withdrawal if it so wished.

They defer to CT DEP to address construction of dams, reservoirs, and other facilities necessary for public water supply.

Salem — Same as East Haddam.

Lyme — Same as East Haddam.

State

CT General Statute 22a365 requires the DEP to regulate all diversions of 50,000 gallons per day or more at locations where there is 100 acres or more of watershed area above the withdrawal/diversion point.

A diversion means any activity which causes, allows or results in the withdrawal from or the alteration, modification or diminution of the instantaneous flow of the waters of the state

Decision criteria include among other things the effect on wetlands, waste assimilation, and fish and wildlife habitat.

Diversions in existence prior to 1982 and registered with the State were never reviewed for environmental impacts and are permanently allowed as of right by the holders of the registration. The Eightmile River Watershed has 8 such diversions, none of which are consumptive at this time.

Stream flow regulations and standards exist for stock streams affected by a dam.

Federal

Potential protection of water quantity comes from the Clean Water Act and the implementation of related state water quality standards (see U.S. Supreme Court decision PUD NO. 1 OF JEFFERSON COUNTY et al. v. WASHINGTON DEPARTMENT OF ECOLOGY et al.) However, CT standards do not currently have a reference to, or standard for, instream flow.

The Wild & Scenic Rivers Act states (Sec. 7a) *"The Federal Power Commission [FERC] shall not license the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works under the Federal Power Act (41 Stat. 1063) as amended (16 U.S.C. 791a et seq.), on or directly affecting any river which is designated in section 3 of this Act . . . and no department or agency of the United States shall assist by loan, grant, license, or otherwise in the construction of any water resources project that would have a direct and adverse effect on the values for which such river was established, as determined by the Secreatry charged with its administration. "* and Section 10 (a): *"Each component of the national wild and scenic rivers system shall be administered in such a manner as to protect and enhance the values which caused it to be included in said system . . ."*

Gap Analysis: Summary of Current Protections

Threat = **Roads—Watercourse Crossings, including bridges and culverts**

Mean Rank Score = 14

Municipal

There are no specific regulations addressing impacts from existing watercourse crossings. New crossings would be reviewed under inland wetland regulations. See wetlands worksheet for details.

East Haddam has detailed requirements for applicants of new developments along existing roads. Road upgrades, including drainage upgrades to the existing road can be required.

State

There are no specific regulations addressing impacts from existing watercourse crossings.

The CT Stormwater Quality Manual does have a brief section devoted to “Other Road, Highway and Bridge Maintenance” (sec. 5.2.4). While it addresses many issues associated with siltation and erosion there are no recommendations addressing aquatic habitat and fish passage.

Federal

There are no specific regulations addressing impacts from existing watercourse crossings.

There are federal/state partnerships in different parts of the country that work on removing upstream passage barriers for targeted fish species.

Gap Analysis: Summary of Current Protections

Threat = **Roads—New Road Creation** Mean Rank Score = 15

Municipal

East Haddam— Pavement width is 18-24 feet. Minimum 50' radius; serving no more than 20 lots; road to be less than or equal to 2000'. Encourage hammer heads. See Stormwater worksheet for details on required stormwater design. Road layout criteria do not directly address habitat fragmentation or conservation.

Salem— Regulations state roads are to be of a width that is 'adequate and convenient for present and prospective traffic'. Town road ordinance 26 feet and curbs required. Cul-de-sac minimum 50' radius; road to be less than or equal to 1500'. See Stormwater worksheet for details on required stormwater design. Road layout criteria do not directly address habitat fragmentation or conservation.

Lyme—No street shall have less than 60 foot right of way. It is recognized some streets may need to be wider. No actual street width is provided. Cul-de-sac only allowed on roads less than or equal to 800'. (Subdivision Regs, Sec. 5) Regs are silent on radius. Lyme hasn't had a new road in nearly 20 years. See Stormwater worksheet for details on required stormwater design. Road layout criteria do not directly address habitat fragmentation or conservation.

State

The State requires any development of real property, improvement of real property, acquisition of transportation facilities, or grants for the acquisition of transportation facilities that costs over $100,000 be consistent with the State Plan of Conservation & Development.

The Secretary of OPM submits to the State Bond Commission, prior to the allocation of any bond funds for any of the above actions, an advisory statement commenting on the extent to which such action conforms to the Plan of C&D. In the State 2004-2009 Draft Plan the great majority of land in the Eightmile Watershed is identified as either: existing preserved open space; conservation area, preservation area, or rural lands. Specific strategies for each classification are included. All are consistent with sustaining rural character and the conservation values of the landscape.

In accordance with Connecticut Environmental Policy Act (CEPA) regulations, state agencies are required to undertake a comprehensive evaluation of any applicable action that might significantly affect the environment. An important requirement of this evaluation process is for the sponsoring agency to assess the consistency of its proposed action with the C&D Plan. After the sponsoring agency has taken into account all public and agency comments and made its final decision on the proposed action, OPM must make a determination as to whether the evaluation satisfies CEPA requirements.

State Permits and Compliance Requirements For Rte. 11 include:

Connecticut Environmental Policy Act (CEPA)

Inland Wetlands and Watercourses Act (IWWA)

Water Quality Certification (CWA §401)

Change of Use Permit for Public Water Company Watershed Lands

Tidal Wetlands Act/Permit

Coastal Consistency Review

National Pollutant Discharge Elimination System

Stormwater and Floodplain Certification

Indirect Sources of Air Pollution Regulations

Federal

Federal permits and compliance requirements for a new road such as Rte. 11 include:

National Environmental Policy Act (NEPA)

Federal Water Pollution Control Act (Clean Water Act), §404 Permit

Clean Air Act Conformity Determination

Endangered Species Coordination

Hazardous Materials Regulations

Historic Preservation Act

Section 4(f) Evaluation

Section 6(f) Evaluation

Public Health Service Act (Safe Drinking Water Act)

Executive Order 11990 (Wetland Protection)

Executive Order 11988 (Flood Hazard Reduction)

Executive Order 12898 (Environmental Justice)

Gap Analysis: Summary of Current Protections

Threat = **Golf Course and recreation Areas** Mean Rank Score = 16

Municipal

There are no specific regulations at the town level that address the creation or management of golf courses per se.

Salem (zoning regs section 4.2.18 stipulates that for a Golf Course Planned Development, if public water supply is to be provided, the applicant shall submit a plan to the Commission as part of the Environmental Management Report. Also requires stormwater management plan and water management budget, emphasis on maintaining water quality, as well as an Environmental Management Report o address development parcel and surrounding land characteristics that influence the site.

State

There are no direct state regulations that address golf course creation and management.

Federal

There are no direct federal regulations that address golf course creation and management.

Gap Analysis: Summary of Current Protections

Threat = **Road Sand/Salt Application & Catch Basing Failure**   Mean Rank Score = 17

Municipal

East. Haddam: No official policy for sand/salt, unofficial is bare tar policy, they excessively sand and salt. They clean catch basins and sweep annually, he is trying to get them to increase catch basin cleaning and sweeping near lakes to twice a year.

Salem: No official policy on roads, they use state recommended mix of 7 to 2 sand to salt ration. Sweeping and cleaning once a year in the spring (after 4/15) or more times as needed in certain areas. They own their own sweeper and catch basin cleaner.

Lyme: no information.

State

DOT policy is a 7 to 2 mix. Sweep and clean basins once a year.

Phase II MS4 Stormwater permits require certain steps to be taken to manage municipal stormwater systems. East Haddam, Salem and Lyme are exempt from this program.

Federal

There are no direct federal regulations that address roads and sand and salt application, sweeping or catch basin cleaning.

Gap Analysis: Summary of Current Protections

Threat = **Forest Management** Mean Rank Score = 18

Municipal

Lyme Zoning Regs Sect 8.4: commercial cutting of timber shall occur only with a permit. Appendix A outlines standards for cutting and stream protection, methods, etc.

East Haddam has extensive zoning regs sect 20, regarding permitting, harvesting methods and restrictions, grading for logging roads, etc. Gateway requires a permit for harvesting more than 5 acres.

Salem: no forest management regs

State

State of CT does not have Timber Harvesting Guidelines or statewide Forestry Regulations (the Forest Practices Act) governing practices (CGS 451a Sec. 23-65f-23-65q). They do have a statewide certification program to license foresters and harvesters for harvests in excess of 25,000 board feet (or 50 cords or 150 tons) in any 12 month period. CGS Sec 23-65k Municipal regulation of forest practices permits Lyme and E. Haddam, among other towns, to authorize its inland wetlands agency to adopt regulations consistent with the state regs as are necessary to protect the forest land within its jurisdiction (except for state owned forestland managed by DEP)

Federal

There are no direct federal regulations that address forest management on private lands.

Gap Analysis: Summary of Current Protections

Threat = **Development —Septic Systems, esp. maintenance**

Mean Rank Score = 19

Municipal

All local sanitarians follow state health code. They all stated that maintenance is on an as needed basis (as in when a system fails).

E. Haddam: Subdiv. Regs sects 3 & 4 stipulate design and install according to CGS and State of CT Public Health Code and conformance with regs and reporting to the Sanitarian and East Haddam Water Pollution Control Authority. Distance between septic and wetlands/watercourses is on a case by case basis.

Lyme and Salem (all towns) must follow CT Public Health Code and Sanitarians reporting requirements. Lyme has 200' upland review area (setback?) for specifically identified waterbodies, and a 150' for all other waterbodies.

State

CGS 7-245,246F defines a community sewerage system and CGS 19a-36 indicates technical requirements. State public health code has 25' setback from streams.

Federal

Sec 319 of the Federal Water Pollution Control Act regulates groundwater quality.

Gap Analysis: Summary of Current Protections

Threat = **Development—Failed Erosion & Sedimentation Controls**

Mean Rank Score = 20

Municipal

All towns recommend use of the E&S guidelines.

E. Haddam: E&S controls are required for disturbed areas less than ½ acre cumulatively on review by zoning enforcement officer. Subdivision regs sect 4 provides detailed stormwater management guidelines and recommends use of State Stormwater Design Manual and CT Guidelines for E&S Control. Requires E&S Control plan.

Lyme: requires a plan for disturbance of any size in the Gateway Conservaion Zone and the Commission has discretion to require E&S Plan for any site that has potential for significant erosion. Subdivision regs sect 3.6 requires a detailed soil erosion and sediment control plan.

Salem: Zoning regs sect 11 states E&S control plan shall include specific locations, diversions, structures, and narrative to indicate design criteria used in the design of control measures. E&S plan requires for Planned Recreational/Residential communities and proposed developments disturbing more than one-half acre of land.

State

The 2002 State Guidelines on Erosion & Sedimentation controls provided guidelines on implementation and design.

Federal

There are no direct federal regulations that address E&S Controls.

Gap Analysis: Summary of Current Protections

Threat = **Roads—Hazardous Materials Spills** Mean Rank Score = 21

Municipal

All local fire departments and emergency planners stated they call DEP and defer to state standards.

State

DEP Oil and Chemical Spill Response Division operates per CGS sections 22a-450, 451 and 454. Division operates 24 hrs a day with a rapid response to addressing all reported spills. CT environmental law establishes "strict liability" meaning the person or business which caused the spill and the owner of the property where the spill occurred are responsible for clean-up (monetarily if not physically).

Federal

Gap Analysis: Summary of Current Protections

Threat = **Earth Material Extraction** Mean Rank Score = 22

Municipal

East Haddam—Filling, removal, or excavation of earth materials is permitted in all zones with the exception of land designated as the “Conservation (Gateway) Zone”, with exceptions for grandfathered and residential uses.

Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc. 100 foot buffer from property line established.

Disturbed may not exceed five acres.

No permit necessary where building permit granted as long as activities not to exceed 300 cubic yards of materials.

Slopes are to be 1:3 for restoration of site.

Bedrock quarrying is prohibited.

Salem—Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc.

No pit deeper than 4 foot unless safe access and egress.

Slopes for drainage to be 1:2.

Excavation allowed in RUA, RUB and I zones by special permit.

Minimum of 40 acres required for manufacturing and processing of material in the I zone, and 500 foot setback from Rural or Residential zone.

Stone crushing allowed only in industrial zone, without approval of Commission. Washing, screening and processing allowed in all zoning districts.

Refers to ponds to be acceptable outcomes of gravel operation.

Lyme—Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc.

200 foot setback from property line for resource extraction activities. Disturbed may not exceed five acres. Removal of soil & earth materials prohibited in the conservation (Gateway) zone, except for residential purposes. Bedrock quarrying, along with washing and crushing operations are not allowed anywhere.

State

Natural Diversity database, stormwater and/or point source discharge permit and 401 water quality certification may be necessary.

Federal

404 Army Corps Permit may be necessary.

Gap Analysis: Summary of Current Protections

Threat = **Change in Topography** Mean Rank Score = 23

Municipal

East Haddam—Requires new streets to follow natural contours wherever practical.

Salem—Requires new streets to follow natural contours wherever possible. (subdiv. Regs. 6.4.2)

State

No direct regulatory control.

Federal

No direct regulatory control.

Appendix 8

Summary of Analysis of Management Issues and Threats to Outstanding Resource Values

Eightmile River Watershed Management Plan

Management Issue			ORVs Impacted	Stresses to ORVs	Assessment Tools (* = analysis not completed due to time/resource constraints)
A.		Earth Material Extraction	a,b,c,d,e,f	a,b,e,f,g,n	Compare Areas of Exisiting or Potential Gravel Deposits with Existing Protected Areas
					Review Soils Data with NRCS for Potential Gravel Areas
					Review Exisiting Regulatory Requirements for Such Activity
B.		Riparian Corridor Mowing/Cutting/Excavation/Filling/Cultivation	b,d,e,f	b,c,f,k,l,m	Determine Amount of Riparian Corridor Protected - 100 feet from stream edge
					Assess Riparian Corridor Use With Land Use/Land Cover Data, possibly aerials, stream walk survey data
					Review Exisitng Regulatory Requirements for Such Activity
C.		Altering/Filling of Streams/Wetlands/Vernal Pools, especially in headwaters	b,c,e,f	a,b,c,e,f,g,k,	Determine Amount of Wetlands/Vernal Pools/Perennial Streams (especially 1st order) Protected
					Asess Wetland/Vernal Pool In Context of Land Use/Land Cover Data, possibly use aerials or streamwalk survey
					Review Exisitng Regulatory Requirements for Such Activity
D.		Groundwater/Surface Water Withdrawals and Impoundments	c,e	a,c,g,j,k,l	Identify High-yield aquifer areas
					Review Water Utility Coordination Committee Reports
					Review Impacts of Exisitng Impoundments with Fisheries Biologists/Dam Safety
					Identfiy potenital of new golf courses (see below) and agricultural or commercial diversions
					Review pertinent individual water supply plans from neighboring water utilities
					Review Regulatory Requirements for New Impoundments
					Review State Diversion Permitting Program
E.		Residential/Commercial Development	a,b,c,d,e,f	a,b,c,d,e,f,g,h,k,l,m,n	Buildout Analysis
					Analyze Land Use/Land Cover Change since 1985
					Assess changes in population/household size
					Assess rate of building permits issued
	1	Impervious Surfaces - roadways, rooftops, driveways, parking lots			Impervious Surface Estimate - Present and at Buildout (recognize building footprints are increasing)
	2	Poor Stormwater Management			Review Exisitng Municipal Stormwater Management Policies/Practices
					Identify where erosion and sedimentation may be more problematic via slopes and erodible soils
	3	Wetland/Vernal Pool Filling or Alteration			see item C.
	4	Destruction of Riparian Vegetation			see Item B.
	5	Failed E&S Controls - enforcement main issue			Review Exisiting Regulations
	6	Suburban Lawns			By-Product of Build-Out Analysis
	7	Change in Topography from Site Development			By-Product of Build-Out Analysis
	8	Septic Systems - esp. maintenance			Build-Out Analysis - assess quality of soils on buildable lands
	9	Habitat Fragmentation			
					Review Exisiting Regulations Regarding Installation and Maintenance
F.		Roadways	b,c,e, f	b, c,e,f,g,h,j,l,m	Impervious Surface Estimate - See E1.
	1	Stormwater Management			Review Stormwater Management/Maintenence Gudielines for local and state roads
					Identify Roads Within 100 Feet of Perennial Streams
					Identify Catch Basin Outfalls within 100 feet of perennial streams
	2	Road salt/sand application, catch basin failure & hydrologic impacts			Perform Catch Basin/Culvert Assessment *
	3	Hazardous Material Spill			Review Hazardous Spill Emergency Plans - local and state
	4	Destruction of Riparian Vegetation			see Item B.
	5	Watercourse Crossings			Review local/state maintenance practices
					Field Assess Bridge and Culvert Crossings check UMASS *
	6	New Road Development			Review New Road Building Standards
	7	Habitat Fragmentation			
G.		Nonnative Invasive Species	d,e	c,k,n	Review Botanical Assessment, Conte Refuge info, stream walk surveys
					Ask DEP regarding deer population statistics
					Undertake Additional Field Work/Consult With Experts to Assess Aquatic and Terestrial Species*
					Identify Extent Of Current and Potential Invasive Presence/e.g. Meshomesic Study*
H.		Forest Management	b,c, d,e	b,c,e,k,l	Identify Riparian Foresed Areas
					Review Exisitng Guidelines/Requirements for Timber Harvesting, state BMPs, role of local land use commissions
I.		Poor Implementation of Agricultural Practices	b,c,d,e,f	a,b,c,d,e,g,h,i,k,m,n	
J.		Golf Course/Recreation Areas - creation and management	b,c,d,e, f	b,c,d,e,f,I,k,m	Identify Area Where Additional Recreation Areas May Occur/parcel size, topography, local recreation plans
					Review Guidelines/Requirements for recreation area management
					Determine any identified need for, and type of, additional municipal recreation areas
K.		Lack of Understanding of Resource Location, Quality, Vunerability	a,b,c,d,e,f	a,b,c,d,e,f,g,h,i,j,k,l,m,n	Assess the quality and quantity of resource information avaiable to community land use commissions
					Survey land use commissions to determine if the have adequate information on resources of the area

Outstanding Resource Values Impacted	
a.	Geology
b.	Water Quality
c.	Hydrology
d.	Unique Species and Natural Communities
e.	Watershed Ecosystem
f.	Cultural Landscape

Note: While all stresses affect outstanding resource values to varying degrees, this process identifies the principal stresses that degrade outstanding resource values.

Stresses to Outstanding Resource Values	
a.	Alteration of Surfacewater/Groundwater Relationship
b.	Sediment Loading
c.	Habitat Loss/Fragmentation - upland, grassland, wetland
d.	Nutrient Loading - Eutrophication
e.	Destroy Important Arch./Historic Sites
f.	Loss of Rural/Eightmile Character
g.	Flow Alteration Changing Natural Flow Pattern
h.	Heavy Metal/Toxin/Salt Loading
i.	Bacteria
j.	Blocked Fish Passage
k.	Loss of Native Species
l.	Thermal Alteration
m.	Eutrophication
n.	Loss of Unique Resource Feature/Species

Management Issue Ranking Exercise Summary - 12/21/2004

Rank	Threat - Sort by Mean Score	Mean Score	# of ORVs Affected	Geology	Water Quality	Hydrology	Unique Species & Natural Communties	River Ecosystem	Cultural Landscape
1	Dev - Habitat Fragmentation	5.00	2				5	5	
2	Nonnative Invasive Species	5.00	2				5	5	
3	Dev - Impervious Surfaces - roadways, rooftops, driveways, parking lots	4.60	5		5	4	5	5	4
4	Dev - Poor Stormwater Management	4.25	4		5	4	4	4	
5	Roads - Habitat Fragmentation	4.00	1					4	
6	Roads - Poor Stormwater Management	4.00	3		4	4		4	
7	Riparian Corridor Mowing/Cutting/Excavation/Filling/Cultivation	3.75	4		4		4	5	2
8	Dev - Suburban Lawns	3.60	5		4	3	4	4	3
9	Lack of Understanding of Resource Location, Quality, Vunerability	3.60	5		4	2	4	4	4
10	Dev - Wetland/Vernal Pool Filling or Alteration	3.50	4		3	2	5	4	
11	Dev - Destruction of Riparian Vegetation	3.40	5		4	2	4	5	2
12	Altering/Filling of Streams/Wetlands/Vernal Pools,	3.00	5		4	2	4	4	1
13	Groundwater/Surface Water Diversions and Impoundments	3.00	2			3		3	
14	Roads - Watercourse Crossings	3.00	4		3	3		3	3
15	Roads - New Road Development	3.00	4		2	3		3	4
16	Golf Course/Recreation Areas - creation and management	3.00	5		3	4	3	3	2
17	Roads - Road salt/sand application & catch basin failure	3.00	3		4	1		4	
18	Forest Management	2.75	4		3	2	3	3	
19	Dev - Septic Systems - esp. maintenance	2.67	3		3		2	3	
20	Dev - Failed E&S Controls - enforcement main issue	2.60	5		3	2	3	3	2
21	Roads - Hazardous Material Spill	2.50	2		3			2	
22	Earth Material Extraction	2.33	6	1	3	2	3	3	2
23	Dev - Change in Topography from Site Development	2.00	5	1		2	2	2	3
24	Roads - Destruction of Riparian Vegetation	1.75	4		2	2		2	1
	Total			2	66	47	60	87	33

Note: Each Management Issue was assessed and ranked for each ORV based on a scale of 1 to 5.
A score of one (1) indicates a potential for a small impact, a score of five (5) indicates a potential for a high impact.
A blank cell indicates no potential impact was identified.

Appendix 9

Tier One Tools - Recommendation Details and Background

Eightmile River Watershed Management Plan

Watershed Management Plan Development:

Tier One Management Issues & Proposed Tools

Eightmile River Wild & Scenic Study

August 1, 2005

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    c. 2004 Connecticut Stormwater Quality Manual - Table of Contents
    d. Development of Stormwater Management Plan – Source: General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems
    e. Massachusetts River and Stream Crossing Standards: Technical Guidelines

Eightmile River Wild & Scenic Study

Watershed Management Plan - Tier One Management Tools Overview

July 22, 2005

Introduction

As a follow up to the March 31, 2005 Land Use Commissioner's Summit the Eightmile River Wild & Scenic Study Committee has been refining a strategy to move forward on key watershed management issues as described at the summit. These top issues include riparian corridor protection, habitat fragmentation, increases in impervious surfaces and stormwater management.[1]

The Committee left the Summit with a host of insightful questions and issues to research and analyze regarding the management issues and what the proposed management tools might specifically mean to each community. Over the last 3 months the Committee has been working on its "homework" that has led to this update. A part of this process has included meetings with the staff and land use board chairs in each community to have further discussions on the recommended actions. Their input to date is incorporated into what is provided here.

Building on Good Work

As discussed at the Summit, the communities of the Eightmile River Watershed have done a tremendous amount of good work to protect the watershed's outstanding resource values through actions such as adopting net buildable area requirements, implementing conservation subdivision guidance and aggressively pursuing open space acquisitions.

These recommendations being made by the Eightmile River Wild & Scenic Study Committee are intended to build upon the community's strong efforts and fine tune the management of the special resources of the Eightmile River Watershed. Through such actions we will be able to present the strongest possible case for Wild & Scenic designation to Congress by showing that adequate local protections are in place to protect the areas outstanding resource values.

Tier One and Tier Two Management Issues

Management issues and recommended actions in the Eightmile River Watershed Management plan will be divided into two tiers.

Tier One issues and actions are the high priority items that we are asking communities to work on first. While we recognize there is not time for local commissions to act on these recommendations within the remaining timeline of the Study process, we are asking for a commitment from each commission to work on the adoption of the recommended actions over the next six to twelve months. The final recommended actions will be established based on the input and preferences of the local land use commissions.

[1] At the Summit we had presented three issues. Since that time we have separated the issue of "Habitat Fragmentation and Increases in Impervious Surfaces" into two separate issues.

(over)

The Tier One Management Issues and Actions include:

Management Issue #1: Riparian Corridor Protection

Recommended Action: Adopt a River Protection Overlay Zone for all perennial streams and rivers in the Eightmile River Watershed that provides a 50 foot setback on small headwater streams, and a 100 foot setback on larger streams.

Management Issue #2: Habitat Fragmentation

Recommended Action: Commit to making protection of important habitat blocks an open space conservation priority and be a partner in pursuing federal funding to support such types of acquisitions.

Management Issue #3: Increases in Impervious Surfaces

Recommended Action: Each community commits to a maximum impervious surface goal of 10% for any local watershed and 4% for the Eightmile River Watershed as a whole. In addition, each community supports working with the Eightmile River Committee to refine the current and future impervious surface modeling, assess the potential for increasing imperviousness in each town and adopts appropriate tools to address limiting impervious surface. The East Haddam model is one recommended approach.

Management Issue #4: Stormwater Management

Recommended Action: Three actions have been identified including: (1) Require the design, implementation and maintenance of all new stormwater systems to be consistent with the 2004 CT DEP Stormwater Quality Manual; (2) Complete a Stormwater Management Plan for each municipality's stormwater system as described in the State's General Permit for Small Municipal Stormwater Systems; (3) Adopt The University of Massachusetts guidance for watercourse crossings, an approach that is used by the Army Corps of Engineers (New England Region).

Also, we are asking each community to consider adding a goal statement into their Plans of Conservation and Development that supports the Eightmile River Watershed, its outstanding resource values and the implementation of the watershed management plan. See "Draft Language Proposed to amend to the Plan of Conservation & Development".

Tier Two items are longer-term actions local communities can make to further protect watershed resources. The tier two recommendations will be presented in the full watershed management plan draft in late August.

Support

It is recognized that the implementation of the above actions take human and financial resources as well as time. It is the intention of the Eightmile River Study Committee that if a Wild & Scenic designation occurs and funding becomes available, top funding priorities will be to support local communities in the implementation of the tier one actions.

Draft Language Proposed to amend to the Plan of Conservation & Development

The following language is proposed to be added into the Plans of Conservation and Development for the towns of East Haddam, Lyme and Salem during their next review of their Plan or sooner if possible.

Goal: The town supports designation of the Eightmile River Watershed as part of the National Wild and Scenic Rivers system. The town will act in partnership with the Eightmile River Wild and Scenic Stewardship Committee in implementing the Eightmile River Watershed Management Plan in order to achieve the long-term protection and enhancement of the watershed's Outstanding Resource Values.

Management Issue #1 - Riparian Corridor Protection

Background

Riparian corridor lands, those lands adjacent to rivers and streams, are the first line of defense for a river system. Protection of these areas is the most important action that can take place to ensure the long-term quality of river and watershed resources. The enclosed brochure, “The Importance of Streamside Buffers”, along with the document “Riparian Buffer Zones: Functions and Recommended Widths” provides important background on why riparian areas are important and the levels of riparian corridor protection needed to protect important river and stream values.

Extensive research was done looking at other riparian corridor protection efforts including:

- The Massachusetts River Protection Act, established in 1996, which requires a 200 foot resource protection area along all perennial streams in the state (except for 14 highly urbanized communities where the area is reduced to 25 feet)
- The Farmington River Protection Zoning Overlay District, adopted in 1992, establishes a 100 foot setback area along the Wild & Scenic Farmington River in four communities in Connecticut
- The new CT River Gateway Standards which establish a 50 foot no activity zone and a 100 foot no structure area along waterbodies in the Gateway Zone. The Town of Lyme in June 2005 adopted these standards for their Gateway area that includes Hamburg Cove.

See “Model River Protection Zoning Overlay Area – Summary of Components” which is based on a compilation of these and other efforts.

An analysis of the parcels in that would intersect the proposed overlay area show:

- In East Haddam only 3.7% of all the parcels in town would intersect the proposed overlay area, with 49% of the actual proposed overlay area already classified as wetlands and 100% of the area already considered within the Inland Wetlands Commission upland review area.

- In Lyme only 9.8% of all the parcels in town would intersect the proposed overlay area, with 60% of the overlay area already classified as wetlands and 100% of the area already considered within the Inland Wetlands Commission upland review area.

- In Salem only 13.4% of all parcels in town would intersect the proposed overlay area, with 50% of the overlay area already classified as wetlands and 89% of the area already considered within the Inland Wetland Commissions Upland Review Area.

A summary analysis for each town and the watershed follows the *Model River Protection Overlay Area – Summary of Components.*

Recommendation

Each community adopts a River Protection Overlay Zone for all perennial streams and rivers in the Eightmile River Watershed that provides a 50 foot setback on small headwater streams, and a 100 foot setback on larger streams. The proposed Overlay zone is flexible, respecting pre-existing uses and providing for uses within the overlay area consistent with protection of riparian corridor function.

Action

1. Adopt the River Protection Zoning Overlay Area.

River Protection Zoning Overlay Area - Summary of Components

NOTE: This document contains the actual recommendations by the Wild and Scenic Study Committee on the details of the Zoning Overlay Area. The model ordinance also included as a separate document varies from the Committee's recommendations on several topics.

Purpose of River Protection Overlay Area

The purpose of the River Protection Overlay Area is to protect and enhance the functions and values of the riparian corridor, including:

- Maintaining high water quality
- Maintaining natural flows and hydrology
- Conserving ecological functions
- Supporting habitat and species diversity and abundance
- Maintaining flood storage
- Protecting valuable aquatic species and habitats
- Conserving natural scenic and topographic features

River Protection Overlay Area Definition

The proposed overlay area includes all perennial rivers or streams in the Eightmile River Watershed and the area landward and horizontal from the stream edge, 50 feet on first order headwater streams and 100 feet on all larger streams. A stream edge is defined as the ordinary high water mark typically identified by vegetation or soil types that are distinct from the upland area. The proposed overlay area does not apply to wetlands, vernal pools, Hamburg Cove or Lake Hayward.

Significant Activities

Where a proposed activity involves work within the overlay area the Planning & Zoning Commission shall presume that such activity is significant to the purposes of the overlay area as stated above. This presumption is rebuttable by an applicant upon clear and convincing evidence that the location of the proposed activity within the overlay area does not undermine the purpose of the overlay area.

Standards

No activity which will result in the alteration of land or vegetation within the overlay area shall be permitted by the Planning and Zoning Commission unless:

- there is no reasonably available alternative with less adverse impact on the purposes of the overlay area as stated above; **and**
- the project as proposed will have insignificant impact on those purposes.

The following exceptions may be allowed:

a) construction and maintenance of unpaved footpaths not more than 4' in width to provide non-motorized access to, or across, the waterbody;

b) construction and maintenance of water dependent structures and uses such as docks;

c) construction of new utility lines where the proposed route is the best environmental alternative;

d) septic system maintenance (other than tank pumping which does not require a permit) and, if a system has failed, repair/replacement meeting state/local standards where the maximum feasible overlay area is maintained;

e) construction of accessory structures/uses associated with lawfully existing single family houses where the Planning & Zoning Commission finds that alternatives outside the overlay area are not available; the size and impacts of the proposed structure/use have been minimized; and the structure/use is located as far from the resource as possible; The commission still reserves the right to deny a permit if the activity would have a significant impact to the purpose of the overlay area.

f) new activities in an overlay area that is already altered such that the required buffer cannot be provided without removal of pre-existing structures and/or pavement, provided that the proposed alteration will not increase adverse impacts on that specific portion of the overlay area and that there is no technically demonstrated feasible construction alternative;

g) where a lot is located entirely within the overlay area, the Commission may permit activities within the overlay area when the applicant has demonstrated that the proposed work has been designed to minimize impacts to the overlay area. As mitigation, the Commission may require the applicant to plant or maintain a naturally vegetated buffer of the maximum feasible width given the size, topography, and configuration of the lot.

Activities Not Needing a Permit

a) planting of native vegetation or habitat management techniques designed to enhance the riparian corridor values protected by the regulation;

b) Fish & wildlife conservation activities;

c) Continuation, but not expansion of pre-existing farming practices;

d) Maintenance of existing structures, utilities, stormwater management structures and paved areas;

e) Fire prevention and emergency operations;

f) Survey and boundary posting;

g) Pruning for a filtered view of the watercourse and removal of dead and diseased and nonnative vegetation consistent with Planning & Zoning Commission standards - if removal of trees 4” diameter or greater at breast height is to occur there must be a plan by a qualified forester approved by the commission or its agent. In all cases the overlay area must be maintained containing a natural buffer of native herbaceous plants, shrubs and trees.

Riparian Buffer Zones: Functions and Recommended Widths

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For the

Eightmile River Wild and Scenic Study Committee

April 2005

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1. Functions of Riparian Buffers

Riparian buffers are vital elements of watersheds, primarily due to their protection of surface and ground water quality from impacts related to human land use. These vegetated buffers are complex ecosystems that provide food and habitat for unique plant and animal species, and are essential to the mitigation and control of nonpoint source pollution. In fact, the removal of streamside vegetation, primarily for development purposes, has resulted in degraded water resources and diminished value for human consumption, recreation, and industrial use.[1]

In the Eightmile River watershed, maintenance of riparian buffers in their natural condition has been identified as one of the most effective means of protecting multiple outstanding resource values (ORVs), including water quality, hydrology, unique species and natural communities, and watershed ecosystem function.

Sedimentation increases turbidity and contributes to rapid siltation of waterbodies, negatively impacting water quality. Increased sediment loads also narrow channel widths and provide substrate for colonization of invasive aquatic plant species. Intact riparian buffers ameliorate these negative impacts by stabilizing streambanks. Roots of riparian vegetation deflect wave action and hold bank soil together. The buffer vegetation also decreases erosional impacts during flood events and prevents undercutting of streambanks.

Excess nitrogen and phosphorous from fertilizers and animal waste, as well as other pollutants originating from pesticides and herbicides, often bond to soil particles. The nutrient-loaded sediment contained in surface runoff then flows to the nearest waterbody and is deposited. This process is the primary cause of accelerated eutrophication of lakes and rivers[2]. Streamside forests function as filters, transformers, and sinks for harmful nutrients and pollutants[3]. Buffer plants slow sediment-laden runoff and depending upon their width and vegetational complexity, may deposit or absorb 50 to 100% of sediments as well as the nutrients and pollutants attached to them[4]. When surface water runoff is filtered by the riparian buffer approximately 80 to 85% of phosphorous is captured[5]. Nitrogen and other pollutants can be transformed by chemical and biological soil activity into less harmful substances. In addition, riparian plants act as sinks, absorbing and storing excess water, nutrients, and pollutants that would otherwise flow into the river, reducing water quality.

One of the most important functions of riparian buffers is enhanced infiltration of surface runoff[6]. Riparian vegetation in the buffer surrounding a waterbody increases surface roughness and slows overland flows. Water is more easily absorbed and allows for groundwater recharge. These slower flows also regulate the volume of water entering rivers and streams, thereby minimizing flood events and scouring of the streambed.

[1] Welsch 1991
[2] Jontos 2004
[3] Welsch 1991
[4] Connecticut River Joint Commission 2005
[5] Connecticut River Joint Commission 2005
[6] Dillaha et al. 1989

Many plant and animal species depend on the distinctive habitat of riparian buffers, which include elements of both terrestrial and aquatic ecosystems. Forested buffers improve habitat quality by providing shade that cools water temperatures, thereby elevating the dissolved oxygen content that is necessary for many species of fish and aquatic insects. Woody debris from shrubs and trees within the vegetated buffer provides food and cover for a multitude of aquatic species. If large enough, buffers also provide corridors essential for terrestrial wildlife movement.

Vegetated buffers may serve as screens along waterways, protecting the privacy of riverfront landowners and blocking views of any unsightly development. Hiking and camping opportunities are also facilitated by forested buffers, which if large enough, allow outdoor enthusiasts to enjoy the proximity of the water. The diversity of plant species provides visual interest and increases aesthetic appeal.

2. Recommended buffer widths

The width of a buffer depends greatly on what resource you are trying to protect. Scientific studies have shown that efficient buffer widths range from 10 feet for bank stabilization and stream shading, to over 300 feet for wildlife habitat. Furthermore, the necessary width for an individual site may be less or more than the average recommendations, depending on soil type, slope, land use and other factors. The ranges cited below come from four literature reviews by The U.S. Army Corps of Engineers New England Division, the University of Georgia's Institute of Ecology, the U.S. Army Engineer Research and Development Center, and researchers from the UK Forestry Commission.[7] Results from studies done in New England fall within the ranges cited below, and no evidence was found in the literature to suggest that buffers should be, on average, either wider or narrower.

a. Erosion control

Erodibility of soil type is a key factor when assessing adequate buffer widths. Widths for effective sediment removal vary from only a few feet in relatively well drained flat areas to as much as several hundred feet in steeper areas with more impermeable soils. In order to prevent most erosion, vegetated buffers of 30 feet to 98 feet have been shown to be effective.

b. Water quality

Nutrients - Nitrogen and phosphorous can be retained in buffers that range from 16 to 164 feet. The wider buffers will be able to provide longer-term storage. Nitrogen is more effectively removed than phosphorous. In 1995, a study conducted in Maine found that the effectiveness of buffers at removing phosphorous is variable but in most cases, a 49-foot natural, undisturbed buffer was effective at removing a majority of the nutrient from surface runoff. However, the U.S. Army Corps of Engineers concluded in their 1991 study that there was insufficient evidence

[7] U.S. Army Corps of Engineers 1991, Wenger 1999, Fischer and Fischenich 2000, Broadmeadow and Nisbet 2004, respectively.

to determine a necessary buffer width for phosphorous retention. It is important, therefore, to combine buffer zones with strategies to reduce phosphorous at its source.

Pesticides – Buffer widths for pesticide removal range from 49 feet to 328 feet. Pesticides that are applied manually require less of a buffer area than aerially-sprayed pesticides.

Biocontaminants – Buffer widths for biocontaminants, such as fecal coliform, were not reviewed in this study. The University of Georgia found that, in general, buffers should be 30 ft. or greater. However, buffers may not be able to adequately filter biocontaminants and it is also important to reduce these pollutants at the source.

c. Aquatic habitat

Wildlife – The minimum width of riparian buffers to protect aquatic wildlife, including trout and invertebrates, range from 33 feet to 164 feet.

Litter and debris input – Recommendations for buffer widths to provide an adequate amount of debris for stream habitat range from 10 feet to 328 feet, although most fall within 50 feet to 100 feet.

Stream temperature. Adequate shading can be provided by a 30-foot buffer, but buffers may need to be up to 230 feet to completely control stream temperature. The amount of shade required is related to the size of the channel. The type of vegetation in the buffer regulates the amount of sunlight reaching the stream channel. Generally, a buffer that maintains 50% of direct sunlight and the rest in dapple shade is considered preferable[8]

d. Terrestrial habitat

The Eightmile River watershed contains a large number of roadless, undeveloped forest blocks and is more than 80% forested in total. Furthermore, the riparian corridor within 300 ft. of the river and its tributaries has remained mostly intact, supporting a high level of biodiversity as well as protecting water quality. The Eightmile River is host to a number of important species, including native brook trout, freshwater mussels, blue back herring, bobcats, great horned owls and cerulean warblers.

The habitat requirements for birds, mammals, reptiles, amphibians and fish vary widely, and the necessary buffer width to protect each species varies widely as well. While trout and salmon can benefit greatly from the shading, habitat, food, and water quality protection that a 150-foot buffer provides, mammals such as the red fox and the bobcat require riparian corridors of approximately 330 feet. Furthermore, birds such as the cerulean warbler, which requires large areas of forest, may need a buffer that is much greater than 330 ft.[9] For this reason, we do not believe that it is feasible to capture all of the habitat needs of all species with a uniform buffer. More careful targeting of potential riparian habitat, work with landowners to create conservation

[8] Broadmeadow and Nisbet 2004
[9] Chase et al. 1995

easements, as well as the creation of protected areas by the town will aid in more specific approaches to habitat preservation for these species.

For a more detailed look at the range of recommended buffer widths, see Appendix 1.

3. Factors influencing buffer width

There are many factors that influence the effectiveness buffers. These include slope, rainfall, the rate at which water can be absorbed into the soil, type of vegetation in the buffer, the amount of impervious surfaces, and other characteristics specific to the site.

a. Slope

As slope increases, the speed at which water flows over and through the buffer increases. Therefore, the steeper the land within the buffer, the wider it needs to be to have time to slow the flow of water and absorb the pollutants and sediments within it. Many researchers suggest that especially steep slopes serve little value as a buffer, and recommend excluding areas of steep slope when calculating buffer width. The definition of "steep" varies from over 10% to over 40% slope[10].

b. Soil type

The type of soil affects how quickly water can be absorbed. Soils that are high in clay are less permeable and may have greater runoff. On the other hand, soils that are largely made up of sand may drain water so rapidly into the groundwater that roots are not able to effectively trap pollutants. Furthermore, soils that are moister and more acidic have a better capacity to take up nitrogen from the soil and release it to the atmosphere (through denitrification).

c. Vegetation mix

Structurally diverse riparian buffers, i.e. those that contain a mix of trees, shrubs and grasses, are much more effective at capturing a wide range of pollutants than a riparian buffer that is solely trees or grass. Removal efficiencies range from 61% of the nitrate, 72% of the total phosphorous and 44% of the orthophosphates from grass buffers to 92% of the nitrate 93% of the total phosphorous and 85% of the orthophosphates from combined grass and woody buffers. [11]

[10] Wenger 1999
[11] Jontos 2004

Table 1: Estimated reduction of nutrient loads from implementation of riparian buffers[12]

Buffer Type	Nitrogen	Phosphorus	Sediment
Forested	48-74%	36-70%	70-90%
Vegetated Filter Strips	4-70%	24-85%	53-97%
Forested and Vegetated Filter Strips	75-95%	73-79%	92-96%

Source: Delaware Department of Natural Resources and Environmental Control

Generally, the grass filter strip works best for sediment removal, while the forested buffer is better for nitrate removal from subsurface flows[13]. Grasses have a shallower and denser root mat that is more effective in slowing runoff and trapping sediments from the surface flow. Trees have a deeper root system that can trap and uptake nutrients from the groundwater, stabilize banks, and regulate the flow of water to the stream.

Forests provide certain functions that grasses cannot. Trees shade the river and provide an input of leaf litter and branches that are necessary for many aquatic species. In addition, a forested buffer provides important habitat for terrestrial wildlife. Native plants species are preferred to ornamentals or exotics due to the habitat advantage they provide for wildlife. Old trees are especially valuable for providing inputs of coarse woody debris.

The most effective riparian buffers should include a mix of trees, shrubs and herbaceous plants native to the region and appropriate to the environment in which they are to be planted. When planting buffers, it is best to use adjacent reference riparian buffers as the basis for selecting floral composition[14].

Table 2: Plant type vs. removal efficiency

Function	Grass	Shrubs	Trees
Sediment trapping	High	Medium	Low
Filtration of Sediment born Nutrients, Microbe and Pesticides	High	Low	Low
Soluble forms of Nutrients and Pesticides	Medium	Low	Medium
Flood Conveyance	High	Low	Low
Reduce Stream Bank Erosion	Medium	High	High

Source: Jontos 2004 (modified after Fisher and Fischenich 2000)

12 (Palace, 1998; Lowrance et al., 1995; Franti, T.G., (1997); Parsons et al. (1994); Gilliam et al. (1997); Osmond et al., (2000)
13 Triangle J. Council of Governments 1999
14 Jontos 2004

4. Buffer types

a. Variable Width

Several models have been created to consider individual site factors in determining buffer width. These range from the complex to the relatively simple. The more complex models take into account multiple factors, such as slope, erodibility and infiltration rates[15]. Examples of such models include:

Brown et al. (1987):

Buffer width = (average slope/erodibility factor)$^{1/2}$

Cook College Department of Environmental Resources:

Buffer width = 2.5 (time of travel of overland flow)(slope)*$^{0.5}$

More simple models only take into account slope. A common formula is to set a fixed buffer width and apply 2 feet per percent slope. Many of these models recommend *not* including impervious surfaces or areas of steep slope in the buffer width (**Figure 1**). Cook College recommends excluding anything greater than 15% slope, while Wenger (1999) recommends excluding all slopes over 25%.

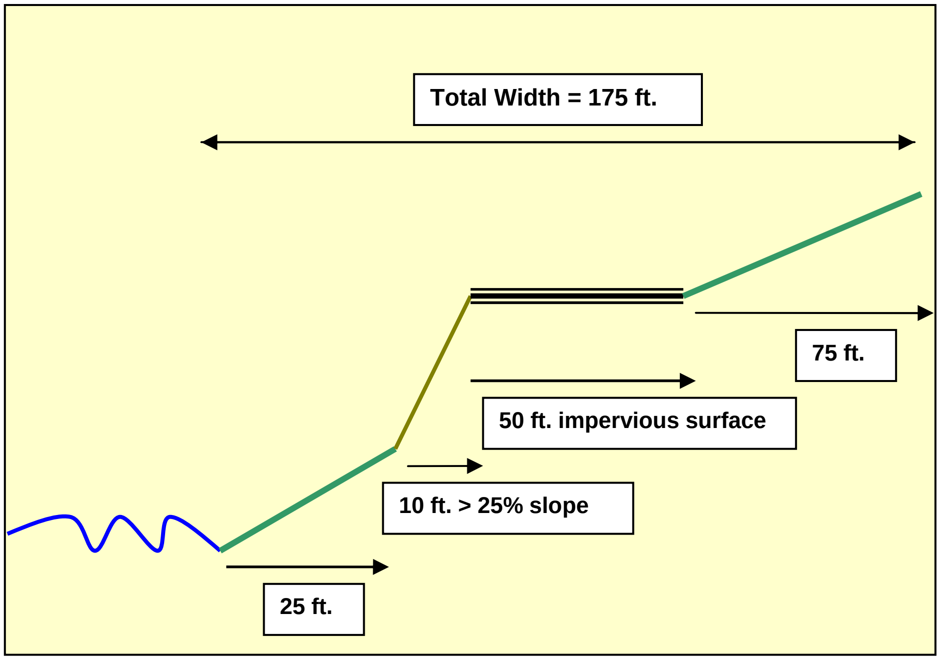
b. Fixed Width

A fixed buffer width is the easiest to administer. However, care must be taken to select the appropriate width for the resources you are targeting. Studies unanimously support the conclusion that buffer efficiency at filtering out pollutants increases with width. However, this does not increase infinitely, and the goal is to find the most efficient width. For example, a study in the Mid-Atlantic[16] found that 90% of sediments were removed by a 62 ft. riparian buffer, but only 94% were removed by more than doubling the buffer width to 164 ft

If a fixed buffer width is chosen, it should be on the conservative side to provide leeway for slope and soil type. Data for the Eightmile River watershed show that significant areas of the land bordering the river have slopes that are above 15%. Therefore, we believe it is necessary to make a fixed buffer width wider than the average minimum recommendation of 100 ft.

[15] Described in the US Army Corps of Engineers (1991) literature review.
[16] Peterjohn and Corell 1994.

Fig.1: Variable buffer width adjusted from 100 feet to 175 feet to account for effects of slope and impervious surface.



c. Three Zone

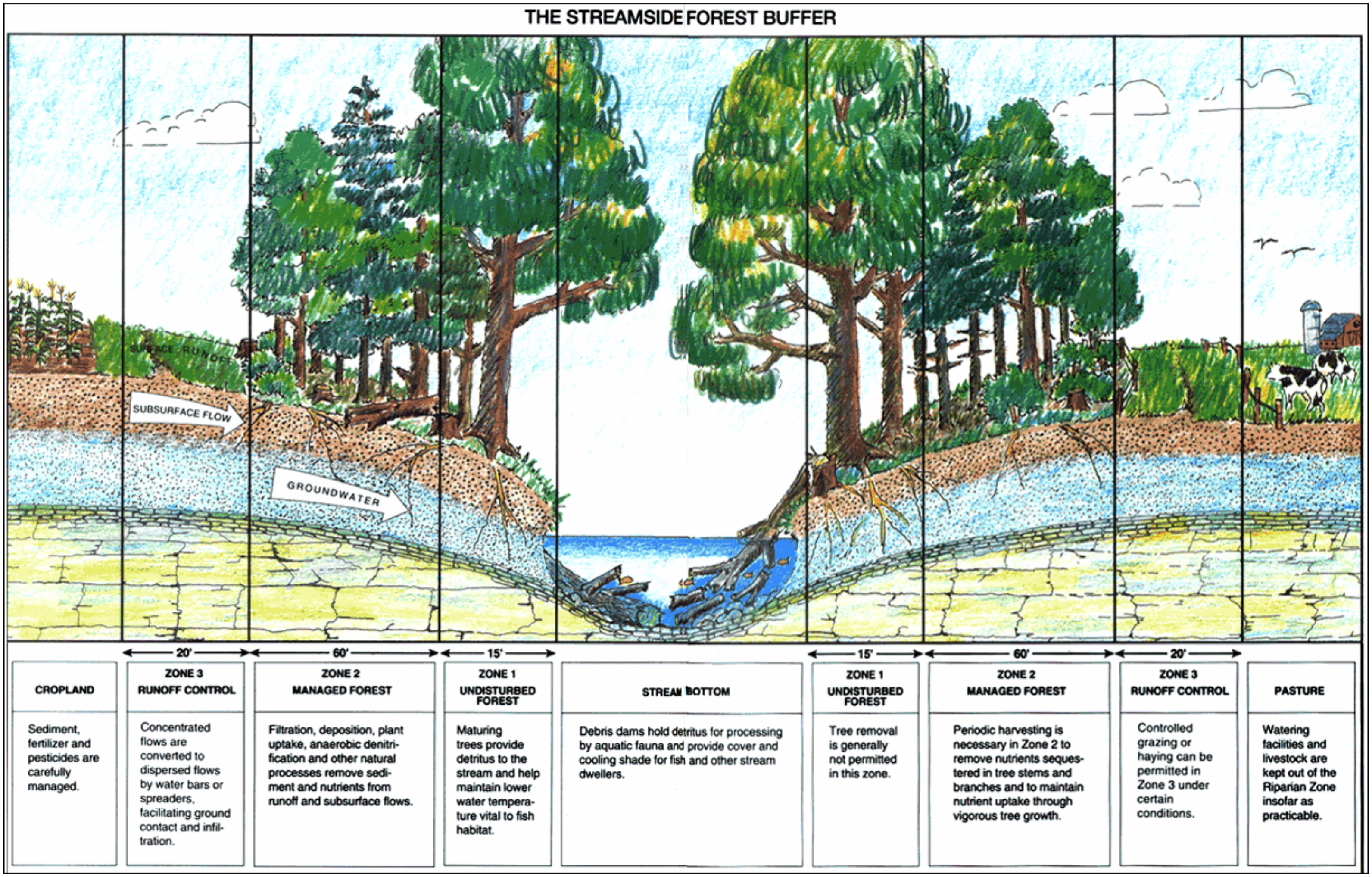
The Three Zone system was originally developed as part of an initiative to protect the Chesapeake Bay. The combination of vegetation types (trees, grass and shrubs) helps maximize the efficiency and diversity of benefits that the buffer provides (Figure 2).

Zone 1
Minimum Width: 15 ft.
Composition: Native trees and shrubs
Function: Bank stabilization, habitat, shade, flood prevention
Management: None allowed except bank stabilization and removal of problem vegetation.

Zone 2
Minimum Width: 60 ft.
Composition: Native trees and shrubs.
Function: Removal of nutrient, sediments and pollutants from surface and groundwater, habitat
Management: Some removal of trees to maintain vigorous growth.

Zone 3
Minimum Width: 30 ft.
Composition: Grasses and herbaceous plants
Function: Slow surface runoff, trap sediments and pesticides
Management: Mowing

Fig. 2: **Three-Zone System**



Source: Welsch 1991. Riparian Forest Buffers: Function and Design For Protection and Enhancement of Water Resources.

5. What order streams to protect

Buffers are most effective when they are contiguous. Guidelines for buffer widths recommend that long, continuous buffer strips should often be a higher priority than fragmented strips of greater width.[17] Small gaps in vegetation along the bank can channelize runoff into the river and effectively negate the effect of surrounding buffers. For this reason, landowners who currently have lawns that run to the edge of the river should be encouraged to replant trees and shrubs along the bank. In addition, footpaths cleared for river access should be winding, rather than straight, and as narrow as possible to minimize sedimentation.

Failure to extend protection to the smaller headwater streams in the river basin also ignores important sources of sedimentation and pollution. To preserve water quality in the Eightmile River, it is essential to protect all of its tributaries. In fact, smaller order streams often account for the greatest miles of watercourse in a basin. Buffering low order streams (1st, 2nd and 3rd) has greater positive influence on water quality than wider buffers on portions of larger order streams already carrying polluted water. While it may be politically infeasible to set wide buffer zones around intermittent and ephemeral streams, this omission is not justified by the science. A University of Georgia study of riparian buffers warns, "Governments that do not apply buffers to certain classes of streams should be aware that such exemptions reduce benefits substantially."[18] A review of buffers by the U.S. Army also notes that "even the best buffer strips along larger rivers and streams cannot significantly improve water that has been degraded by improper buffer practices higher in the watershed".[19]

Smaller headwater streams have the greatest area of land-water interaction, and have the greatest potential to accept and transport sediment. Ephemeral streams, which only exist during periods of high rain, can serve as important sources of sediment and pollutants to the river. It is important that they are maintained in a vegetated condition in order to help trap and slow the flow of pollutants. Furthermore, removing riparian vegetation from the banks of small, heavily shaded streams will have a much greater impact on stream temperature and aquatic habitat throughout the watershed than removing vegetation from larger rivers, where only a fraction of the water is shaded. Rather than ignoring these streams completely, a compromise would be to create a smaller setback. Clinnick et al (1985) advocate a minimum of a 20 m wide buffer for ephemeral streams, and where that is not possible, at least leaving the banks vegetated[20].

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[17] Fisher and Fischenich 2000
[18] Wenger 1999
[19] Fisher and Fishenich 2000
[20] Wenger 1999

Appendix 1–Summary of Effective Buffer Widths from Literature Review

	Effective Width of Buffer (in feet)							
Author	**Aquatic Wildlife**	**Terrestrial Wildlife**	**Stream Temperature**	**Litter/Debris input**	**Nutrient Retention**	**Sediment Control**	**Bank Stabilization**	**Pesticide Retention**
Wenger 1999		220-574 ft.	33 – 98 ft.	50 ft.	50 – 100 ft.	82 – 328 ft.	–	> 49 ft.
Army Corps 1991	98 ft.	30 – 656 ft.	33 – 66 ft.	66-102 ft.	52 – 164 ft.	33 – 148 ft.	49 – 98 ft.	49 – 328 ft.
Fisher and Fischenich 2000	> 98 ft.	98-1,640 ft.	–	10 – 33 ft.	16.4-98 ft.	30-200 ft.	30 -66 ft.	–
Broadmeadow and Nisbet 2004	33 –164 ft.	–	49 – 230 ft.	82 – 328 ft.	16.4-98 ft.	49 – 213 ft.	–	–

Appendix 2 - General Recommended Widths of Buffer Zones

Source: Jontos 2004 (modified after Fisher and Fischenich 2000)

Function		**Recommended Width**
Water Quality Protection	Buffers, especially dense grassy or herbaceous buffers on gradual slopes, intercept overland runoff, trap sediments, remove pollutants, and promote ground water recharge. For low to moderate slopes, most filtering occurs within the first 10 m, but greater widths are necessary for steeper slopes, buffers comprised of mainly shrubs and trees, where soils have low permeability, or where NPS loads are particularly high.	5 to 30 m
Stream Stabilization	Buffers, particularly diverse stands of shrubs and trees, provide food and shelter for a wide variety of riparian and aquatic wildlife	10 to 20 m
Riparian Habitat	Riparian vegetation moderates soil moisture conditions in stream banks, and roots provide tensile strength to the soil matrix, enhancing bank stability. Good erosion control may only require that the width of the bank be protected, unless there is active bank erosion, which will require a wider buffer. Excessive bank erosion may require additional bioengineering techniques.	30 to 500 m +
Flood Attenuation	Riparian buffers promote floodplain storage due to backwater effects, they intercept overland flow and increase travel time, resulting in reduced flood peaks.	20 to 150 m
Detrital Input	Leaves, twigs and branches that fall from riparian forest canopies into the stream are an important source of nutrients and habitat.	3 to 10 m

Appendix 3

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Appendix 4 - Web Resources

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East Haddam Summary **August 16, 2005**

Analysis of Parcels Intersecting Proposed River Protection Overlay Area
50 feet on First Order Headwater Streams and 100 feet on all Larger Streams

Note: This summary page includes only parcels in the Eightmile River Watershed that are on perennial streams. Protected open space parcels and parcels abutting Lake Hayward are not included.

- 209 Parcels Intersect the Proposed River Protection Overlay Area – 3.7% of all parcels in town
- 737 Total Acres in the Proposed River Protection Overlay Area – 2% of the total town area
- 49% of all Acres in the Proposed River Protection Overlay Area are Already Regulated Wetlands (359 acres)
- 100 % of all Acres in the Proposed River Protection Overlay Area are Already Within the Inland Wetlands Commission's 100 foot Upland Review Area.
- There is No Creation of Non-buildable Lots

East Haddam Summary - Analysis of Parcels Affected by 50 foot Riparian Setback on 1st Order Streams, 100 foot Setback on All Other Streams

Analysis is on Perennial Streams in the Eightmile Watershed and Does Not Include Parcels That Are Already Protected Open Space or Parcels abutting Lake Hayward

June 15, 2005 DRAFT

East Haddam Totals	# of Parcels	Total Acres of Parcels	Acres in Setback	Setback as Percent of Total Parcel	Acres of Wetlands in Setback	Percent of Wetlands in Setback
East Haddam 1st Order (50 ft setback)	60	1397	91	7%	31	34%
East Haddam 2nd Order (100 ft setback)	120	5116	541	11%	253	47%
East Haddam 3rd Order (100 ft setback)	21	338	85	25%	59	69%
East Haddam 4th Order (100 foot setback)	8	100	20	20%	16	80%
Total	209	6951	737	11%	359	49%
# of Parcels With No Wetlands in Setback						
East Haddam 1st Order (50 ft setback)	14	244	8.5	3%	0	0%
East Haddam 2nd Order (100 ft setback)	22	386	26	7%	0	0%
East Haddam 3rd Order (100 ft setback)	2	2	0.3	15%	0	0%
East Haddam 4th Order (100 foot setback)	0	0	0	0%	0	0%
Total	38	632	35	6%	0	0%
# of Parcels With >50% Wetlands in Setback						
East Haddam 1st Order (50 ft setback)	20	278	26	9%	20	77%
East Haddam 2nd Order (100 ft setback)	62	2532	217	9%	144	66%
East Haddam 3rd Order (100 ft setback)	9	218	61	28%	51	84%
East Haddam 4th Order (100 foot setback)	8	100	20	20%	16	80%
Total	99	3128	324	10%	231	71%

EIGHTMILE RIVER

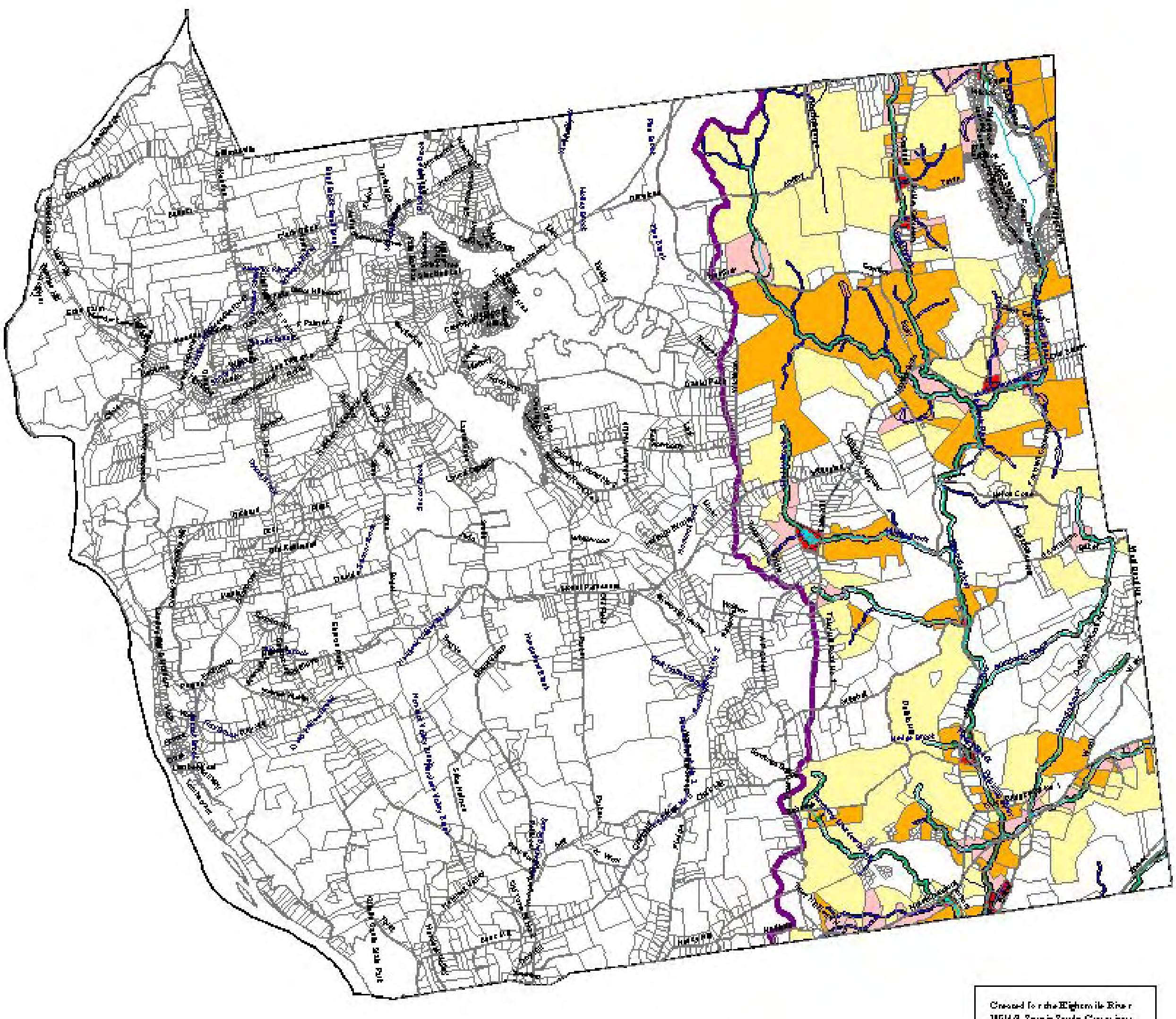
WILD & SCENIC RIVER STUDY

PARCELS THAT INTERSECT PROPOSED RIVER PROTECTION OVERLAY AREA

100' OVERLAY SETBACK ON LARGER STREAMS, 50' OVERLAY SETBACK ON HEADWATER STREAMS

EAST HADDAM

Watershed Boundary
Stream Order
Headwater Streams
Larger Streams
Proposed Regulated Area
Wetlands in Proposed Regulated Area
Pcls in Reg. Area by Pct of Parcel
0 - 10% 69 Pcls
10% - 25% 59 Pcls
25% - 50% 57 Pcls
50% - 100% 23 Pcl



Created for the Eightmile River Wild & Scenic Study Committee by the CT River Coastal Conservation District

Town boundaries, hydrology, watershed boundary, roads, aerial photos (1990), topographic maps: CT DEP

Map for planning purposes. Not to be used for conveyances

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Ken Geisler, July 29, 2005

Lyme Summary **August 11, 2005**

Analysis of Parcels Intersecting Proposed River Protection Overlay Area
50 feet on First Order Headwater Streams and 100 feet on all Larger Streams

Note: This summary page includes only parcels in the Eightmile River Watershed that are on perennial streams. Protected open space parcels and parcels abutting Hamburg Cove are not included.

- 171 Parcels Intersect the Proposed River Protection Overlay Area – 9.8% of all parcels in town
- 428 Total Acres in the Proposed River Protection Overlay Area – 2.1% of the total town area
- 60% of all Acres in the Proposed River Protection Overlay Area are Already Regulated Wetlands (256 acres)
- 100 % of all Acres in the Proposed River Protection Overlay Area are Already Within the Inland Wetlands Commission’s 100 foot Upland Review Area.
- The proposed River Protection Overlay is similar to Lyme’s recently adopted setbacks in the Gateway Zone.
- There are No New Parcels that are not already Regulated by the Upland Review Area
- There is No Reduction in the Number of Buildable Lots
- There is No Creation of Non-buildable Lots

Lyme Summary - Analysis of Parcels Affected by 50 foot Riparian Setback on 1st Order Streams, 100 foot Setback on All Other Streams
Analysis is on Perennial Streams in the Eightmile Watershed and Does Not Include Parcels That Are Already Protected Open Space or Abutting Hamburg Cove
August 11, 2005 DRAFT

Lyme Totals	# of Parcels	Total Acres of Parcels	Acres in Setback	Setback as Percent of Total Parcel	Acres of Wetlands in Setback	Percent of Wetlands in Setback
Lyme 1st Order (50 ft setback)	46	796	32	4%	15	47%
Lyme 2nd Order (100 ft setback)	54	2,038	258	13%	177	69%
Lyme 3rd Order (100 ft setback)	35	266	62	23%	38	61%
Lyme 4th Order (100 ft setback)	14	63	22	35%	6	27%
Lyme 5th Order (100 ft setback)	22	299	54	18%	20	37%
Total	171	3,462	428	12%	256	60%
# of Parcels With No Wetlands in Setback						
Lyme 1st Order (50 ft setback)	5	173	4	2%	0	0%
Lyme 2nd Order (100 ft setback)	5	127	10	8%	0	0%
Lyme 3rd Order (100 ft setback)	7	12	6	55%	0	0%
Lyme 4th Order (100 ft setback)	7	25	13	50%	0	0%
Lyme 5th Order (100 ft setback)	8	99	8	8%	0	0%
Total	32	436	40	9%	0	0%
# of Parcels With >50% Wetlands in Setback						
Lyme 1st Order (50 ft setback)	21	366	18	5%	14	78%
Lyme 2nd Order (100 ft setback)	36	1,599	218	14%	166	76%
Lyme 3rd Order (100 ft setback)	21	230	44	19%	36	82%
Lyme 4th Order (100 ft setback)	5	30	8	27%	6	75%
Lyme 5th Order (100 ft setback)	5	119	20	17%	13	65%
Total	88	2,344	308	13%	235	76%

EIGHTMILE RIVER

WILD & SCENIC RIVER STUDY

PARCELS THAT INTERSECT PROPOSED RIVER PROTECTION OVERLAY AREA

100' OVERLAY SETBACK ON LARGER STREAMS, 50' OVERLAY SETBACK ON HEADWATER STREAMS

LYME

Watershed Boundary

Stream Order

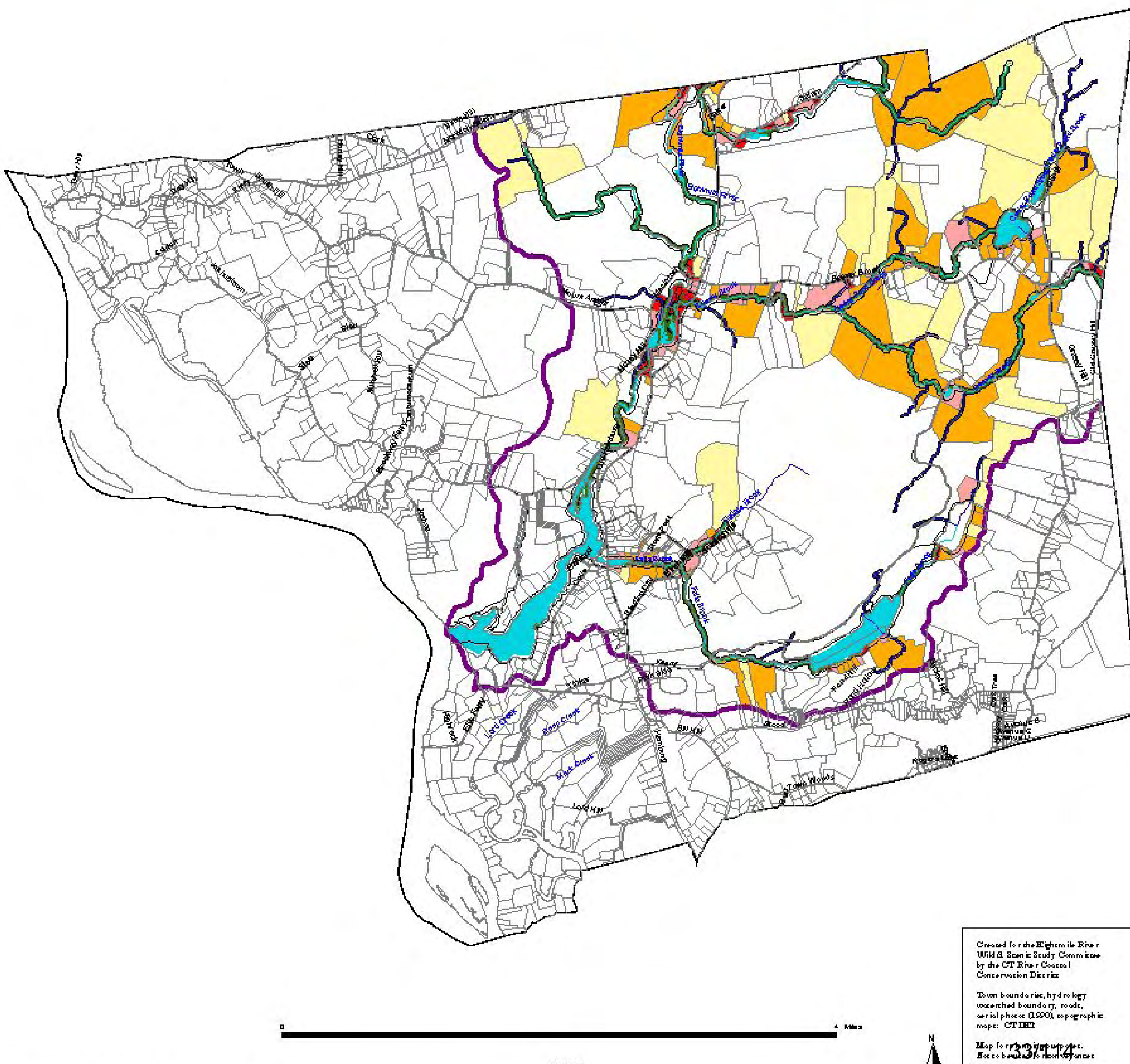
- Headwater Streams
- Larger Streams

Proposed Regulated Area

Wetlands in Proposed Regulated Area

Pcls in Reg. Area by Pct of Parcel

- 0 - 10% 36 Pcls
- 10% - 25% 50 Pcls
- 25% - 50% 45 Pcls
- 50% - 100% 39 Pcls



Created for the Eightmile River Wild & Scenic Study Committee by the CT River Coastal Conservation District

Town boundaries, hydrology, watershed boundary, roads, aerial photos (1990), topographic maps: CT DEP

Ken Geisler, July 29, 2005

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Salem Summary July 20, 2005

Analysis of Parcels Intersecting Proposed River Protection Overlay Area
50 feet on First Order Headwater Streams and 100 feet on all Larger Streams

Note: Analysis includes only parcels in the Eightmile River Watershed that are on perennial streams. Protected open space parcels are not included.

- 239 Parcels Intersect the Proposed River Protection Overlay Area – 13.4% of all parcels in town
- There are 636 Total Acres in the Proposed River Protection Overlay Area – 3.3% of the total town area
- 50% of all Acres in the Proposed River Protection Overlay Area are Already Regulated Wetlands (321 acres)
- 89 % of all Acres in the Proposed River Protection Overlay Area are Already Within the Inland Wetlands Commission's 75 foot Upland Review Area.

Salem Summary - Analysis of Parcels Intersecting Proposed River Protection Overlay Area 20-Jul-05

50 Feet on First Order Headwater Streams, 100 Feet on All Larger Streams Draft

Analysis is on Perennial Streams in the Eightmile River Watershed in Salem and Does Not Include Parcels That Are Already Protected Open Space

Salem Totals	# of Parcels	Total Acres of Parcels	Acres in Setback	Setback as Percent of Total Parcel	Acres of Wetlands in Setback	Percent of Wetlands in Setback
Salem 1st Order (50 ft setback)	124	3,801	209	5%	107	51%
Salem 2nd Order (100 ft setback)	66	1,541	198	13%	97	49%
Salem 3rd Order (100 ft setback)	41	836	133	16%	69	52%
Salem 4th Order (100 ft setback)	8	588	96	16%	48	50%
Total	239	6,766	636	9%	321	50%
# of Parcels With No Wetlands in Setback						
Salem 1st Order (50 ft setback)	34	413	34	8%	0	0%
Salem 2nd Order (100 ft setback)	17	255	17	7%	0	0%
Salem 3rd Order (100 ft setback)	5	6	1.2	20%	0	0%
Salem 4th Order (100 ft setback)	0	0	0	0%	0	0%
Total	56	674	52	8%	0	0%
# of Parcels With >50% Wetlands in Setback						
Salem 1st Order (50 ft setback)	73	1,967	120	6%	92	77%
Salem 2nd Order (100 ft setback)	26	720	99	14%	72	73%
Salem 3rd Order (100 ft setback)	23	384	72	19%	58	81%
Salem 4th Order (100 ft setback)	3	8	2	25%	1.8	90%
Total	125	3,079	293	10%	223.8	76%

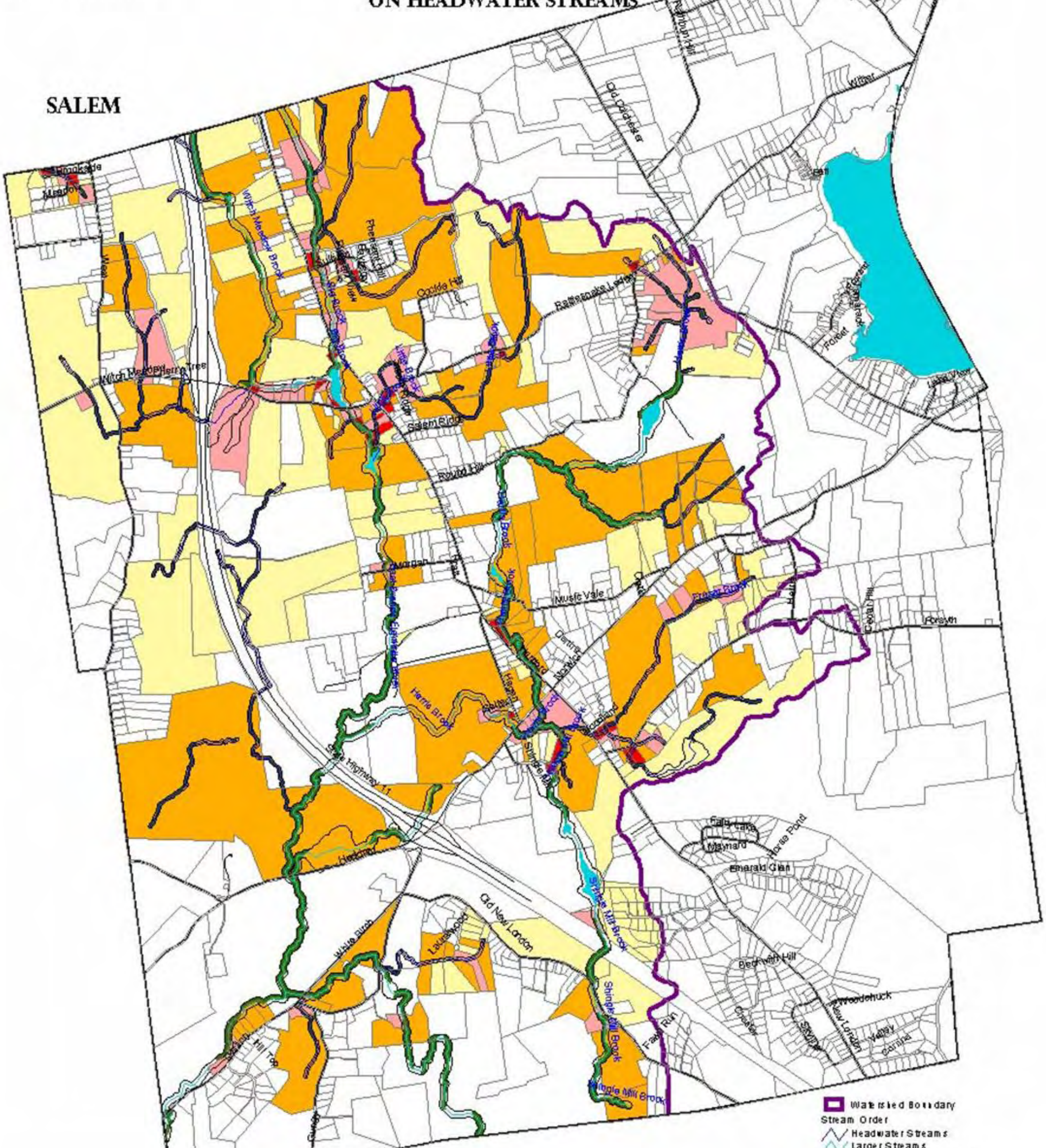
EIGHTMILE RIVER

WILD & SCENIC RIVER STUDY

SALEM

PARCELS THAT INTERSECT PROPOSED RIVER PROTECTION OVERLAY AREA

100' OVERLAY SETBACK ON LARGER STREAMS, 50' OVERLAY SETBACK ON HEADWATER STREAMS



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Ken Geisler: July 20, 2005

Eightmile River Watershed Summary - Analysis of Parcels Intersecting Proposed River Protection Overlay Area

50 Feet on First Order Headwater Streams, 100 Feet on All Larger Streams

Analysis Does Not Include Parcels That Are Already Protected Open Space or Abutting Hamburg Cove

August 11, 2005 DRAFT

Stream Order	# of Parcels	Total Acres of Parcels	Acres in Setback	Setback as Percent of Total Parcel	Acres of Wetlands in Setback	Percent of Wetlands in Setback
Total 1st Order	279	7,102	410	6%	197	48%
Total 2nd Order	289	9,544	1,126	12%	598	53%
Total 3rd Order	97	1,440	280	19%	166	59%
Total 4th Order	30	751	138	18%	70	51%
Total 5th Order	22	299	54	18%	20	37%
Total All	717	19,136	2,008	10%	1,051	52%

Management Issue # 2 - Habitat Fragmentation

Background

The enclosed article “Carving up the Landscape – Habitat Fragmentation and What to Do About It” from the UCONN NEMO program provides a good background on the causes and impacts of habitat fragmentation. The Eightmile River Watershed has substantial unfragmented areas – 26% of the unfragmented blocks are greater than 500 acres in size, 15% are greater than 1,000 acres in size and 5% are greater than 2,500 acres in size. The map “Eightmile River Watershed – Existing Habitat Blocks” depicts the large intact areas still in existence in the Watershed. The second map “The Potential Affects of Buildout on Unfragmented Habitat Blocks – Eightmile River Watershed” depicts locations in each town where large unfragmented habitat blocks exist, the location of existing protected lands associated with the habitat blocks, and the potential increase in density of residential units if each community were fully built out. As can be seen significant habitat fragmentation is potentially feasible, changing considerably the habitat characteristics and ultimately species composition of the Eightmile River Watershed.

Recommendation

Commit to making protection of important habitat blocks an open space conservation priority and be a partner in pursuing federal funding to support such types of acquisitions.

Actions

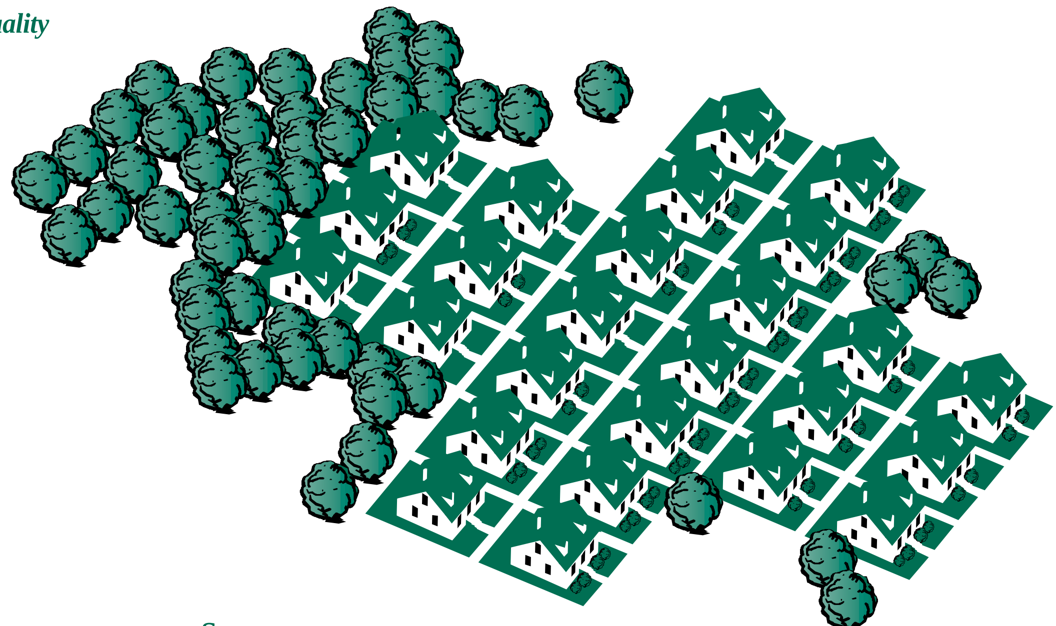
The most effective strategy to protect key habitat blocks in the watershed is though working with willing landowners on a voluntary basis to achieve open space conservation of important habitat areas.

1. Endorse the remaining unfragmented habitat blocks as high priority open space conservation areas through pertinent town planning documents such as the Town Plan of Conservation and Development and the Town Open Space Plan.
2. Establish a land protection goal for each community and the watershed as a whole.
3. Commit to working with other partners, such as local land trusts, the Nature Conservancy and the State to leverage resources and collaborate when opportunities arise to protect priority lands.
4. Endorse support for federal funding assistance to help support such open space conservation actions. While the federal government will not own or manage any land associated with a Wild & Scenic designation, a designation may create an opportunity to access federal funds that local agencies could use to support open space conservation. Clearly stating such an interest in the Management Plan will be helpful in pursuing such funding resources.

Linking Land Use to Water Quality

Carving up the Landscape

Habitat Fragmentation and What to Do About It



SUMMARY

The rise of suburban sprawl as the prevalent developmentt pattern in America has resulted in extensive disruption, or fragmentation, of the landscape. Fragmentation reduces the diversity of wildlife, contributes to the degradation of water resources, and impacts community character. Retaining the environmental, social and economic benefits of unfragmented open land requires a strategy that combines natural resource-based community planning and design, land conservation, and wise management of both developed and natural areas.

A Joint Publication of UConn Cooperative Extension's NEMO Project and Forestry Program

WHAT IS FRAGMENTATION?

As development occurs, elements like roads, houses, railways, parking lots and utility lines divide the natural landscape into ever-smaller pieces, or fragments. Natural habitat areas are reduced in size and quality, and native populations of plants and animals decline. Some of the more sensitive species disappear. Compared to the obvious damage of a filled wetland or a clear-cut forest, the effects of fragmentation are subtle. However, we have begun to realize that "everyday" development can disrupt and degrade ecosystems even where substantial natural lands remain.

Every type of animal or plant has certain requirements to "make a living" — key elements like food, water, and shelter needed for survival. The minimum area required to provide these needs and the amount of human disturbance that can be tolerated within this area vary widely by species, and are subject to much scientific scrutiny. As research continues, it is becoming clear that for many types of wildlife, it's not the total acreage of habitat that counts, but how much of that habitat exists in large, undisturbed tracts.

SO WHAT?

Does it really matter if you haven't seen a warbler in your neighborhood lately, or if there are no more otter or bobcats in the woods? The answer is yes. Biological diversity is a measure of both our natural wealth and health, and a certain level of it is essential for our environment to function. If too much diversity is lost, the food web breaks down and an ecosystem becomes unable to renew itself: its species, its soils, and its habitats. Natural processes like decomposition and nutrient cycling, upon which we all depend, begin to break down.

Fragmentation also impacts water resources. Nonpoint source pollution, carried by runoff from developed areas into watercourses and wetlands, is now the number one water quality problem in the country. As development occurs, pavement and other impervious surfaces disrupt the water cycle, channel pollutants into waterways, and otherwise contribute to the degradation of our water resources *(NEMO fact sheet #2 and #3).* Suburban sprawl, the post-World War II pattern of development founded on automobile transportation, creates more impervious surfaces and eats up more open space than more compact styles of development *(NEMO fact sheet #9).*

Natural resources are not the only thing affected as the landscape is transformed from green to gray. The homogenizing effects of sprawl wreak havoc on community character, as strip malls replace traditional village or urban centers. Furthermore, studies from around the country indicate that sprawl is costly, while other studies show that open space is important both to the economic and social health of a community. Public opinion surveys consistently highlight the importance of natural lands, clean drinking water and healthy waterways to citizens.

HOW DOES FRAGMENTATION WORK?

Fragmentation can have many different impacts on native species (see box). For instance, as wooded areas shrink, forest birds like the cerulean warbler, which build nests on or near the ground, become susceptible to housecats and other suburban predators. Similarly, amphibian populations decline as ponds and vernal pools become surrounded by developed areas. Research in southern New England suggests that to survive, frogs and salamanders need undisturbed woodland contiguous to their aquatic habitat. For these small species even minor aspects of development can have a major impact — road curbs, for example, can serve as barriers preventing movement to and from vernal pools *(See Figure 1).*

Fragmentation also affects large mammal and bird species. Large predators needing sizeable hunting ranges, like bears, bobcats, and owls, seem most affected. Some species are so adaptable to human landscapes that they make generalizations hard to make; for instance, deer populations in southern New England are at record highs. Even this gain may be connected to fragmentation, since most experts believe that the deer explosion is due, in part, to the absence of large predators (including hunters). Fragmentation can also directly affect human health; for instance, most experts believe that Lyme disease, carried

Figure 1: What constitutes fragmentation is highly species-dependent. A power line may be a barrier to forest birds, while a salamander's eye view of fragmentation might be a simple road curb.

FRAGMENTATION IMPACTS

- *habitat destruction*
- *critical changes to vegetation and hydrology*
- *increased predation by domestic animals*
- *increased access for other predators*
- *barriers to wildlife movement*
- *road kill*
- *health effects caused by pesticides and other pollutants*
- *behavioral effects caused by noise, lights, and other disturbances*

Also available:
NEMO **Fact Sheet #1:** *Project Brief*
NEMO **Fact Sheet #2:** *Nonpoint Source Water Pollution*
NEMO **Fact Sheet #3:** *Impacts of Development on Waterways*
NEMO **Fact Sheet #4:** *Strategies for Coping with Polluted Runoff*
NEMO **Fact Sheet #5:** *How to Get Started: Protecting Your Town from Polluted Runoff*
NEMO **Fact Sheet #6:** *Asking the Right Questions: Raising the Issue of Polluted Runoff at a Public Meeting*
NEMO **Fact Sheet #7** *Reviewing Site Plans of Stormwater Management*
NEMO **Fact Sheet #8** *They Can't Do That (Can They?!!)*
NEMO **Fact Sheet #9** *Conservation Subdivisions*

by the "deer" (wood) tick, has spread as deer populations have grown.

The toll of disappearing species is mounting. While our understanding is incomplete, it's generally true that the wildlife base dwindles as the average size of natural parcels decreases *(Figure 2*).

What Can Be Done?

In the past 30 years, much of New England has actually experienced a growth in wooded areas, as unused farmland reverts to forest. This has allowed animals like moose, fisher, and even bear to return to some areas they had long abandoned. So, it is possible that some species of wildlife can make a comeback, if given the opportunity in the form of suitable habitat. However, the landscape conversion now taking place — that of forest and field to developed land — entails more permanent changes from which recovery is unlikely, if not impossible.

Development will continue, but we can do a much better job guiding how and where development occurs. Minimizing fragmentation requires an approach that combine several overlapping strategies:

1. natural resource-based community planning and design;
2. land conservation;
3. wise management of both conservation land and developed land.

Strategy #1: Natural Resource-Based Land Use Planning & Design

Comprehensive, natural resource-based community planning is the most effective way to combat fragmentation. Natural resource-based planning typically involves these steps:

- conducting a natural resource inventory;
- reaching consensus on priority natural resources on which to focus protection efforts;
- directing development (through town plans and zoning regulations) to areas where it has the least impact on priority natural resources.

Unlike traditional development-driven planning, natural resource-based planning considers the long-term economic and environmental health of the community *(NEMO Soapbox Editorial #3)*.

An open space plan identifying community goals, uses, and funding for open space preservation is a critical component of the natural resource-based planning approach

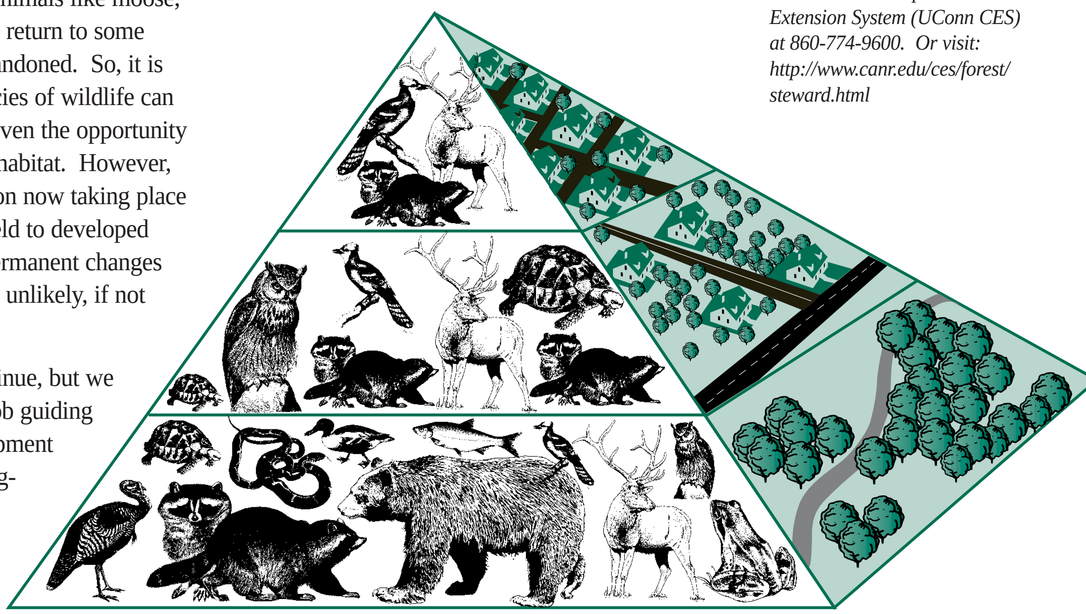
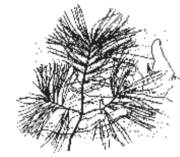


Figure 2: In general, as "patch size" of unfragmented land decreases, so does the diversity of native wildlife (species shown are for illustrative purposes only).

(UConn CES Open Space Packet). In Connecticut, Planning Commissions and Conservation Commissions need to take the lead in municipal open space planning. Planning Commissions should see that the town Plan of Conservation and Development includes or references an open space plan. The enabling legislation for Conservation Commissions charges them with conducting natural resource inventories and ad vising the other land use boards on conservation of priority resources; this mandate makes Conservation Commissions the ideal group to provide leadership in open space planning, particularly in the context of a regional approach where inter-town



FOR MORE INFORMATION

The University of Connecticut Forestry Program educates forest owners on managing forest and wildlife resources, and on methods for long term protection of their lands, including estate planning. Call the University of Connecticut's Cooperative Extension System (UConn CES) at 860-774-9600. Or visit: http://www.canr.edu/ces/forest/steward.html

NEMO stands for "Nonpoint Education for Municipal Officials". The NEMO Project offers educational programs on linking land use with water quality, impervious surface reduction, watershed management, open space planning, and homeowner practices to protect water quality.

For more information, contact the NEMO Project c/o Chester Arnold, University of Connecticut CES, 1066 Saybrook Road, Haddam, CT 06438-0070 Tel: (860) 345-4511 Fax: (860) 345-3357 Internet: carnold@canr1.cag.uconn.edu.

On the World Wide Web? *Check out the NEMO Home Page! Learn more about NEMO, and order publications electronically. [http://www.canr.uconn.edu/ces/nemo/]*

cooperation is needed. Local land trusts can be key players as well. Although land trusts are private organizations, they can provide leadership and expertise to municipal open space planning efforts.

As noted, good natural-resource based planning addresses where development should occur and what type of development is desired. Zoning and subdivision regulations then implement plan goals, including design elements that can reduce fragmentation. At the neighborhood level, for instance, conservation or cluster subdivisions can help to conserve open and sensitive areas like wetlands, wildlife corridors, and agricultural fields *(NEMO fact sheet #9)*. On the individual site level, design elements that reduce impervious surfaces, retain natural vegetation, protect riparian corridors, and make use of vegetated stormwater systems help to reduce fragmentation and support wildlife populations, while serving to protect water quality.

STRATEGY #2: LAND CONSERVATION

Permanent conservation of land — both private and public — constitutes a major portion of any strategy to preserve open space and minimize fragmentation. It's beyond the scope of this fact sheet to review conservation mechanisms *(see Open Space packet)*. However, below are a few general concepts regarding open space and fragmentation that are important when considering conservation priorities.

Conservation Objective #1: Protect a few large tracts of natural land.

For biodiversity, bigger is better. Ecologists tell us that we need to maintain relatively large areas of continuous, unfragmented natural lands with a diversity of habitat types — grassland, shrubland, and forest. This may seem like a tall order, but it's still achievable in many parts of the country. You might be surprised to learn how much conservation land already exists in your area.

To ensure the protection of sensitive species, you need a lot of unfragmented land. Research in southern New England, for example, shows that forest interior birds seem to require a minimum of 1500 acres, while 5000 acres or more is ideal. This may be an extreme example, but even tracts this size may be possible to protect when you take a regional view, such as a watershed perspective. By building partnerships and combining forces with neighboring counties, towns, state and federal agencies, and non-profit organization, it may well be possible to protect a large block in perpetuity.

Conservation Objective #2: Protect a network of smaller tracts.

Experts also suggest that we need a scattering of moderate size natural areas, in the 125 to 500 acre range. These "satellite" preserves can support species that don't need really large forests in which to breed, and may even support small populations of the more sensitive species. Wildlife from these satellite areas can repopulate the larger tracts should something catastrophic happen there. Ideally, these smaller tracts should be as close as possible to any larger tracts, contain a diversity of habitat/landscape types, and be connected to other natural areas *(see below)*. As tracts decrease in size, their shape can become an important factor. Most biologists agree that straight-line boundaries encourage harmful "edge effects" that include predation and competition from generalist species. Gradual, nonlinear transitional edges help to minimize these impacts.

Conservation Objective #3: Make connections.

Isolated pockets of natural lands are of value to the community, but to maximize ecological value it's important to connect open space wherever possible. Parcels contiguous to existing large and medium-sized tracts should be given high priority for conservation. Stream valleys and ridge tops also should be targeted — these areas often do "double duty," serving as both critical habitat and wildlife corridors. Riparian (streamside) corridors, for example, are used by almost 70% of all vertebrate species. Protected land in riparian corridors should include the banks and floodplain areas, as well as contiguous upland forest on at least one side. The width of wildlife corridors is subject to debate, but some studies have suggested that corridors must be at least 100 meters in width to maintain at least some “interior” (as opposed to “edge”) conditions.

Small but strategic properties can often be protected through conservation easements or other creative techniques. At the community or regional scale, “greenway” initiatives are obviously good opportunities to make connections. (Note: conservation biologists are concerned about the spread of invasive species, so when connecting land please consider this factor.)

To make connections, it’s invaluable to see it on a map. This gets back to the value of natural resource inventories, and knowing what you’ve got. Examining a map showing the mosaic of existing open space in your town or watershed, and how it relates to waterways, wetlands, ridgetops and other key areas, is one of the best ways to get a handle on implementing the conservation strategies listed above.

Wise Land Management

Property owners (both public and private) can further protect natural resources and minimize fragmentation through management and design, whether their property is in a natural or developed state.

Management Objective #1: Manage conservation lands to provide diverse habitat. Not only do we need to add to conservation land, but we also need to manage conservation lands and other property to support key species. Whether natural lands are publicly or privately owned, management usually means making some decisions about what constitutes a “key” species. For instance, birds that live in grassy or shrubby habitats, like the bobolink, eastern meadowlark, and blue-winged warbler, have declined dramatically in the past 30 years as farmland shrinks. To preserve these species, some conservation lands must be managed to create or maintain shrub and grasslands (clearing, mowing, burning, etc.). On the other hand, some forest species require extensive tracts of undisturbed forest. The need for a diversity of habitats further underscores the value of having large parcels that can

The elusive bobcat near Wildcat Ridge – highly unlikely! How many ironically named subdivisions like this have you seen around your town?

accommodate different landscapes.

Management Objective #2: Manage individual properties to provide diverse habitat.

There are many species that don’t need large forests in which to live. These are species that you may catch glimpses of as you walk through nearby woods, or that may come into your backyard to feed, even if they live in more secluded areas. For these species, such as woodpeckers, many song birds, small mammals and some larger ones, even narrow woodland corridors can provide critical travel routes. As noted, often such pathways are located on ridgetops or along waterways. Permanent conservation of these small but important areas is ideal, but wise management by private landowners can also work. Streamside buffers of natural vegetation, and the use of naturalistic landscaping in these areas instead of lawns, are important contributions that individual homeowners can make. For owners of large forested properties, a forest stewardship plan (see page 6) can help enhance their property’s value to wildlife while accommodating timber harvesting or other economic activities.

The Wildlife Conservation Research Center (WCRC) of the University of Connecticut offers a practical means for helping communities and individuals resolve difficult questions on habitat fragmentation and other wildlife issues. Supported by private donations and gifts, WCRC brings the resources of a Land Grant University to bear on wildlife issues. For information call 860-486-5896.

The Connecticut Forest Stewardship Program offers technical and financial assistance to private forest landowners in the planning and implementation of wildlife habitat enhancement and other forestland management activities. For information call 1-888-30WOODS or 1-860-345-4511. Or visit: http://www.canr.edu/ces/forest/

BUT WHAT CAN I DO? GET SPECIFIC!

Reducing habitat fragmentation may seem a bit overwhelming for the individual. But there are many things that you can do to help, based on the strategies listed above. Here are a few ideas:

- You can contribute time and/or money to land conservation in your area, whether it's accomplished through a local land trust, your town's land use boards, or nonprofit conservation organizations.
- You can ask whether these groups have open space plans. Many towns and local groups simply take any piece of property that comes their way, with no attempt to target critical areas like streamside corridors and areas contiguous to existing open space. Municipal open space plans should prioritize land to be acquired, and address funding mechanisms.
- You can check with your town's Conservation Commission — have they conducted a natural resource inventory, identified priority natural resources, or developed an open space plan? If the answer to these questions is *"we're too busy regulating wetlands to take on new responsibilities,"* suggest that the town consider separating their Inland Wetland and Conservation Commissions to allow for more proactive conservation.
- If you own farm or forest land and you wish to preserve it for future generations, you can investigate conservation easements, estate planning, and other tools that can make conservation a economically feasible option.
- You can manage your own property to improve wildlife habitat, employing naturalistic landscaping, stream buffers and other mechanisms. If you are a forest owner, you can implement a stewardship plan. Even if you live on a quarter acre lot in the middle of town, you can grow native, berry-producing shrubs and other plants that are food sources for local wildlife.
- You can ask your local land use boards to rethink their land use plans and regulations to ensure they protect critical natural resources and wildlife habitats. Does your town ask developers to propose open space or conservation subdivisions in key areas? If biodiversity doesn't move them, maybe the mounting list of studies showing the economic benefits of open space will!
- You can volunteer (or run) to serve on a land use board yourself, and have a direct hand in the decisions that shape the future of your town *(NEMO fact sheet #8)*.
- You can support wildlife conservation and habitat management programs in local schools.

CONCLUSION

Fragmentation impoverishes both the natural and human landscapes. Researchers still have much to learn about the effects of habitat fragmentation, but the basic concept is simple — a parking lot can't support a bobcat, nor can a suburban lawn accommodate grassland bird species. Whenever a streamside forest is replaced by manicured lawn, a wildlife corridor is severed and fish habitat is degraded. When forest understory plants are removed to create a park-like appearance, certain plant and animal species may lose their last foothold for miles around. When a large forest is fragmented into house lots, rare songbirds and other deep woods species lose another place to reproduce and thrive. And, as habitat goes, so does water quality and community character. As individuals and communities, we can help to reduce the impacts of fragmentation through a combination of planning, design, conservation, and management.

This fact sheet was written by Chester Arnold, UConn CES, Rosemary Monahan, EPA Region One, and Stephen Broderick, UConn CES. Printed March 1999.

NEMO is a project of the University of Connecticut's Cooperative Extension System, collaborating with the University of Connecticut Natural Resources Management and Engineering Department and the Connecticut Sea Grant College Program. Major funding provided by The Water Quality Program, USDA Cooperative State Research, Education and Extension Service.

3/99

University of Connecticut
Cooperative Extension System
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

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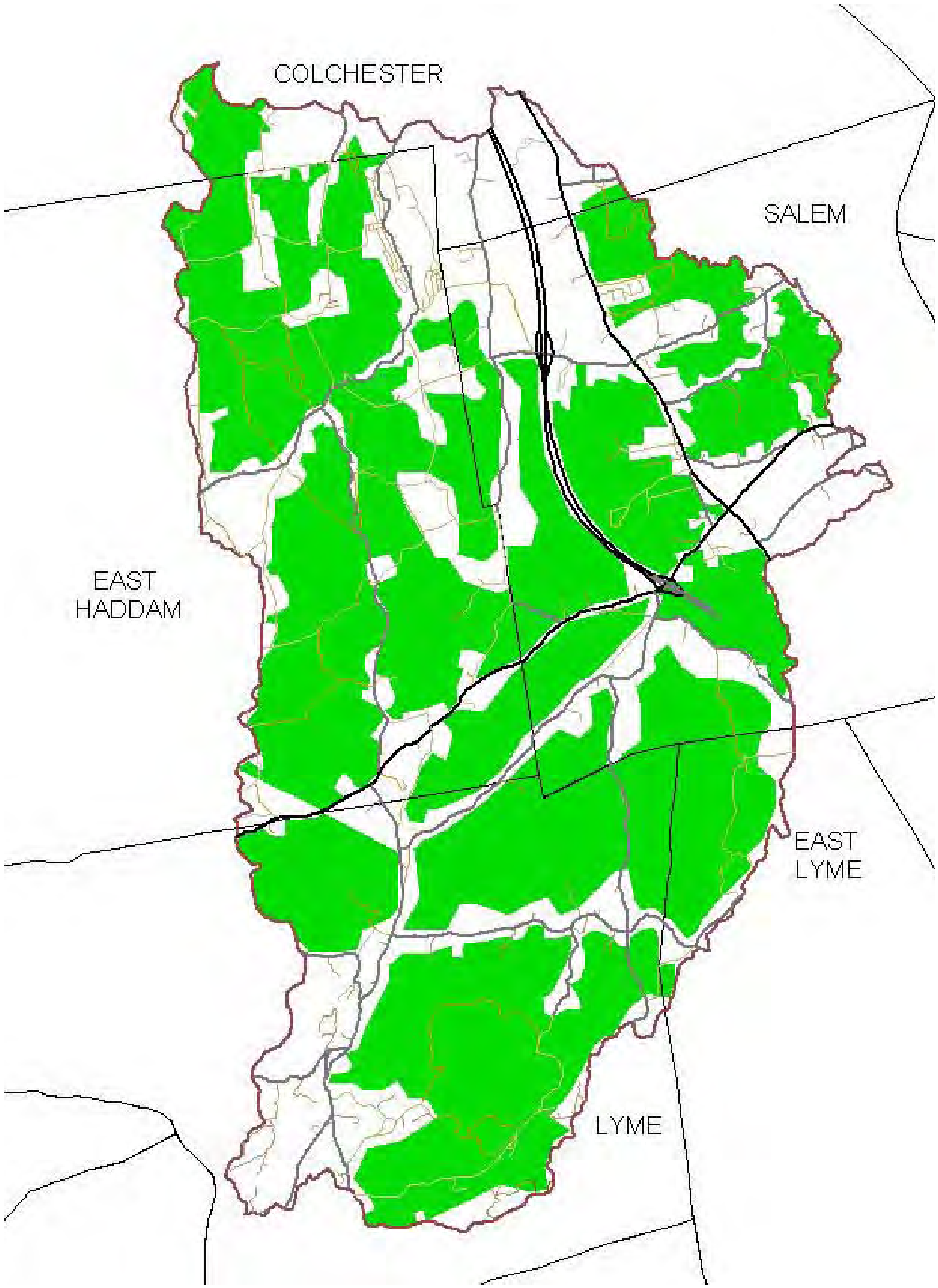
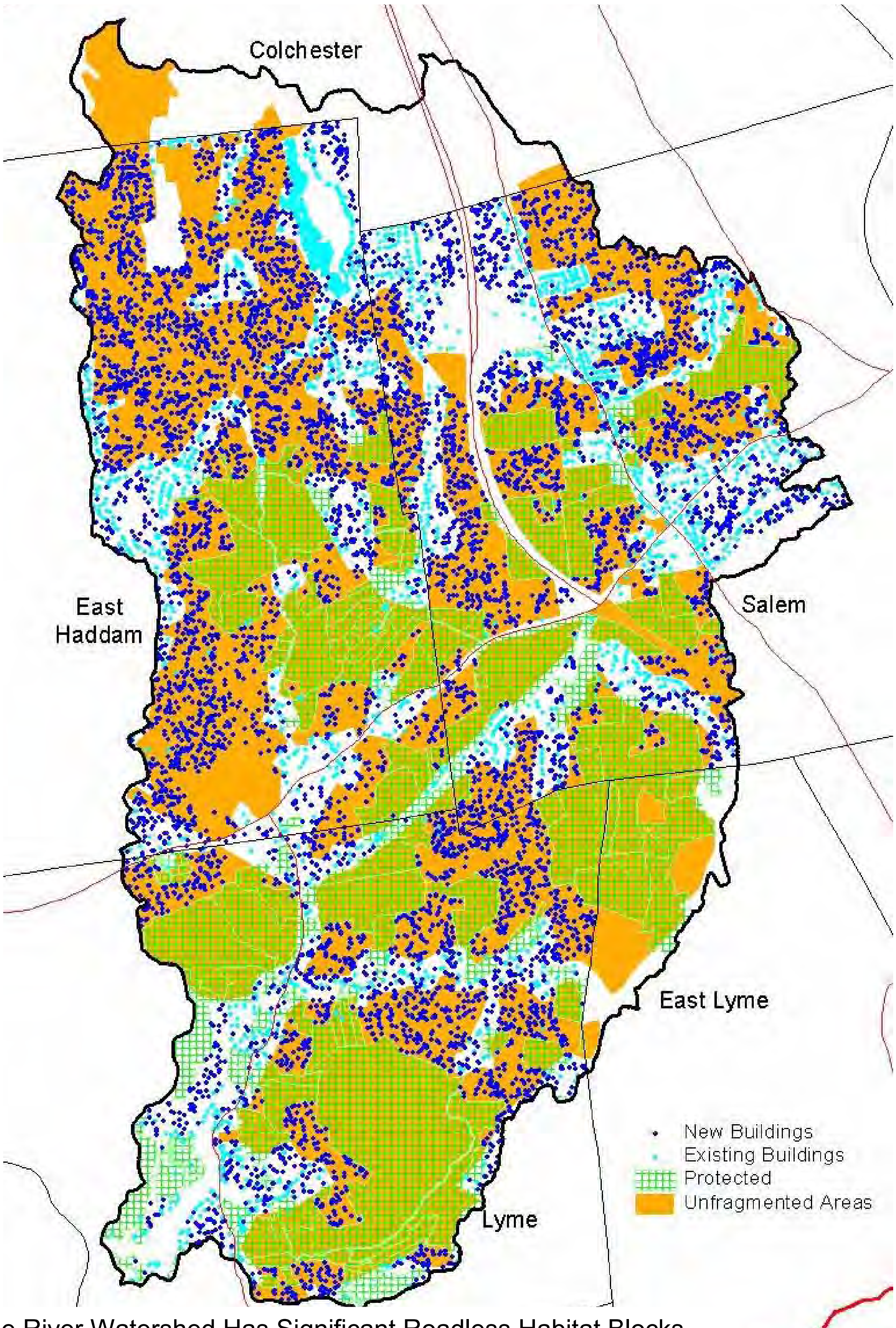
Eightmile River Watershed
Existing Habitat Blocks



The Eightmile River Watershed Has Significant Roadless Habitat Blocks

- 26% of the Blocks >500 Acres
- 15% of the Blocks >1,000 Acres
- 5% of the Blocks >2,500 Acres

The Potential Affects of Buildout on Unfragmented Habitat Blocks—Eightmile River Watershed



The Eightmile River Watershed Has Significant Roadless Habitat Blocks

- 26% of the Blocks >500 Acres
- 15% of the Blocks >1,000 Acres
- 5% of the Blocks >2,500 Acres

Management Issue #3 - Increases in Impervious Surfaces

Background

The enclosed article from the UCONN NEMO program, “Impacts of Development on Waterways” provides a good primer on the issues associated with impervious cover and the affects it has on water quality, aquatic habitat, and stream morphology among other things. Since this article was published more recent research has shown that impervious cover levels as low as 4-5% in a watershed can cause aquatic ecosystems to begin to degrade (“The Effects of Urbanization on the Biological, Physical and Chemical Characteristics of Coastal New England Streams” U.S. Geological Survey 2004). As depicted in the enclosed map the Eightmile River Watershed currently has a fairly low impervious cover level of approximately 3%. This level is a key reason why the Eightmile River Watershed is still an intact and functioning watershed ecosystem, the key outstanding resource value for the Wild & Scenic Study. The second map shows the potential impervious levels possible for each of the local subwatersheds within the Eightmile River Watershed if the communities were fully built out. As can be seen local watersheds could experience substantial increases in imperviousness causing significant degradation of water quality, aquatic habitats and watershed hydrology.

Recommendation

Each community commits to a maximum impervious surface limit of 10% for any local watershed and 4% for the Eightmile River Watershed as whole. This approach asks each community to work with the Eightmile River Committee to refine and assess the current and future levels imperviousness in your community and adopt appropriate tools to address impervious surface growth in your community. The East Haddam model is one recommended approach.

The East Haddam Model

East Haddam is exploring an approach to managing impervious surfaces based on the possible implementation of zone changes. The approach involves adjusting the zoning classification for an area to manage residential density. By doing so the maximum number of residential units per local watershed is adjusted to a level that will not cause the exceedance of established impervious surface limits. If, for example, it was determined a local watershed at buildout would exceed the impervious surface limits, the zoning classification of the watershed could be adjusted to match the maximum amount of residential units possible in order to not exceed those limits. The advantage of this approach is that once the zoning is re-adjusted there is no other process the commission or applicants must go through to address imperviousness issues - the goal is built into the zoning classification.

Following is numerical example of how the process might work, based on a generic watershed that is 6,000 acres in size and has 2-acre zoning.

Step 1: Set maximum impervious surface limits for each watershed in the community.

10% maximum impervious cover limits is established per local watershed

Step 2: Determine acreage of existing impervious cover in watershed.

Current Imperviousness in 6,000 acre Generic Watershed = 5% or 300 acres

Step 3: Determine acreage of imperviousness at maximum impervious limit of 10%

Maximum Impervious in 6,000 acre Generic Watershed = 600 acres

Step 4: Determine the remaining buildable land in the watershed.

Remaining Buildable Land in Generic Watershed = 2,000 acres

Step 5: Determine potential new residential units if fully built out.

Potential New Residential Units = (2000acres/2-acre zoning) x 0.8 (efficiency factor to account for land taken up by new roads or other natural feature limitations) = 800 new units

Step 6: Determine potential new impervious cover based on number of new residential units.

Potential New Impervious = 800 units x 2 acres per unit x 0.2267 (ISAT coefficient developed by UCONN to calculate impervious cover for developed areas) = 362 acres

Step 7: Calculate total imperviousness at full buildout.

Total Impervious at Buildout = 300 ac. + 362 ac. = 662 ac. or 10.9% of generic watershed area. This exceeds the 10% limit.

Step 8: Determine the maximum increase in impervious acreage in the generic watershed based on the impervious surface limit.

Maximum Imperviousness of 600 acres less existing imperviousness of 300 acres = Maximum Impervious Increase = 300 Acres

Step 9: Determine the maximum number of residential units that would not cause an exceedance of the impervious surface limit of 10%.

Target Maximum Residential Units = 300 acres / (2 acres x 0.2267 (ISAT coefficient)) = 662 units

Step 10: Determine what the maximum lot size could be to support the impervious surface limit of 10%. This would be the lot size used to determine the new zoning classification for the generic watershed.

Total Potential Lots = Maximum Residential Units That Would Not Cause an Exceedance on Impervious Surface Limits (662) divided by the efficiency factor (0.8) = 828 lots

Maximum Acres Per Unit = 2000 acres / 828 units = 2.42 acres per unit

Actions

1. Each community adopts maximum impervious surface limits of 10% per local watershed and 4% for the Eightmile River Watershed as a whole.

2. Working with the Eightmile River Committee, undertake a detailed assessment of current and potential imperviousness in each local watershed for each community. Through such an analysis identify the amount of impervious cover still possible in each local watershed before the maximum impervious cover limit is reached.

3. Analyze the implementation of different tools to manage impervious surface levels, including the East Haddam model. Determine the most effective, appropriate and realistic tool for managing impervious surfaces and pursue its adoption.

IMPACTS OF DEVELOPMENT ON WATERWAYS

Linking Land Use to Water Quality

Key Finding

Standard land development can drastically alter waterways. Increase stormwater runoff associated with development often begins a chain of events that includes flooding, erosion, stream channel alteration and ecological damage. Combined with an increase in man-made pollutants, these changes in waterway form and function result in degraded systems no longer capable of providing good drainage, healthy habitat or natural pollutant processing. Local officials interested in protecting town waters must go beyond standard flood and erosion control practices and address the issue of polluted runoff through a multilevel strategy of planning, site design and stormwater treatment.

"Polluted runoff is now widely recognized by environmental scientists and regulators as the single largest threat to water quality in the United States."

Disruption of the Water Cycle

When development occurs, the resultant alteration to the land can lead to dramatic changes to the *hydrology*, or the way water is transported and stored. Impervious man-made surfaces (asphalt, concrete, rooftops) and compacted earth associated with development create a barrier to the percolation of rainfall into the soil, increasing surface runoff and decreasing groundwater infiltration (Figure 1). This disruption of the natural water cycle leads to a number of changes, including:

- increased volume and velocity of runoff;
- increased frequency and severity of flooding;
- peak (storm) flows many times greater than in natural basins;
- loss of natural runoff storage capacity in vegetation, wetland and soil;
- reduced groundwater recharge; and
- decreased base flow, the groundwater contribution to stream flow. (This can result in streams becoming intermittent or dry, and also affects water temperature.)

Impacts on Stream Form and Function

Impacts associated with development typically go well beyond flooding. The greater volume and intensity of runoff leads to increased erosion from construction sites, downstream areas and stream banks. Because a stream's shape evolves over time in response to the water and sediment loads that it receives, development-generated runoff and sediment cause significant changes in stream form. To facilitate increased flow, streams in urbanized areas tend to become deeper and straighter than wooded streams, and as they become clogged with eroded sediment, the ecologically important "pool and riffle" pattern of the stream bed is usually destroyed (Figure 2).

These readily apparent physical changes result in less easily discerned damage to the ecological function of the stream. Bank erosion and sever flooding destroy valuable streamside, or riparian, habitat. Loss of tree cover leads to greater water temperature fluctuations, making the water warmer in the summer and colder in the winter. Most importantly, there is substantial loss of aquatic habitat as the varied natural

Hy•drolo•ogy:
A science dealing with the properties, distribution and circulation of water.

Ri•par•i•an:
Of or related to or living or located on the bank of a watercourse.

Hab•i•tat:
The place where a plant or animal species naturally lives and grows.

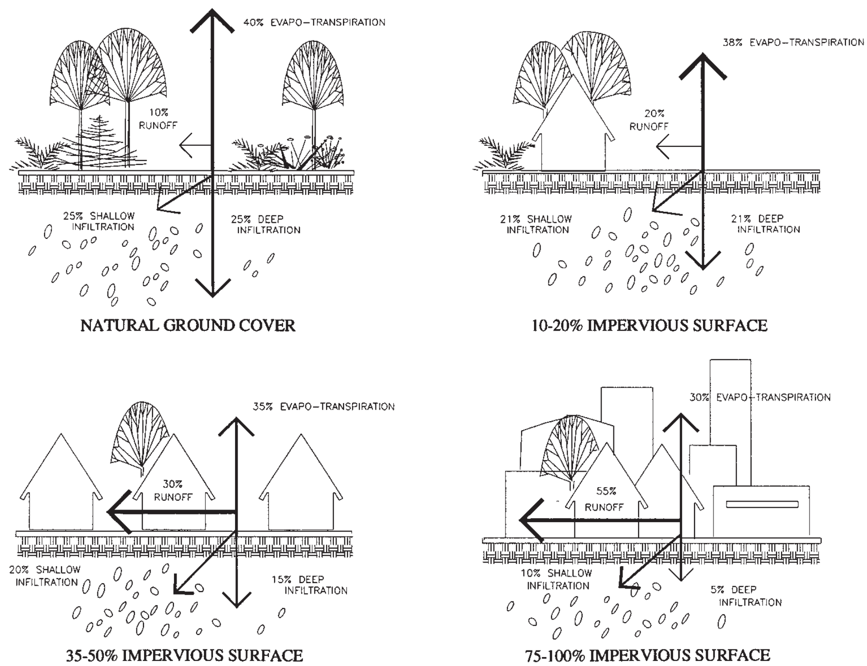


Figure 1. Water cycle changes associated with urbanization (after Toubier and Westmacott, 1981).

streambed of pebbles, rock ledges and deep pools is covered by a uniform blanket of eroded sand and silt.

All of this of course assumes that the streams are left to adjust on their own. However, as urbanization increases, physical alterations like stream diversion, channelization, damming and piping become common. As these disturbances increase, so do the ecological impacts—the endpoint being a biologically sterile stream completely encased in underground concrete pipes. In addition, related habitats like ponds and wetlands may be damages or eliminated by grading and filling activities.

Then There's Water Quality

With development comes more intensive land use and a related increase in the generation of pollutants. Increased runoff serves to transport these pollutants directly into waterways, creating *nonpoint source pollution, or polluted runoff.* Polluted runoff is now widely recognized by environmental scientists and regulators as the single largest threat to water quality in the United States. The major pollutants of concern are pathogens (disease-causing microorganisms), nutrients, toxic contaminants and debris. Sediment is also a major nonpoint source pollutant, both for its effects on aquatic ecology (see above), and because of the fact that many of the other pollutants tend to adhere to eroded soil particles. NEMO Fact Sheet #2 provides more detail on polluted runoff and its effects.

The Total Picture: A System Changed for the Worse

The hydrologic, physical and ecological changes caused by development can have a dramatic impact on the natural function of our waterways.

Figure 2. Changes in stream form associated with urbanization.

When increased pollution is added, the combination can be devastating. In fact, many studies are finding a direct relationship between the intensity of development in an area—as indicated by the amount of impervious surfaces—and the degree of degradation of its streams (Figure 3). These studies suggest that aquatic biological systems begin to degrade at impervious levels of 12% to 15%, or at even lower levels for particularly sensitive streams. As the percentage of imperviousness climbs above these levels, degradation tends to increase accordingly.

The end result is a system changed for the worse. Properly working water systems provide drainage, aquatic habitat and a degree of pollutant removal through natural processing. Let's look at those functions in an urbanized watershed where no remedial action has been taken:

Drainage: Increased runoff leads to flooding. Drainage systems that pipe water off-site often improve that particular locale at the expense of moving flooding (and erosion) problems downstream. Overall systemwide water drainage and storage capacity is impaired.
Habitat: Outright destruction, physical alteration, pollution and wide fluctuations in water conditions (levels, clarity, temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic riparian organisms. In addition, waterway obstructions like bridge abutment, pipes and dams create barriers to migration.

Pollutant removal: Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Damage to bank, streams and wetland vegetation further reduces their ability to naturally process pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by stormwater runoff impair natural processing by decreasing the time that water is in the system.

What Towns Can Do

Flood and erosion control have long been part of the municipal land use regulatory process, and are usually addressed with engineered systems designed to pipe drainage off-site as quickly and efficiently as possible. Flooding and erosion, however, are only two of the more easily recognized components of the overall impact of development on waterways.

Nonpoint Education for Municipal Officials (NEMO) is a University of Connecticut educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

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Illustrations by:
Dr. John Alexopoulos

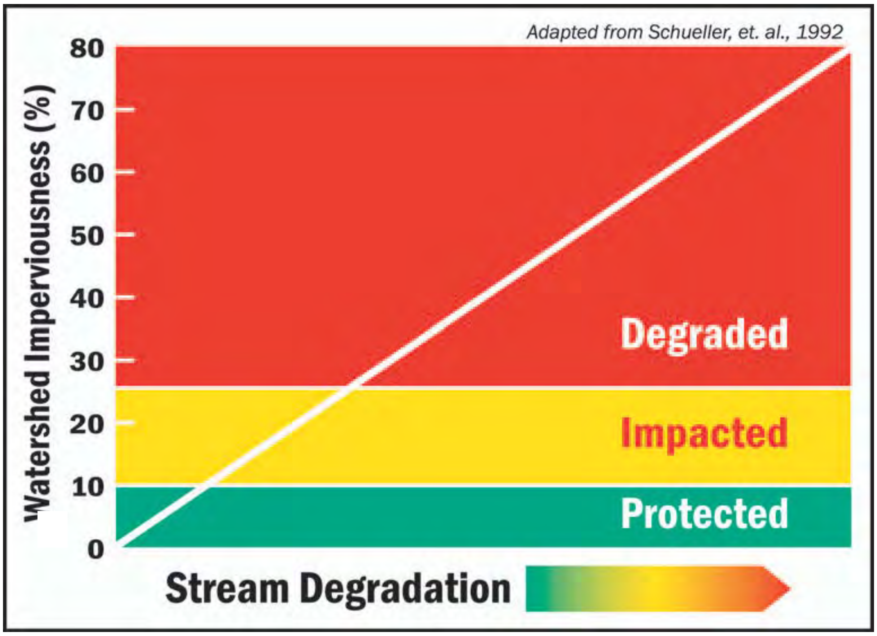


Figure 3. Stylized relationship between watershed imperviousness and receiving stream impacts (adapted from Schueler, 1992).

Standard drainage "solutions" address neither the root cause of these symptoms—increased runoff due to the way we develop land—nor the resultant environmental effects.

To begin to truly address the impacts of development, town officials need to look at their waterways as an interconnected system and recognize the fundamental changes that development brings to the water cycle, stream form and function, aquatic ecology and water quality. Incorporating this understanding into local land use decisions can help to guide appropriate development (see NEMO Fact Sheet #5). There are a number of options that can be employed to reduce the impacts of development on water quantity and quality. Preventing such impacts in the first place is the most effective (and cost effective) approach and should always be emphasized. To this end, town officials should consider a three-tiered strategy of natural resource based planning, appropriate site design and use of best management practices (stormwater treatment). NEMO Fact Sheet #4 goes into this strategy in more detail.

University of Connecticut
COOPERATIVE EXTENSION SYSTEM
College of Agriculture and Natural Resources

NEMO is an educational program of the University of Connecticut, Cooperative Extension System, Connecticut Sea Grant College Program and Natural Resource Management and Engineering Department. In addition to support from UConn, NEMO is funded by grants from the CT DEP Nonpoint Source Program and the NOAA National Sea Grant College Program. NEMO is a program of the Center for Land Use Education and Research (CLEAR). Land, Sea and Space Grant collaborating. For more information about CLEAR, visit clear.uconn.edu.

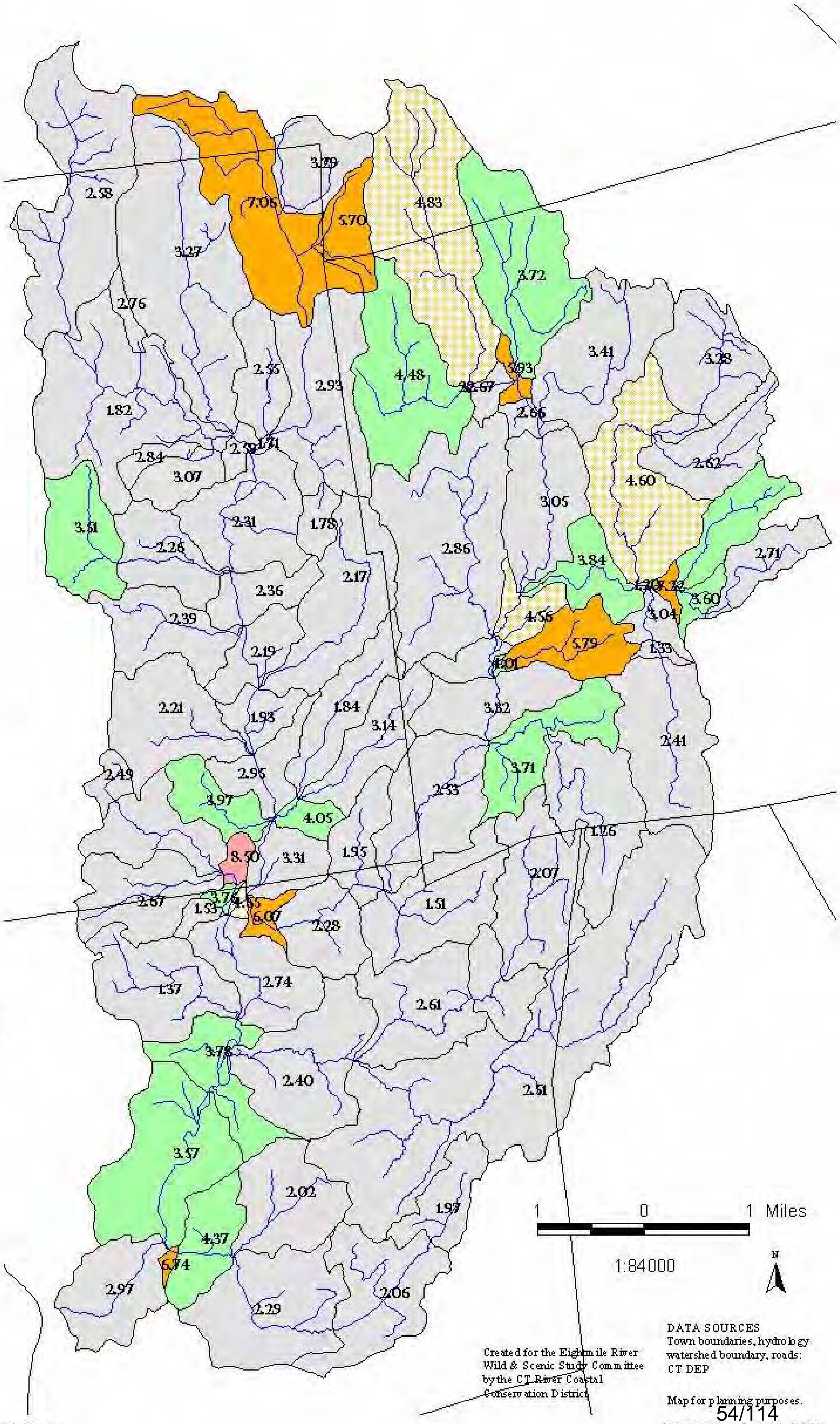
EIGHTMILE RIVER

WILD & SCENIC RIVER STUDY

Impervious Surface Current Conditions By Local Basin

Based On: 2002 Land Cover UCONN Center for Land Use Education & Research

% Impervious for Entire Eightmile River Watershed 2.97%



Percent of impervious surface calculated using the ISAT extension for Arcview 3.3. Coefficients revised by NEMO for the 2002 Land Cover.

Created for the Eightmile River Wild & Scenic Study Committee by the CT River Coastal Conservation District

DATA SOURCES
Town boundaries, hydrology watershed boundary, roads: CT DEP

Map for planning purposes.

c:\gis\8milews\projects\isat_mgmtplan_june05_2.apr

Ken Geisler, July 15, 2005

EIGHTMILE RIVER

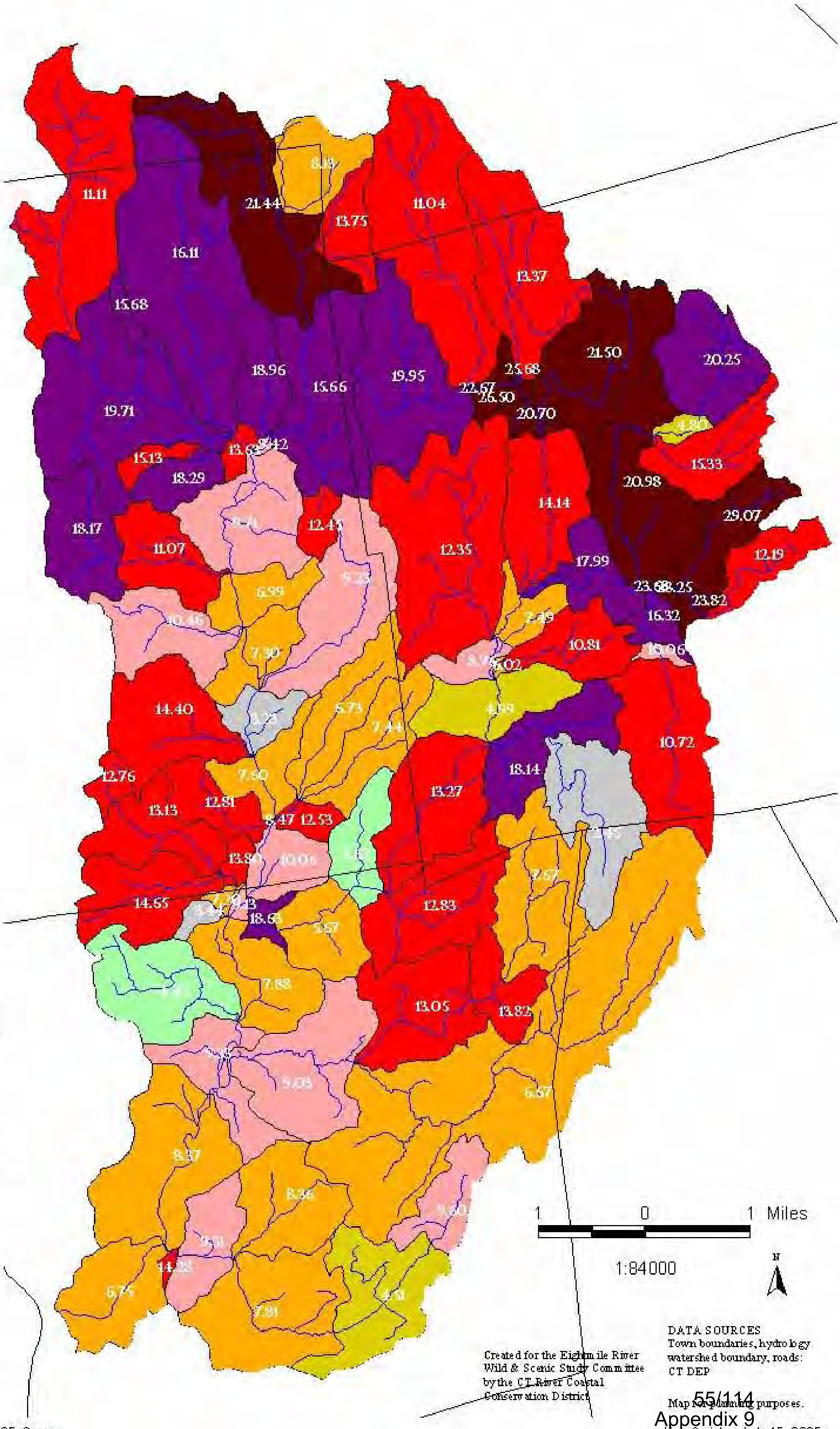
WILD & SCENIC RIVER STUDY

Impervious Surface Analysis

ASSUMES:
Current Buildings and New Buildings converted to 1/2, 1, or 2 acres of developed land based on zone.

2002 Land Cover (UCONN-CLEAR) Local Basins

% Impervious for entire watershed 12.6% as an average of the basins; 11.8% for the regional basin as one entity.



% Impervious @ BO

- 0 - 3
- 3 - 4
- 4 - 5
- 5 - 8
- 8 - 10
- 10 - 15
- 15 - 20
- 20 - 30

Percent of impervious surface calculated using the ISAT extension for Arcview 3.3. Coefficients revised by NEMO for the 2002 Land Cover.

Used Calculated Coefficients from Basins BODENS(buildout density) field based on existing buildings & new buildings determined in Buildout Analysis (Community Viz extension for ArcView 3.3).

Population density assumes 2.5 persons per household.

Buildable land excludes developed land, rivers, wetlands, and protected land. Commercial and Industrial land assumed developed. Used the Land Cover Change Scenario in ISAT to convert 2002 Land Cover to Developed for these areas in the calculation.

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Management Issue # 4 - Stormwater Management

Background

The enclosed excerpt from the CT DEP Stormwater Quality Manual (Chapter 2 Why Stormwater Matters: The Impacts of Urbanization) describes the many impacts caused by poorly managed stormwater runoff and how it has impacted waterbodies throughout Connecticut. Stormwater runoff could have profound affects on some of the Eightmile River Watershed's key outstanding resource values including water quality, hydrology and unique species and natural communities. The proposed actions are some of the most current best management practices available to provide communities guidance in how to effectively manage stormwater runoff and minimize its impacts.

Recommendation

Adopt a series of actions that will provide better guidance and apply state-of-the-art approaches to managing stormwater runoff.

Actions

1. Require the CT DEP Stormwater Quality Manual be used as guidance for the design, implementation and maintenance of all new and exiting stormwater systems in each community. See enclosed 2004 Connecticut Stormwater Quality Manual – Table of Contents.

2. Complete and implement a Stormwater Management Plan for each municipality's stormwater system as described in the State's General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems. See enclosed "General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems – Section 6. Development of Stormwater Management Plan" for guidance on the development of the plan.

3. Adopt The University of Massachusetts guidance for watercourse crossings, an approach that is used by Army Corps of Engineers (New England Region). See enclosed "Massachusetts River and Stream Crossing Standards: Technical Guidelines" for details.

2004 Connecticut Stormwater Quality Manual

by
The Connecticut Department of Environmental Protection

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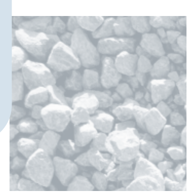

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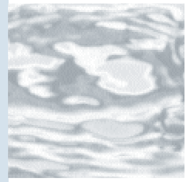

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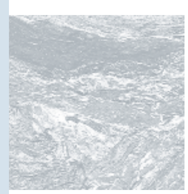

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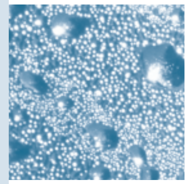

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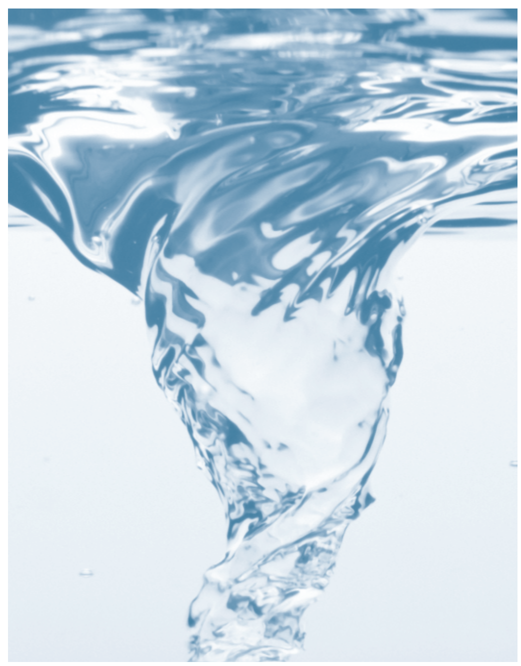
Chapter 2

Why Stormwater Matters: The Impacts of Urbanization



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Why Stormwater Matters: The Impacts of Urbanization

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2.1 What is Urban Stormwater Runoff?

Traditional development of the landscape with impervious surfaces such as buildings, roads, and parking lots, as well as storm sewer systems and other man-made features, alters the hydrology of a watershed and has the potential to adversely affect water quality and aquatic habitat. As a result of development, vegetated and forested land that consists of pervious surfaces is largely replaced by land uses with impervious surfaces. This transformation increases the amount of stormwater runoff from a site, decreases infiltration and groundwater recharge, and alters natural drainage patterns. This effect is shown schematically in **Figure 2-2.** In addition, natural pollutant removal mechanisms provided by on-site vegetation and soils have less opportunity to remove pollutants from stormwater runoff in developed areas. During construction, soils are exposed to rainfall, which increases the potential for erosion and sedimentation. Development can also introduce new sources of pollutants from everyday activities associated with residential, commercial, and industrial land uses. The development process is known as "urbanization." Stormwater runoff from developed areas is commonly referred to as "urban stormwater runoff."

Urban stormwater runoff can be considered both a point source and a nonpoint source of pollution. Stormwater runoff that flows into a conveyance system and is discharged through a pipe, ditch, channel, or other structure is considered a point source discharge under EPA's National Pollutant Discharge Elimination System (NPDES) permit program, as administered by DEP. Stormwater runoff that flows over the land surface and is not concentrated in a defined channel is considered nonpoint source pollution. In most cases stormwater runoff begins as a nonpoint source and becomes a point source discharge (MADEP, 1997). Both point and nonpoint sources of urban stormwater runoff have been shown to be significant causes of water quality impairment (EPA, 2000).

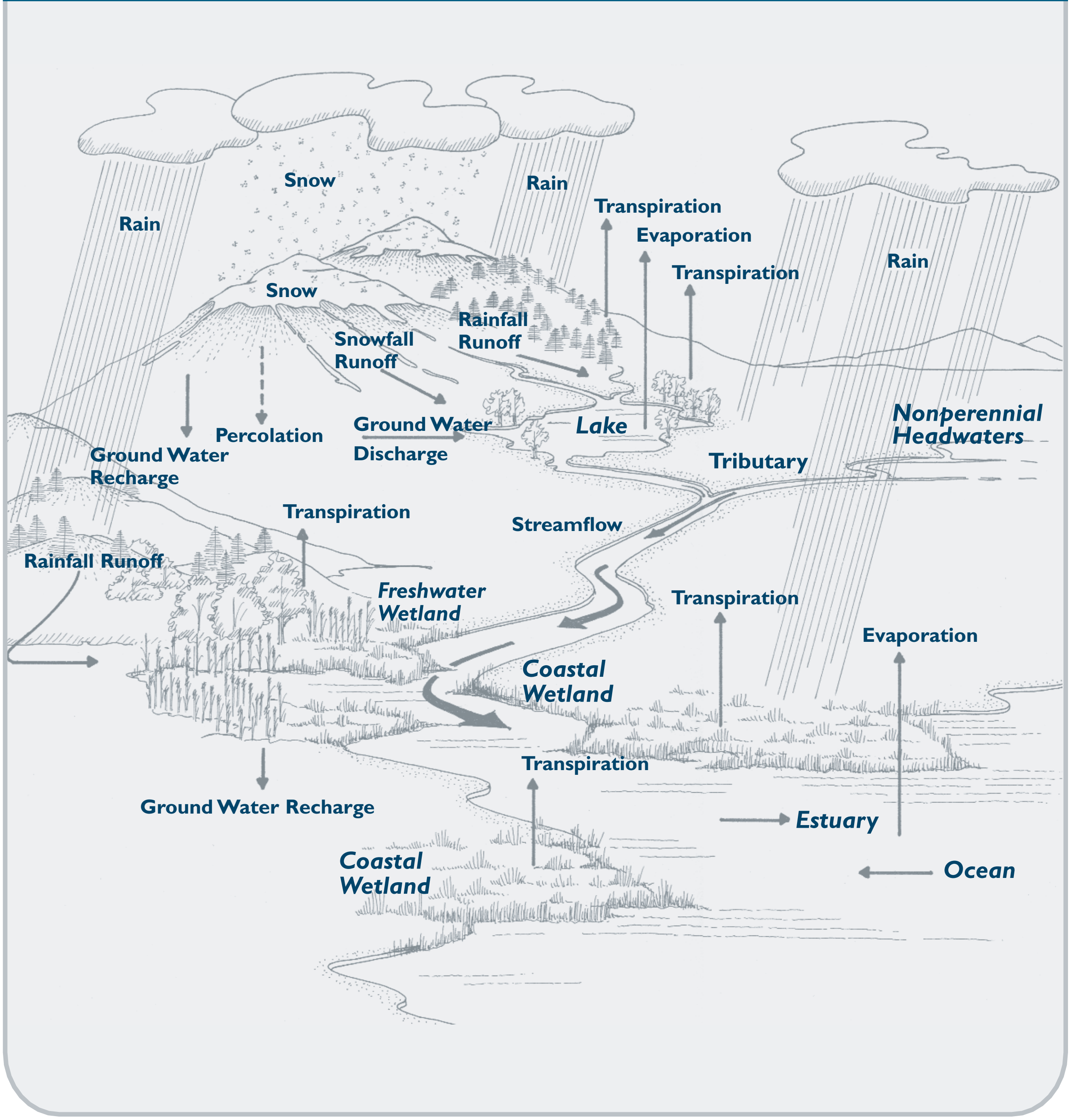
According to the draft 2004 Connecticut list of impaired waters ("303(d)") list prepared pursuant to Section 303(d) of the Federal Clean Water Act), urban runoff and stormwater discharges were a significant cause of aquatic life and contact recreation (e.g. swimming and boating) impairment to approximately one-quarter of the state's 893 miles of major rivers and streams. Urban runoff is also reported as a contributor to excessive nutrient enrichment in numerous lakes and ponds throughout the state, as well as a continued threat to estuarine waters and Long Island Sound (EPA, 2001). **Table 2-1** summarizes impaired Connecticut water bodies (i.e., those not meeting water quality standards) for which urban runoff, stormwater discharges, or other wet-weather sources are suspected causes of impairment (DEP, 2004 draft). This list does not include water bodies impaired as a result of other related causes such as combined sewer overflows (CSOs) and agricultural runoff or unknown sources.

Impervious cover has emerged as a measurable, integrating concept used to describe the overall health of a watershed. Numerous studies have documented the cumulative effects of urbanization on stream and watershed ecology (See, e.g., Schueler et al., 1992; Schueler, 1994; Schueler, 1995; Booth and Reinelt, 1993, Arnold and Gibbons, 1996; Brant, 1999; Shaver and Maxted, 1996). Research has shown that when impervious cover in a watershed reaches between 10 and 25 percent, ecological stress becomes clearly apparent. Beyond 25 percent, stream stability is reduced, habitat is lost, water quality becomes degraded, and biological diversity decreases (NRDC, May 1999). **Figure 2-3** illustrates this effect.

To put these thresholds into perspective, typical total imperviousness in medium density, single-family home residential areas ranges from 25 to nearly 60 percent (Schueler, 1995). **Table 2-2** indicates typical percentages of impervious cover for various land uses in Connecticut and the Northeast

Stormwater runoff is a natural part of the hydrological cycle, which is the distribution and movement of water between the earth's atmosphere, land, and water bodies. Rainfall, snowfall, and other frozen precipitation send water to the earth's surfaces. Stormwater runoff is surface flow from precipitation that accumulates in and flows through natural or man-made conveyance systems during and immediately after a storm event or upon snowmelt. Stormwater runoff eventually travels to surface water bodies as diffuse overland flow, a point discharge, or as groundwater flow. Water that seeps into the ground eventually replenishes groundwater aquifers and surface waters such as lakes, streams, and the oceans. Groundwater recharge also helps maintain water flow in streams and wetland moisture levels during dry weather. Water is returned to the atmosphere through evaporation and transpiration to complete the cycle. A schematic of the hydrologic cycle is shown in **Figure 2-1**.

Figure 2-1 Hydrologic Cycle



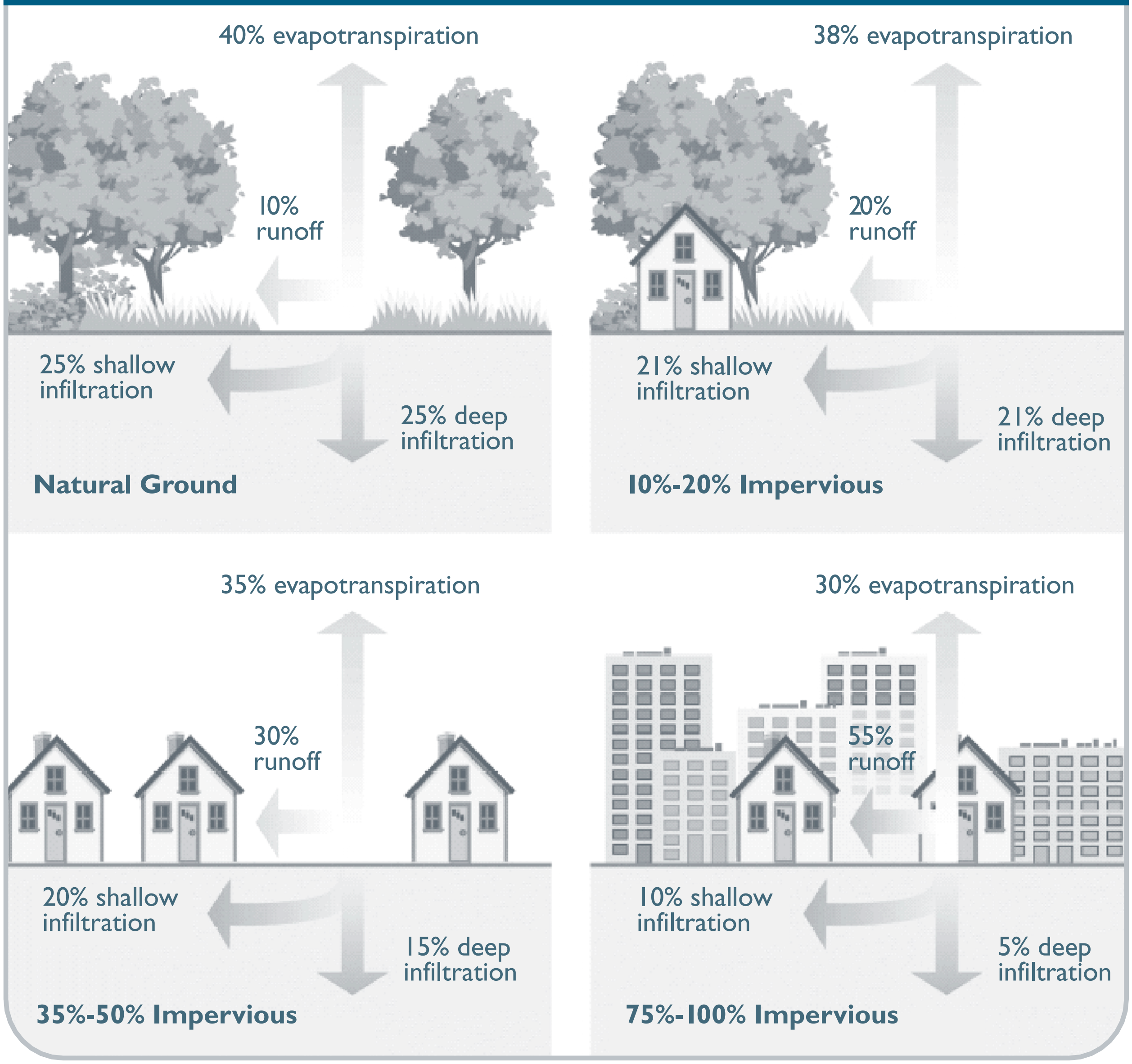
Source: National Water Quality Inventory, U.S. EPA, 1998.

Table 2-1 Connecticut Water Bodies Impaired by Urban Stormwater Runoff

Major Basin	Water Body	Major Basin	Water Body
Pawcatuck River Basin	Pawcatuck River Estuary	Thames River Basin	Thames River Estuary Eagleville Brook Quinebaug River
Southeast Coastal Basins	Fenger Brook Stonington Harbor West and Palmer Coves Mumford Cove Alewife Cove Long Island Sound East Niantic Bay: upper bay, river and offshore Wequetequock Cove Copps Brook Estuary/Quiambog Cove Mystic River Estuary Pequonock River Estuary/Baker Cove Jordan Cove Pattagansett River Estuary Fourmile River	Housatonic River Basin	Housatonic River Housatonic River Estuary Hitchcock Lake Ball Pond Still River Kenosia Lake Padanaram Brook Sympaug Brook Naugatuck River Naugatuck River, West Branch Steele Brook Mad River Hop Brook Lake
Southwest Coastal Basins	Bridgeport Harbor Blackrock Harbor Sherwood Mill Pond/Compo Cove Westcott Cove Greenwich Cove Byram Beach Captain Harbor Rooster River Ash Creek Upper/Lower Mill Ponds Sasco Brook/Estuary Saugatuck River Estuary Norwalk River and Harbor Ridgefield Brook Five Mile River/Estuary Darien Cove Holly Pond/Cove Harbor Stamford Harbor Cos Cob Harbor Byram River/Estuary Long Island Sound West: Southport Harbor	South Central Coastal Basins	Oyster River Tributary Madison Beaches Island Bay/Joshua Cove Thimble Islands Plum Bank Indiantown Harbor Patchogue River Clinton Harbor Guilford Harbor Cedar Pond Linsley Pond Branford Harbor Hanover Pond Quinnipiac River New Haven Harbor Tenmile River Sodom Brook Harbor Brook Wharton Brook Mill River Edgewood Park Pond West River Milford Harbor/Gulf Pond Long Island sound Central Menunnketesuck River Hammonasset River Indian River Hammock Riber Branford Supply Pond West Pisgah River Pine Gutter Brook Allen Brook
Connecticut River Basin	Pequabuck River Birge Pond Pine Lake Park River, South Branch Batterson Park Pond Piper Brook Trout Brook Park River, North Branch Hockanum River Union Pond Mattabesset River Willow Brook Pocotopaug Creek Connecticut River Estuary Crystal Lake John Hall Brook Little Brook Spruce Brook Coles Brook Miner Brook Belcher Brook Webster Brook Sawmill Brook		

Source: 2004 List of Connecticut Waterbodies Not Meeting Water Quality Standards (draft 5/14/02). The impaired waters list is updated by DEP every two to three years.

Figure 2-2 Impacts of Urbanization on the Hydrologic Cycle



Source: Federal Interagency SRWG, 2000.

United States. It is important to note that these tabulated values reflect impervious coverage within individual land uses, but do not reflect overall watershed imperviousness, for which the ecological stress thresholds apply. However, in developed watersheds with significant residential, commercial, and industrial development, overall watershed imperviousness often exceeds the ecological stress thresholds.

Table 2-2
Typical Impervious Coverage of Land Uses in the Northeast U.S.

Land Use	% Impervious Cover
Commercial and Business District	85-100
Industrial	70-80
High Density Residential	45-60
Medium Density Residential	35-45
Low Density Residential	20-40
Open Areas	0-10

Source: MADEP, 1997; Kauffman and Brant, 2000; Arnold and Gibbons, 1996; Soil Conservation Service, 1975.

The impacts of development on stream ecology can be grouped into four categories:

1. Hydrologic Impacts
2. Stream Channel and Floodplain Impacts
3. Water Quality Impacts
4. Habitat and Ecological Impacts

The extent of these impacts is a function of climate, level of imperviousness, and change in land use in a watershed (WEF and ASCE, 1998). Each of these impacts is described further in the following sections.

2.2 Hydrologic Impacts

Development can dramatically alter the hydrologic regime of a site or watershed as a result of increases in impervious surfaces. The impacts of development on hydrology may include:

- *Increased runoff volume*
- *Increased peak discharges*
- *Decreased runoff travel time*
- *Reduced groundwater recharge*
- *Reduced stream baseflow*
- *Increased frequency of bankfull and overbank floods*
- *Increased flow velocity during storms*
- *Increased frequency and duration of high stream flow*

Figure 2-4 depicts typical pre-development and post-development streamflow hydrographs for a developed watershed.

2.3 Stream Channel and Floodplain Impacts

Stream channels in urban areas respond to and adjust to the altered hydrologic regime that accompanies urbanization. The severity and extent of stream adjustment is a function of the degree of watershed imperviousness (WEF and ASCE, 1998). The impacts of development on stream channels and floodplains may include:

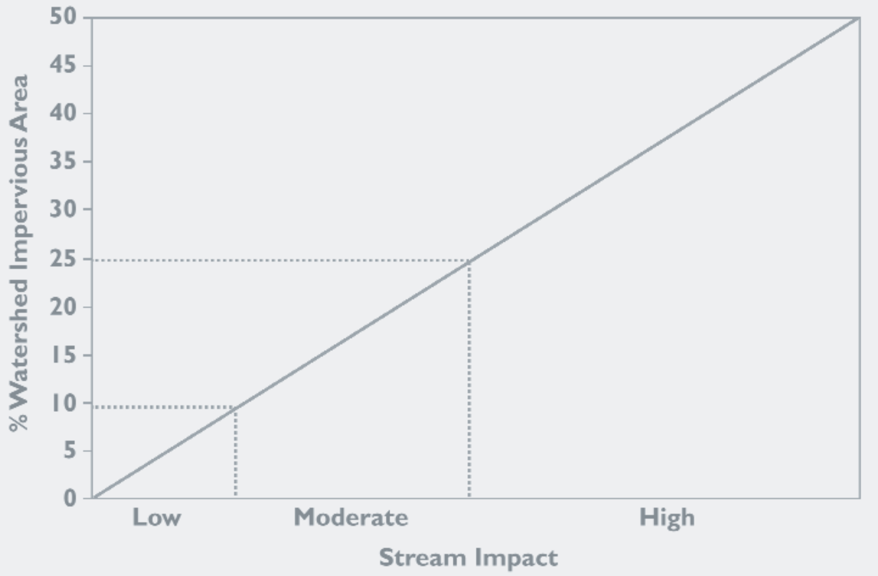
- *Channel scour, widening, and downcutting*
- *Streambank erosion and increased sediment loads*
- *Shifting bars of coarse sediment*
- *Burying of stream substrate*
- *Loss of pool/riffle structure and sequence*
- *Man-made stream enclosure or channelization*
- *Floodplain expansion*

2.4 Water Quality Impacts

Urbanization increases the discharge of pollutants in stormwater runoff. Development introduces new sources of stormwater pollutants and provides impervious surfaces that accumulate pollutants between storms. Structural stormwater collection and conveyance systems allow stormwater pollutants to quickly wash off during storm or snowmelt events and discharge to downstream receiving waters. By contrast, in undeveloped areas, natural processes such as infiltration, interception, depression storage, filtration by vegetation, and evaporation can reduce the quantity of stormwater runoff and remove pollutants. Impervious areas decrease the natural stormwater purification functions of watersheds and increase the potential for water quality impacts in receiving waters.

Urban land uses and activities can also degrade groundwater quality if stormwater with high pollutant loads is directed into the soil without adequate treatment. Certain land uses and activities, sometimes referred to as stormwater "hotspots" (e.g., commercial parking lots, vehicle service and maintenance facilities,

Figure 2-3
Relationship Between Watershed Imperviousness and Stream Health



Source: Adapted from Schueler, 1992 and Prince George's County, Maryland, 1999.

and industrial rooftops), are known to produce higher loads of pollutants such as metals and toxic chemicals. Soluble pollutants can migrate into groundwater and potentially contaminate wells in groundwater supply aquifer areas.

Table 2-3 lists the principal pollutants found in urban stormwater runoff, typical pollutant sources, related impacts to receiving waters, and factors that promote pollutant removal. **Table 2-3** also identifies those pollutants that commonly occur in a dissolved or soluble form, which has important implications for the selection and design of stormwater management practices described later in this manual. Chapter Three contains additional information on pollutant removal mechanisms for various stormwater pollutants.

Excess Nutrients

Urban stormwater runoff typically contains elevated concentrations of nitrogen and phosphorus that are most commonly derived from lawn fertilizer, detergents, animal waste, atmospheric deposition, organic matter, and improperly installed or failing septic systems. Nutrient concentrations in urban runoff are similar to those found in secondary wastewater effluents (American Public Works Association and Texas Natural Resource Conservation Commission). Elevated nutrient concentrations in stormwater runoff can result in excessive growth of vegetation or algae in streams, lakes, reservoirs, and estuaries, a process known as accelerated eutrophication. Phosphorus is typically the growth-limiting nutrient in freshwater systems, while nitrogen is growth-limiting in estuarine and marine systems. This means that in marine waters algal growth usually responds to the level of nitrogen in the water, and in fresh waters algal growth is usually stimulated by the level of available or soluble phosphorus (DEP, 1995).

Nutrients are a major source of degradation in many of Connecticut's water bodies. Excessive nitrogen loadings have led to hypoxia, a condition of low dissolved oxygen, in Long Island Sound. A Total Maximum Daily Load (TMDL) for nitrogen has been developed for Long Island Sound, which will restrict nitrogen loadings from point and non-point sources throughout Connecticut. Phosphorus in runoff has impacted the quality of many of Connecticut's lakes and ponds, which are susceptible to eutrophication from phosphorus loadings. Nutrients are also detrimental to submerged aquatic vegetation (SAV). Nutrient enrichment can favor the growth of epiphytes (small plants that grow attached to other things, such as blades of eelgrass) and increase amounts of phytoplankton and zooplankton in the water column, thereby decreasing available light. Excess nutrients can also favor the growth of macroalgae, which can dominate and displace eelgrass beds and dramatically change the food web (Deegan et al., 2002).

Table 2-3 Summary of Urban Stormwater Pollutants

Stormwater Pollutant	Potential Sources	Receiving Water Impacts	Removal Promoted by[1]
Stormwater Pollutant Excess Nutrients Nitrogen, Phosphorus (soluble)	Animal waste, fertilizers, failing septic systems, landfills, atmospheric deposition, erosion and sedimentation, illicit sanitary connections	Algal growth, nuisance plants, ammonia toxicity, reduced clarity, oxygen deficit (hypoxia), pollutant recycling from sediments, decrease in submerged aquatic vegetation (SAV)	Phosphorus: High soil exchangeable aluminum and/or iron content, vegetation and aquatic plants Nitrogen: Alternating aerobic and anaerobic conditions, low levels of toxicants, near neutral pH (7)
Sediments Suspended, Dissolved, Deposited, Sorbed Pollutants	Construction sites, streambank erosion, washoff from impervious surfaces	Increased turbidity, lower dissolved oxygen, deposition of sediments, aquatic habitat alteration, sediment and benthic toxicity	Low turbulence, increased residence time
Pathogens Bacteria, Viruses	Animal waste, failing septic systems, illicit sanitary connections	Human health risk via drinking water supplies, contaminated swimming beaches, and contaminated shellfish consumption	High light (ultraviolet radiation), increased residence time, media/soil filtration, disinfection
Organic Materials Biochemical Oxygen Demand, Chemical Oxygen Demand	Leaves, grass clippings, brush, failing septic systems	Lower dissolved oxygen, odors, fish kills, algal growth, reduced clarity	Aerobic conditions, high light, high soil organic content, low levels of toxicants, near neutral pH (7)
Hydrocarbons Oil and Grease	Industrial processes; commercial processes; automobile wear, emissions, and fluid leaks; improper oil disposal	Toxicity of water column and sediments, bioaccumulation in food chain organisms	Low turbulence, increased residence time, physical separation or capture techniques
Metals Copper, Lead, Zinc, Mercury, Chromium, Aluminum (soluble)	Industrial processes, normal wear of automobile brake linings and tires, automobile emissions and fluid leaks, metal roofs	Toxicity of water column and sediments, bioaccumulation in food chain organisms	High soil organic content, high soil cation exchange capacity, near neutral pH (7)
Synthetic Organic Chemicals Pesticides, VOCs, SVOCs, PCBs, PAHs (soluble)	Residential, commercial, and industrial application of herbicides, insecticides, fungicides, rodenticides; industrial processes; commercial processes	Toxicity of water column and sediments, bioaccumulation in food chain organisms	Aerobic conditions, high light, high soil organic content, low levels of toxicants, near neutral pH (7), high temperature and air movement for volatilization of VOCs
Deicing Constituents Sodium, Calcium, Potassium Chloride Ethylene Glycol Other Pollutants (soluble)	Road salting and uncovered salt storage. Snowmelt runoff from snow piles in parking lots and roads during the spring snowmelt season or during winter rain on snow events.	Toxicity of water column and sediments, contamination of drinking water, harmful to salt intolerant plants. Concentrated loadings of other pollutants as a result of snowmelt.	Aerobic conditions, high light, high soil organic content, low levels of toxicants, near neutral pH (7)
Trash and Debris	Litter washed through storm drain network	Degradation of aesthetics, threat to wildlife, potential clogging of storm drainage system	Low turbulence, physical straining/capture
Freshwater Impacts	Stormwater discharges to tidal wetlands and estuarine environments	Dilution of the high marsh salinity and encouragement of the invasion of brackish or upland wetland species such as Phragmites	Stormwater retention and volume reduction
Thermal Impacts	Runoff with elevated temperatures from contact with impervious surfaces (asphalt)	Adverse impacts to aquatic organisms that require cold and cool water conditions	Use of wetland plants and trees for shading, increased pool depths

Source: Adapted from DEP, 1995; Metropolitan Council, 2001; Watershed Management Institute, Inc., 1997.

1 Factors that promote removal of most stormwater pollutants include:
- Increasing hydraulic residence time
- Low turbulence
- Fine, dense, herbaceous plants
- Medium-fine textured soil

Sediments

Sediment loading to water bodies occurs from washoff of particles that are deposited on impervious surfaces such as roads and parking lots, soil erosion associated with construction activities, and streambank erosion. Although some erosion and sedimentation is natural, excessive sediment loads can be detrimental to aquatic life including phytoplankton, algae, benthic invertebrates, and fish, by interfering with photosynthesis, respiration, growth, and reproduction. Solids can either remain in suspension or settle to the bottom of the water body. Suspended solids can make the water cloudy or turbid, detract from the aesthetic and recreational value of a water body, and harm SAV, finfish, and shellfish. Sediment transported in stormwater runoff can be deposited in a stream or other water body or wetland and can adversely impact fish and wildlife habitat by smothering bottom dwelling aquatic life and changing the bottom substrate. Sediment deposition in water bodies can result in the loss of deep-water habitat and can affect navigation, often necessitating dredging. Sediment transported in stormwater runoff can also carry other pollutants such as nutrients, metals, pathogens, and hydrocarbons.

Pathogens

Pathogens are bacteria, protozoa, and viruses that can cause disease in humans. The presence of bacteria such as fecal coliform or enterococci is used as an indicator of pathogens and of potential risk to human health (DEP, 1995). Pathogen concentrations in urban runoff routinely exceed public health standards for water contact recreation and shellfishing. Sources of pathogens in stormwater runoff include animal waste from pets, wildlife, and waterfowl; combined sewers; failing septic systems; and illegal sanitary sewer cross-connections. High levels of indicator bacteria in stormwater have commonly led to the closure of beaches and shellfishing beds along coastal areas of Connecticut.

Organic Materials

Oxygen-demanding organic substances such as grass clippings, leaves, animal waste, and street litter are commonly found in stormwater. The decomposition of such substances in water bodies can deplete oxygen from the water, thereby causing similar effects to those caused by nutrient loading. Organic matter is of primary concern in water bodies where oxygen is not easily replenished, such as slower moving streams, lakes, and estuaries. An additional concern for unfiltered water supplies is the formation of trihalomethane (THM), a carcinogenic disinfection byproduct generated by the mixing of chlorine with water high in organic carbon (NYDEC, 2001).

Hydrocarbons

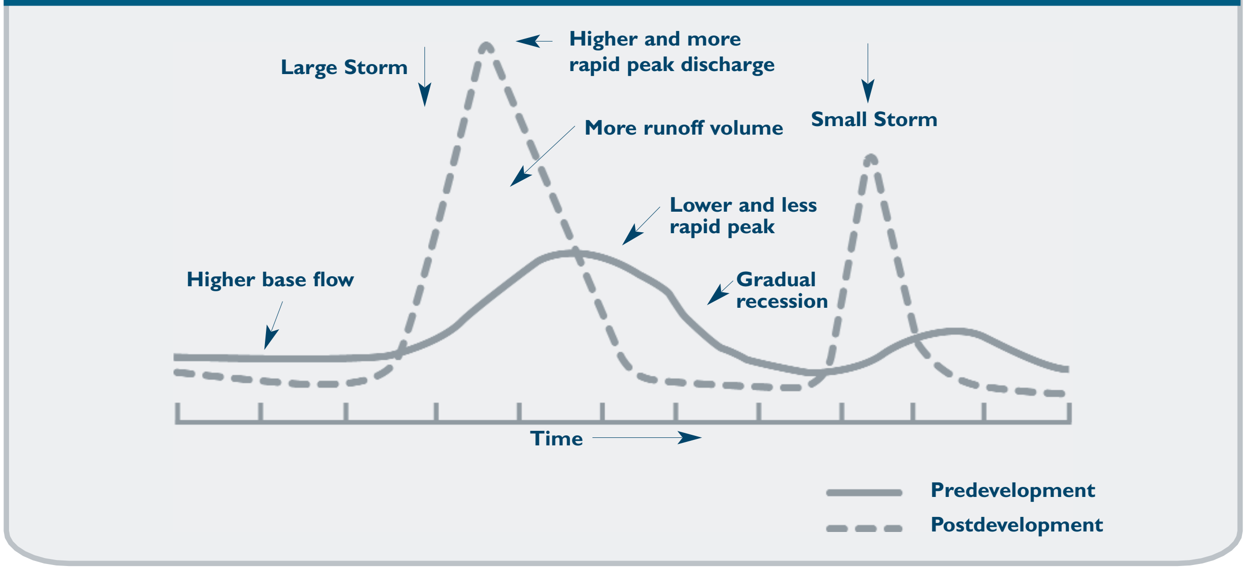
Urban stormwater runoff contains a wide array of hydrocarbon compounds, some of which are toxic to aquatic organisms at low concentrations (Woodward-Clyde, 1990). The primary sources of hydrocarbons in urban runoff are automotive. Source areas with higher concentrations of hydrocarbons in stormwater runoff include roads, parking lots, gas stations, vehicle service stations, residential parking areas, and bulk petroleum storage facilities.

Metals

Metals such as copper, lead, zinc, mercury, and cadmium are commonly found in urban stormwater runoff. Chromium and nickel are also frequently present (USEPA, 1983). The primary sources of these metals in stormwater runoff are vehicular exhaust residue, fossil fuel combustion, corrosion of galvanized and chrome-plated products, roof runoff, stormwater runoff from industrial sites, and the application of deicing agents. Architectural copper associated with building roofs, flashing, gutters, and downspouts has been shown to be a source of copper in stormwater runoff in Connecticut and other areas of the country (Barron, 2000; Tobiason, 2001). Marinas have also been identified as a source of copper and aquatic toxicity to inland and marine waters (Sailer Environmental, Inc. 2000). Washing or sandblasting of boat hulls to remove salt and barnacles also removes some of the bottom paint, which contains copper and zinc additives to protect hulls from deterioration.

In Connecticut, discharge of metals to surface waters is of particular concern. Metals can be toxic to aquatic organisms, can bioaccumulate, and have the potential to contaminate drinking water supplies. Many major rivers in Connecticut have copper levels that exceed Connecticut's Copper Water Quality Criteria. Although metals generally attach themselves to the solids in stormwater runoff or receiving waters, recent studies have demonstrated that dissolved metals, particularly copper and zinc, are the primary toxicants in stormwater runoff from industrial facilities throughout Connecticut (Mas et al., 2001; New England Bioassay, Inc., 2001). Additionally, stormwater runoff can contribute to elevated metals in aquatic sediments. The metals can become bioavailable where the bottom sediment is anaerobic (without oxygen) such as in a lake or estuary. Metal accumulation in sediments has resulted in impaired aquatic habitat and more difficult maintenance dredging operations in estuaries because of the special handling requirements for contaminated sediments.

Figure 2-4 Changes in Stream Hydrology as a Result of Urbanization



Source: Schueler, 1992, in Metropolitan Council, 2001.

Synthetic Organic Chemicals

Synthetic organic chemicals can also be present at low concentrations in urban stormwater. Pesticides, phenols, polychlorinated biphenyls (PCBs), and polynuclear or polycyclic aromatic hydrocarbons (PAHs) are the compounds most frequently found in stormwater runoff. Such chemicals can exert varying degrees of toxicity on aquatic organisms and can bioaccumulate in fish and shellfish. Toxic organic pollutants are most commonly found in stormwater runoff from industrial areas. Pesticides are commonly found in runoff from urban lawns and rights-of-way (NYDEC, 2001). A review of monitoring data on stormwater runoff quality from industrial facilities has shown that PAHs are the most common organic toxicants found in roof runoff, parking area runoff, and vehicle service area runoff (Pitt et al., 1995).

Deicing Constituents

Salting of roads, parking lots, driveways, and sidewalks during winter months and snowmelt during the early spring result in the discharge of sodium, chloride, and other deicing compounds to surface waters via stormwater runoff. Excessive amounts of sodium and chloride may have harmful effects on water, soil and vegetation, and can also accelerate corrosion of metal surfaces. Drinking water supplies, particularly groundwater wells, may be contaminated by runoff from roadways where deicing compounds have been applied or from highway facilities where salt mixes are improperly stored. In addition, sufficient concentrations of chlorides may prove toxic to certain aquatic species. Excess sodium in drinking water can lead to health problems in infants ("blue baby syndrome") and individuals on low sodium diets. Other deicing compounds may contain nitrogen, phosphorus, and oxygen demanding substances. Antifreeze from automobiles is a source of phosphates, chromium, copper, nickel, and cadmium.

Other pollutants such as sediment, nutrients, and hydrocarbons are released from the snowpack during the spring snowmelt season and during winter rain-on-snow events. The pollutant loading during snowmelt can be significant and can vary considerably during the course of the melt event (NYDEC, 2001). For example, a majority of the hydrocarbon load from snowmelt occurs during the last 10 percent of the event and towards the end of the snowmelt season (Oberts, 1994). Similarly, PAHs, which are hydrophobic materials, remain in the snowpack until the end of the snowmelt season, resulting in highly concentrated loadings (Metropolitan Council, 2001).

Trash and Debris

Trash and debris are washed off of the land surface by stormwater runoff and can accumulate in storm drainage systems and receiving waters. Litter detracts from the aesthetic value of water bodies and can harm aquatic life either directly (by being mistaken for food) or indirectly (by habitat modification). Sources of trash and debris in urban stormwater runoff include residential yard waste, commercial parking lots, street refuse, combined sewers, illegal dumping, and industrial refuse.

Freshwater Impacts

Discharge of freshwater, including stormwater, into brackish and tidal wetlands can alter the salinity and hydroperiod of these environments, which can encourage the invasion of brackish or freshwater wetland species such as Phragmites.

Thermal Impacts

Impervious surfaces may increase temperatures of stormwater runoff and receiving waters. Roads and other impervious surfaces heated by sunlight may transport thermal energy to a stream during storm events. Direct exposure of sunlight to shallow ponds and impoundments as well as unshaded streams may further elevate water temperatures. Elevated water temperatures can exceed fish and invertebrate tolerance limits, reducing survival and lowering resistance to disease. Coldwater fish such as trout may be eliminated, or the habitat may become marginally supportive of coldwater species. Elevated water temperatures also contribute to decreased oxygen levels in water bodies and dissolution of solutes.

Concentrations of pollutants in stormwater runoff vary considerably between sites and storm events. Typical average pollutant concentrations in urban stormwater runoff in the Northeast United States are summarized in **Table 2-4.**

Table 2-4
Average Pollutant Concentrations in Urban Stormwater Runoff

Constituent	Units	Concentration
Total Suspended Solids[1]	mg/l	54.5
Total Phosphorus[1]	mg/l	0.26
Soluble Phosphorus[1]	mg/l	0.10
Total Nitrogen[1]	mg/l	2.00
Total Kjeldahl Nitrogen[1]	mg/l	1.47
Nitrite and Nitrate[1]	mg/l	0.53
Copper[1]	µg/l	11.1
Lead[1]	µg/l	50.7
Zinc[1]	µg/l	129
BOD[1]	mg/l	11.5
COD[1]	mg/l	44.7
Organic Carbon[2]	mg/l	11.9
PAH[3]	mg/l	3.5
Oil and Grease[4]	mg/l	3.0
Fecal Coliform[5]	Colonies/100 ml	15,000
Fecal Strep[5]	Colonies/100 ml	35,400
Chloride (snowmelt)[6]	mg/l	116

Source: Adapted from NYDEC, 2001; original sources are listed below.
[1]Pooled Nationwide Urban Runoff Program/USGS (Smullen and Cave, 1998)
[2]Derived from National Pollutant Removal Database (Winer, 2000)
[3]Rabanal and Grizzard, 1996
[4]Crunkilton et al., 1996
[5]Schueler, 1999
[6]Oberts, 1994
mg/l = milligrams per liter
µg/l= micrograms per liter

2.5 Habitat and Ecological Impacts

Changes in hydrology, stream morphology, and water quality that accompany the development process can also impact stream habitat and ecology. A large body of research has demonstrated the relationship between urbanization and impacts to aquatic habitat and organisms (**Table 2-5**). Habitat and ecological impacts may include:

- *A shift from external (leaf matter) to internal (algal organic matter) stream production*
- *Reduction in the diversity, richness, and abundance of the stream community (aquatic insects, fish, amphibians)*
- *Destruction of freshwater wetlands, riparian buffers, and springs*
- *Creation of barriers to fish migration*

2.6 Impacts on Other Receiving Environments

The majority of research on the ecological impacts of urbanization has focused on streams. However, urban stormwater runoff has also been shown to adversely impact other receiving environments such as wetlands, lakes, and estuaries. Development alters the physical, geochemical, and biological characteristics of wetland systems. Lakes, ponds, wetlands, and SAV are impacted through deposition of sediment and particulate pollutant loads, as well as accelerated eutrophication caused by increases in nutrient loadings. Estuaries experience increased sedimentation and pollutant loads, and more extreme salinity swings caused by increased runoff and reduced baseflow. **Table 2-5** summarizes the effects of urbanization on these receiving environments.

Table 2-5 Effects of Urbanization on Other Receiving Environments

Receiving Environment	Impacts
Wetlands	❍ Changes in hydrology and hydrogeology ❍ Increased nutrient and other contaminant loads ❍ Compaction and destruction of wetland soil ❍ Changes in wetland vegetation ❍ Changes in or loss of habitat ❍ Changes in the community (diversity, richness, and abundance) of organisms ❍ Loss of particular biota ❍ Permanent loss of wetlands
Lakes and Ponds	❍ Impacts to biota on the lake bottom due to sedimentation ❍ Contamination of lake sediments ❍ Water column turbidity ❍ Aesthetic impairment due to floatables and trash ❍ Increased algal blooms and depleted oxygen levels due to nutrient enrichment, resulting in an aquatic environment with decreased diversity ❍ Contaminated drinking water supplies
Estuaries	❍ Sedimentation in estuarial streams and SAV beds ❍ Altered hydroperiod of brackish and tidal wetlands, which results from larger, more frequent pulses of fresh water and longer exposure to saline waters because of reduced baseflow ❍ Hypoxia ❍ Turbidity ❍ Bio-accumulation ❍ Loss of SAV due to nutrient enrichment ❍ Scour of tidal wetlands and SAV ❍ Short-term salinity swings in small estuaries caused by the increased volume of runoff which can impact key reproduction areas for aquatic organisms

Source: Adapted from WEF and ASCE, 1998.

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STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER MANAGEMENT
PERMITTING, ENFORCEMENT AND REMEDIATION DIVISION
860-424-3018

General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems

Issuance Date: January 9, 2004

Printed on recycled paper

General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems

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Appendix A: Connecticut Towns with Urbanized Areas **A1**

General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems

Section 1. Authority

This general permit is issued under the authority of Section 22a-430b of the Connecticut General Statutes.

Section 2. Definitions

The definitions of terms used in this general permit shall be the same as the definitions contained in Sections 22a-423 of the Connecticut General Statutes and Section 22a-430-3(a) of the Regulations of Connecticut State Agencies. As used in this general permit, the following definitions shall apply:

"Authorized activity" means any activity authorized under this general permit.

"Best Management Practices (BMP)" means those practices, which reduce pollution and which have been determined by the Commissioner to be acceptable based on, but not limited to, technical, economic, and institutional feasibility.

"Coastal area" means coastal area as defined in Section 22a-94 of the Connecticut General Statutes.

"Coastal waters" means coastal waters as defined in Section 22a-93 of the Connecticut General Statutes.

"Department" means the Department of Environmental Protection.

"Fresh-tidal wetland" means a tidal wetland with an annual average salinity of less than 0.5 parts per thousand.

"Guidelines" means the Connecticut Guidelines for Soil Erosion and Sediment Control, as amended, established pursuant to Section 22a-328 of the Connecticut General Statutes.

"High tide line" means high tide line as defined in Section 22a-359(c) of the Connecticut General Statutes.

"Illicit Discharge" means any unpermitted discharge to waters of the state that does not consist entirely of stormwater or uncontaminated ground water except those discharges identified in Section 3(a)(2) of this general permit when such non-stormwater discharges are approved, in writing, by the Commissioner as discharges that are not significant contributors of pollution to a discharge from an identified MS4.

"Individual permit" means a permit issued to a named permittee under Section 22a-430 of the Connecticut General Statutes.

"Inland wetland" means wetlands as that term is defined in Section 22a-38 of the Connecticut General Statutes.

"Municipal separate storm sewer system (MS4)" means conveyances for stormwater, including, but not limited to, roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains owned or operated by any municipality, State agency or Federal agency and discharging directly to surface waters of the state.

"Permittee" means any municipality, that initiates, creates originates or maintains a discharge authorized by this general permit and that has filed a registration pursuant to Section 4 of this permit.

"Point Source" means any discernible, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged.

"Registration" means a registration form filed with the Commissioner pursuant to Section 4 of the general permit.

"Regulated Small MS4" means any municipally-owned or municipally-operated Small MS4 (as defined below) authorized by this general permit including all those located partially or entirely within an Urbanized Area and those additional municipally-owned or municipally-operated Small MS4s located outside an Urbanized Area as may be designated by the Commissioner. (Note: A list of municipalities containing Small MS4s is included in Appendix A of this general permit.)

"Retain or retention" means to permanently hold stormwater runoff on-site with no subsequent point source release.

"Small MS4" means any MS4 that is not already covered by the Phase I MS4 stormwater program including state- and federally-owned systems, such as colleges, universities, prisons, and military bases. (Note: state- and federally-owned MS4s are authorized under separate general permits.)

"Stormwater" means waters consisting of precipitation runoff.

"Tidal wetland" means a wetland as that term is defined in Section 22a-29(2) of the Connecticut General Statutes.

"Urbanized Area (UA)" means the areas of the State of Connecticut so defined by the U.S. Census Bureau for the 2000 census.

"Total Maximum Daily Load (TMDL)" means the maximum capacity of a surface water to assimilate a pollutant as established by the Commissioner including pollutants contributed by point and non-point sources and a margin of safety.

Section 3. Authorization Under This General Permit

(a) Eligible Activities

(1) The discharge of stormwater from or associated with a Regulated Small MS4 is authorized by this general permit, provided the requirements of subsection (b) of this section are satisfied and the activity is conducted in accordance with the conditions listed in Section 5 of this general permit.

(2) This permit authorizes the following non-stormwater discharges provided they do not contribute to a violation of water quality standards and such discharges are identified in the Stormwater Management Plan and approved, in writing, by the Commissioner as discharges that are not significant contributors of pollutants to any identified MS4:

- landscape irrigation;
- uncontaminated ground water discharges such as pumped ground water, foundation drains, water from crawl space pumps and footing drains;
- irrigation water;
- lawn watering runoff;
- residual street wash water;
- discharges or flows from fire fighting activities (except training); and
- naturally occurring discharges such as rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)), springs, diverted stream flows and flows from riparian habitats and wetlands.

(b) Requirements for Authorization

This general permit authorizes the activity listed in subsection (a) of this section provided:

(1) Coastal Management Act

Such activity is consistent with all applicable goals and policies in Section 22a-92 of the Connecticut General Statutes, and shall not cause adverse impacts to coastal resources as defined in Section 22a-93(15) of the Connecticut General Statutes.

(2) Endangered and Threatened Species

Such activity shall not threaten the continued existence of any species listed as endangered or threatened pursuant to Section 26-306 of the Connecticut General Statutes and shall not result in the destruction or adverse modification of habitat designated as essential to such species.

(3) National Historic Preservation Act

Stormwater discharges or implementation of the registrant's stormwater management plan shall not adversely affect properties listed or eligible for listing in the National Register of Historic Places, unless the registrant is in compliance with requirements of the National Historic Preservation Act and has coordinated with the appropriate State Historic Preservation Officer to avoid or minimize impacts from any necessary activities.

(4) The stormwater is *not* discharged to a Publicly Owned Treatment Works (POTW) or to ground water except for stormwater infiltration through a designed basin or structure.

(c) Registration

Pursuant to Section 4 of this permit, any municipality that initiates, creates, originates or maintains any discharge of water from a regulated Small MS4 shall submit a registration using forms prescribed and provided by the Commissioner (or a photocopy thereof).

(d) Geographic Area

This general permit applies throughout the State of Connecticut.

(e) Effective Date and Expiration Date of this General Permit

This general permit is effective January 9, 2004 and expires on January 8, 2009.

(f) Effective Date of Authorization

An activity is authorized by this general permit on the date the general permit becomes effective or on the date the authorized activity is initiated.

(g) Waiver of Authorization

A municipality may request a waiver from authorization under this general permit if the population within the Urbanized Area portion of town is less than 1000 people, the discharge from the MS4 within the UA does not exceed a Total Maximum Daily Load (TMDL) allocation or is not otherwise a significant contributor to degradation of water quality and the Commissioner issues such waiver in writing.

Section 4. Registration Requirements

(a) Who Must File a Registration

Any municipality that initiates, creates, originates or maintains a discharge of stormwater from or associated with a regulated Small MS4 shall file with the Commissioner a two-part registration form that meets the requirements of this section of this general permit. Part A of the registration shall be submitted on or before April 9, 2004. Part B of the registration shall be submitted on or before July 9, 2004.

(b) Scope of Registration

A registrant shall register on one set of registration forms for all discharges that are operated by the registering municipality. A municipality may not submit more than one registration under this general permit.

(c) Contents of Registration

(1) Fees

(A) The municipal registration fee of $250.00 shall be submitted with the Part A registration form. No activity shall be authorized by this general permit until the registration fee has been paid in full.

(B) The registration fee shall be paid by check or money order payable to the **Department of Environmental Protection.**

(C) The registration fee is non-refundable.

(2) Part A Registration Form

Part A of the registration shall be filed on forms prescribed and provided by the Commissioner and shall include the following:

(A) Name of the municipality and the name, title, address, and telephone number of the chief elected official or principal executive officer.

(B) Name, address, and telephone number of the primary contact person for the municipality.

(C) Name, primary contact, address, and telephone number of any consultant(s) or engineer(s) retained by the municipality to prepare the registration,

(D) Name of receiving stream(s), watershed(s) or waterbody(s) to which the MS4 discharges.

(3) Part B Registration Form

Part B of the registration shall be filed on forms prescribed and provided by the Commissioner and shall include the following:

(A) Name of the municipality and the name, title, address, and telephone number of the chief elected official or principal executive officer.

(B) For each of the Minimum Control Measures in Section 6(a), the following information shall be included:

(i) each Best Management Practice (BMP) to be implemented;

(ii) the person(s) responsible for implementing each BMP;

(iii) the date by which each BMP will be implemented;

(iv) the measurable goal(s) by which each BMP will be evaluated.

(C) The signature of the chief elected official or principal executive officer of the municipality or their designee (as specified in RCSA Section 22a-430-3(b)(2)(B) or as acceptable to the Commissioner) and of the individual or individuals responsible for actually preparing the registration, each of whom shall certify in writing as follows:

"I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify that, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, the submitted information is true, accurate and complete to the best of my knowledge and belief.

I certify that this permit registration is on complete and accurate forms as prescribed by the Commissioner without alteration of the text.

I also certify under penalty of law that I have read and understand all requirements of the General Permit for the Discharge of Stormwater from a Municipal Separate Storm Sewer System issued on January 9, 2004 and that all requirements for authorization under the general permit are met and that a system is in place to ensure that all terms and conditions of this general permit will continue to be met for all discharges authorized by this general permit for the municipality. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowingly making false statements." (See CGS § 53a-157b.)

(d) Availability of Part B Registrations, Annual Reports, and Stormwater Management Plans

(1) At least thirty days prior to submission of the Part B Registration to the Department, each municipality shall make available for public review and comment a draft copy of the complete Part B Registration. Reasonable efforts to inform the public of this document shall be undertaken by such municipality. Such draft copies shall be made available at the municipality's main office or at a local library for public inspection and copying consistent with the federal and state Freedom of Information Acts.

(2) At least thirty days prior to submission of each Annual Report to the Department, each municipality shall make available for public review and comment a draft copy of the complete Annual Report. Reasonable efforts to inform the public of this document shall be undertaken by such municipality. Such draft copies shall be made available at the municipality's main office or at a local library for public inspection and copying consistent with the federal and state Freedom of Information Acts.

(3) Draft copies of each Storm Water Management Plan shall be made available for upon request.

(e) Where to File a Registration

A registration shall be filed with the Commissioner at the following address:

CENTRAL PERMIT PROCESSING UNIT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
79 ELM STREET
HARTFORD, CT 06106-5127

(f) Additional Information

The Commissioner may issue a written request to require a municipality, state agency or federal agency to submit additional information that the Commissioner reasonably deems necessary to evaluate the consistency of the subject activity with the requirements for authorization under this general permit. A response to the Commissioner's request for additional information shall be submitted to the Department within thirty days of the Commissioner's request.

(1) A copy of the Stormwater Management Plan shall be made available for review by the general public upon request at a designated town office(s) during regular town business hours.

(2) The permittee shall make a copy of the Stormwater Management Plan available to the following immediately upon request:

(A) the Commissioner (see Section 6(e));

(B) in the case of a municipality, state or federal agency adjacent to or interconnected with the permittee's storm sewer system, to the owner or operator of that MS4; and

(C) in the case of an MS4 stormwater discharge to a water supply watershed, to the pubic water supply company.

(g) Action by Commissioner

(1) In the event the Commissioner determines that a Minimum Control Measure or Best Management Practice as identified in the Part B Registration or in the Stormwater Management Plan may not reduce stormwater discharges from a municipal separate storm sewer system to the maximum extent practicable, the Commissioner may allow or require a municipality to resubmit the Part B Registration prior to the Commissioner issuing a notice to obtain an individual permit for a discharge provided the municipality conducts a timely pubic hearing, after adequate public notice, to investigate what, if any, additional plans, measures or practices are necessary to reduce stormwater discharges to the maximum extent practicable. Any such request to resubmit a Part B Registration shall be in writing, and may be submitted to the Commissioner by the

municipality or by any interested person. Written notice of the Commissioner's decision to allow a municipality to resubmit the Part B Registration shall be provided to the chief elected official or principal executive officer of such municipality and to any other person submitting a written request for such notice.

(2) The Commissioner may require that a permittee obtain an individual permit for any discharge authorized by this permit in accordance with Section 22a-430b of the Connecticut General Statutes.

(3) The Commissioner shall disapprove a registration:

(A) if the Commissioner finds that the subject activity is ineligible for this general permit, or that the municipality cannot or is unlikely to comply with this general permit; or

(B) for any other reason provided by law.

(4) Disapproval of a registration shall constitute notice to the applicant that the subject activity may not lawfully be conducted or maintained or that the subject activity may not lawfully be conducted or maintained without issuance of an individual permit issued pursuant to Section 22a-430 of the Connecticut General Statutes.

(5) Disapproval of a registration shall be in writing.

Section 5. Requirements of this General Permit

The permittee shall at all times continue to meet the requirements for authorization set forth in Section 3 of this general permit. In addition, a permittee shall ensure that authorized activities are conducted in accordance with the following conditions:

(a) Conditions Applicable for Certain Discharges

(1) If the permittee initiates, creates, or originates a discharge of stormwater which is located less than 500 feet from a tidal wetland that is not a fresh-tidal wetland, such discharge shall flow through a system designed to retain the volume of stormwater runoff generated by 1 inch of rainfall on the watershed for that system.

(2) If the permittee wishes to initiate, create, or originate a discharge of stormwater below the high tide line into coastal, tidal, or navigable waters for which a permit is required under the Structures and Dredging Act in accordance with Section 22a-361(a) of the Connecticut General Statutes or into tidal wetlands for which a permit is required under the Tidal Wetlands Act in accordance with Section 22a-32 of the Connecticut General Statutes, the municipality shall obtain such permit(s) from the Commissioner prior to initiating, creating or originating such discharge.

(b) ***Stormwater Management Plan***

The permittee shall develop, implement, and enforce a stormwater management plan designed to reduce the discharge of pollutants from the Small MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. Under this program, the permittee shall prepare a Stormwater Management Plan pursuant to Section 6 of this general permit, which plan shall be completed, and all Minimum Control Measures implemented, by January 8, 2009.

Section 6. Development of Stormwater Management Plan

The Stormwater Management Plan (the Plan) shall address the Minimum Control Measures as indicated in this section. Those measures indicated as required within the Urbanized Area portion of the Regulated Small MS4 shall be implemented, at a minimum, within those areas. At the discretion of the permittee, the Minimum Control Measures required within the Urbanized Areas may also be applied to any MS4 outside of the Urbanized Area. Those measures indicated as required throughout the municipality shall be implemented for all areas of the municipality regardless of Urbanized Area.

(a) ***Minimum Control Measures***

For each Minimum Control Measure, the permittee shall: define appropriate BMPs; designate a person(s) and job title responsible for each BMP; define a time line for implementation of each BMP; and define measurable goals for each BMP. The Minimum Control Measures in the Stormwater Management Plan include, but are not limited to:

(1) Public education and outreach on stormwater impacts.

(A) Required throughout the municipality:

(i) implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of stormwater discharges on waterbodies and the steps that the public can take to reduce pollutants in stormwater runoff.

(2) Public Involvement/Participation.

(A) Required throughout the municipality:

(i) comply with state and local public notice and Freedom of Information requirements when implementing a public involvement/participation program. Where notice requirements are inconsistent, the notice provisions providing for the most notice and opportunity for public comment shall be followed.

(ii) develop a public involvement/participation program that includes the public in developing, implementing, and reviewing your stormwater management plan.

(3) Illicit discharge detection and elimination.

(A) Required throughout the municipality:

(i) implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges, except as provided in Section 3(a)(2), into the MS4, as well as sanctions to ensure compliance, to the extent allowable under State or local law;

(ii) inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste; and

(iii) by the end of the third year of the general permit, expand the map required by subsection (B)(i) below to identify on such map all outfalls of 15" or greater where such outfalls are located anywhere within each municipality;

(B) Required within the Urbanized Area:

(i) by the end of the second year of the general permit, develop a map or series of maps at a minimum scale of 1"=2000' and maximum scale of 1"=100' showing all stormwater discharges from a pipe or conduit with a diameter of 15" or greater (or equivalent cross-sectional area) owned or operated by the municipality. For each discharge the following information shall be included:

a. Type, material, and size of conveyance, outfall or channelized flow (e.g. 24" concrete pipe);

b. The name and Surface Water Quality Classification of the immediate surface waterbody or wetland to which the stormwater runoff discharges;

c. If the outfall does not discharge directly to a named waterbody, the name of the nearest named waterbody to which the outfall eventually discharges;

d. The name of the watershed in which the discharge is located.

(ii) By the end of the fourth year of the general permit, expand the map required by subsection (B)(i) above to identify on the map all outfalls of 12" or greater that are located within an urbanized area;

(iii) develop, implement and enforce a program to detect and eliminate existing illicit discharges, as defined in 40CFR 122.26(b)(2), into the MS4; and

(iv) develop and implement a plan to detect and address future non-stormwater discharges, including illegal dumping, to the MS4.

(4) Construction site stormwater runoff control.

(A) Required throughout the municipality:

(i) develop, implement, and enforce a program, or modify an existing program, to reduce pollutants in any stormwater runoff to the MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of stormwater discharges from construction activity disturbing less than one acre shall be included in the program if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more. The program shall include, but not be limited to, the development and implementation of: an ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions for non-compliance, to the extent allowable under state or local law;

a. procedures for notifying construction site developers and operators of the requirements for registration under the General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities;

b. requirements for construction site operators to implement appropriate erosion and sediment control best management practices in accordance with the Guidelines;

c. requirements for construction site operators to control waste at the site such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste that may cause adverse impacts to water quality;

d. procedures for site plan review which incorporate consideration of potential water quality impacts;

e. procedures for receipt and consideration of information submitted by the public; and

f. procedures for site inspection and enforcement of control measures.

(5) Post-construction stormwater management in new development and redevelopment.

(A) Required throughout the municipality:

(i) develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4 or directly to waters of the State. This program shall ensure that controls are implemented to require appropriate infiltration practices, reduction of impervious surface, creation of or conversion to sheet flow, measures and/or structures to reduce sediment discharge and any other innovative measures that will prevent or minimize water quality impacts;

(ii) develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for your municipality;

(iii) use an ordinance or other regulatory mechanism to address the elements of subsection (i) above regarding post-construction runoff from new development and redevelopment projects to the extent allowable under State or local law; and

(iv) ensure adequate long-term operation and maintenance of BMPs.

(6) Pollution prevention/good housekeeping for municipal operations.

(A) Required throughout the municipality:

(i) develop and implement an operation and maintenance program that includes a training component for municipal employees and contractors and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations;

(ii) using training materials that are available from the EPA, the State or other organizations, this program shall include employee training to prevent and reduce stormwater pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance;

(iii) develop and implement a program to sweep all streets at least once a year as soon as possible after snowmelt;

(iv) develop and implement a program to evaluate and, if necessary, clean catch basins and other stormwater structures that accumulate sediment at least once a year, including a provision to identify and prioritize those structures that may require cleaning more than once a year; and

(v) develop and implement a program to evaluate and, if necessary, prioritize for repairing, retrofitting or upgrading the conveyances, structures and outfalls of the MS4.

(B) Required within the Urbanized Area:

(i) develop and implement a program to evaluate and prioritize those streets that may require sweeping more than once a year.

(b) Sharing Responsibility

(1) Qualifying Local Program

The permittee may satisfy the requirement to implement a BMP for a Minimum Control Measure by having a third party implement the BMP.

When a permittee is relying on a third party to implement one or more BMP(s), the permittee shall note that fact in the registration and annual report required in subsection (i) below. If the third party fails to implement the BMP(s), the permittee remains responsible for its implementation.

(Note: For example, if a local watershed organization performs an annual "river clean-up", this event may be used to satisfy a BMP for the Public Participation and/or the Pollution Prevention and Good Housekeeping Minimum Control Measure.)

(2) Qualifying State or Federal Program

If a BMP or Minimum Control Measure is the responsibility of a third party under another NPDES stormwater permit, the permittee is not required to include such BMP or Minimum Control Measure in its stormwater management plan. The permittee shall reference this qualifying program in their Stormwater Management Plan. However, the permittee is not responsible for its implementation if the third party fails to perform. The permittee shall periodically confirm that the third party is still implementing this measure. If the third party fails to implement the measure, the Stormwater Management Plan may be modified to address the measure, if necessary.

In the case of a permitted municipal industrial activity that is covered by the General Permit for the Discharge of Stormwater Associated with Industrial Activity, the permittee may reference the activity's Stormwater Pollution Prevention Plan to address a portion of the permittee's Stormwater Management Plan.

(Note: For example, the permittee may reference a regional mall's requirement to perform sweeping and catch basin cleaning under the General Permit for the Discharge of Stormwater Associated with Commercial Activity. This third party action may be used to address a portion of the permittee's requirement under the Good Housekeeping and Pollution Prevention Minimum Control Measure.)

(3) Coordination of Permit Responsibilities

Where a portion of the separate storm sewer system within a municipality is owned or otherwise the responsibility of another municipality, or a state or federal agency the entities shall coordinate the development and implementation of their respective Stormwater Management Plans to address all the elements of Section 6. A description of the respective responsibilities for these elements shall be included in the Stormwater Management Plan for each municipality.

(Note: For example, a storm sewer system within a municipality may be operated and maintained by the DOT. In cases such as these, the two entities shall coordinate their Stormwater Management Plans to address the Minimum Control Measures, particularly at the interface between the two storm sewer systems.)

(c) Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control, including related appurtenances, which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures. Proper operation and maintenance requires the operation of backup or auxiliary facilities or similar systems, installed by a permittee when necessary to achieve compliance with this permit.

(d) Signature Requirements

The Plan shall be signed by the chief elected official or principal executive officer, as those terms are defined in Section 22a-430-3(b)(2) of the Regulations of Connecticut State Agencies. The Plan shall be retained by the chief elected official or principal executive officer and copies retained by town officials or employees responsible for implementation of the Plan.

(e) Plan Review Fee

When submitting a Stormwater Management Plan as requested by the Commissioner in accordance with Section 4(f)(2)(A) each municipal permittee shall submit a plan review fee of $187.50.

(f) Keeping Plans Current

The permittee shall amend the Plan whenever: (1) there is a change which has the potential to cause pollution of the waters of the state; or (2) the actions required by the Plan fail to ensure or adequately protect against pollution of the waters of the state; or (3) the Commissioner requests modification of the Plan. The amended Plan shall be completed and all actions required by such Plan shall be completed within a time period determined by the Commissioner.

The Commissioner may notify the permittee in writing at any time that the Plan does not meet one or more of the requirements of this general permit. Within 30 days of such notification, unless otherwise specified by the Commissioner in writing, the permittee shall respond to the Commissioner indicating how they plan to modify the Plan to address these requirements. Within 90 days of this response or within 120 days of the original notification, whichever is less, unless otherwise specified by the Commissioner in writing, the permittee shall then revise the Plan, perform all actions required by the revised Plan, and shall certify to the Commissioner that the requested changes have been made and implemented. The permittee shall provide such information as the Commissioner requires to evaluate the Plan and its implementation.

(g) Failure to Prepare or Amend Plan

In no event shall failure to complete or update a Plan in accordance with Sections 5(b) and 6 of this general permit relieve a permittee of responsibility to implement actions required to protect the waters of the state and to comply with all conditions of this general permit.

(h) Monitoring Requirements

(1) Schedule of Monitoring

(A) Stormwater monitoring shall be conducted by the Regulated Small MS4 annually starting in 2004. At least two outfalls apiece shall be monitored from areas of primarily industrial development, commercial development and residential development, respectively, for a total of six (6) outfalls monitored. Each monitored outfall shall be selected based on an evaluation by the MS4 that the drainage area of such outfall is representative of the overall nature of its respective land use type.

(B) The municipality may submit a request to the Commissioner in writing for implementation of an alternate sampling plan of equivalent or greater scope. The Commissioner will approve or deny such a request in writing.

(2) Parameters to be monitored

The parameters to be monitored for each discharge point shall include:

pH (SU)

Hardness (mg/l)

Conductivity (umos)

Oil and grease (mg/l)

Chemical Oxygen Demand (mg/l)

Turbidity (NTU)

Total Suspended Solids (mg/l)

Total Phosphorous (mg/l)

Ammonia (mg/l)

Total Kjeldahl Nitrogen (mg/l)

Nitrate plus Nitrite Nitrogen (mg/l)

E. coli (col/100ml)

In addition to this list of parameters, uncontaminated rainfall pH shall be measured at the time the runoff sample is taken.

(3) Stormwater Monitoring Procedures

(A) Samples shall be collected from discharges resulting from a storm event that is greater than 0.1 inch in magnitude and that occurs at least 72 hours after any previous storm event of 0.1 inch or greater. Runoff events resulting from snow or ice melt cannot be used to meet the minimum annual monitoring requirements. Grab samples shall be used for all monitoring. Grab samples shall be collected during the first 6 hours of a storm event discharge. The uncontaminated rainfall pH measurement shall also be taken at this time. Samples for all discharges shall be taken during the same storm event.

(B) Storm Event Information

The following information shall be collected for the storm events monitored:

(i) The date, temperature, time of the start of the discharge, time of sampling, and magnitude (in inches) of the storm event sampled.

(ii) The duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event.

(C) Test Procedures

Unless otherwise specified in this permit, all pollutant parameters shall be tested according to methods prescribed in Title 40, CFR, Part 136 (1990).

(i) Reporting & Record Keeping Requirements

(1) The permittee shall keep records required by this permit for at least 5 years following its expiration or longer if requested by the Commissioner in writing. Such records, including the Stormwater Management Plan, shall be available to the public at reasonable times during regular business hours.

(2) By January 1, 2005 and annually thereafter by January 1, the permittee shall submit an Annual Report to:

STORMWATER PERMIT COORDINATOR
BUREAU OF WATER MANAGEMENT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
79 ELM STREET
HARTFORD, CT 06106-5127

The report shall include:

(i) A municipal plan review fee of $187.50;

(ii) The status of compliance with this general permit, an assessment of the appropriateness of the identified best management practices and progress towards achieving the implementation dates and measurable goals for each of the Minimum Control Measures;

(iii) All monitoring data collected and analyzed pursuant to Section 6(g);

(iv) All other information collected and analyzed, including data collected under Section 6(a)(3), during the reporting period;

(v) A summary of the stormwater activities the permittee plans to undertake during the next reporting cycle; and

(vi) A change in any identified measurable goals or implementation dates that apply to the program elements.

(j) Other Requirements

(1) There shall be no distinctly visible floating scum, oil or other matter contained in the stormwater discharge. Excluded from this are naturally occurring substances such as leaves and twigs provided no person has placed such substances in or near the discharge.

(2) The stormwater discharge shall not result in pollution due to acute or chronic toxicity to aquatic and marine life, impair the biological integrity of aquatic or marine ecosystems, or result in an unacceptable risk to human health.

(k) Total Maximum Daily Load (TMDL) Allocations

If a TMDL is approved for any waterbody into which the permittee discharges, the permittee shall review its Stormwater Management Plan if the TMDL includes requirements for control of stormwater discharges. If the stormwater discharge(s) do not meet the TMDL allocations, the permittee shall modify its Stormwater Management Plan to implement the TMDL within four months of the TMDL's approval and notify the Commissioner of this modification.

Section 7. Additional Requirements of this General Permit

(a) Regulations of Connecticut State Agencies Incorporated into this General Permit

The permittee shall comply with all laws applicable to the subject discharges, including but not limited to, the following Regulations of Connecticut State Agencies which are hereby incorporated into this general permit, as if fully set forth herein:

(1) Section 22a-430-3:

Subsection (b) General - subparagraph (1)(D) and subdivisions (2),(3),(4) and (5)
Subsection (c) Inspection and Entry
Subsection (d) Effect of a Permit - subdivisions (1) and (4)
Subsection (e) Duty to Comply
Subsection (f) Proper Operation and Maintenance
Subsection (g) Sludge Disposal
Subsection (h) Duty to Mitigate
Subsection (i) Facility Modifications, Notification - subdivisions (1) and (4)

Subsection (j) Monitoring, Records and Report Requirements - subdivisions (1), (6), (7), (8), (9) and (11) (except subparagraphs (9) (A) (2) and (9) (c)
Subsection (k) Bypass
Subsection (m) Effluent Limitation Violations
Subsection (n) Enforcement
Subsection (p) Spill Prevention and Control
Subsection (q) Instrumentation, Alarms, Fbw Recorders
Subsection (r) Equalization

(2) Section 22a-430-4

Subsection (t) Prohibitions
Subsection (p) Revocation, Denial, Modification
Appendices

(b) Reliance on Registration

In evaluating the permittee's registration, the Commissioner has relied on information provided by the permittee. If such information proves to be false or incomplete, the permittee's authorization may be suspended or revoked in accordance with law, and the Commissioner may take any other legal action provided by law.

(c) Duty to Correct and Report Violations

Upon learning of a violation of a condition of this general permit, a permittee shall immediately take all reasonable action to determine the cause of such violation, correct and mitigate the results of such violation and prevent further such violation. The permittee shall report in writing such violation and such corrective action to the Commissioner within five (5) days of the permittee's learning of such violation. Such information shall be filed in accordance with the certification requirements prescribed in Section 7(e) of this general permit.

(d) Duty to Provide Information

If the Commissioner requests any information pertinent to the authorized activity or to compliance with this general permit or with the permittee's authorization under this general permit, the permittee shall provide such information within thirty (30) days of such request. Such information shall be filed in accordance with the certification requirements prescribed in Section 7(e) of this general permit.

(e) Certification of Documents

Any document, including but not limited to any notice, information or report, which is submitted to the Commissioner under this general permit shall be signed by the chief elected official or principal executive officer of the municipality, and by the individual or individuals responsible for actually preparing such document, each of whom shall certify in writing as follows:

"I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify that, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that a false statement made in this document or its attachments may be punishable as a criminal offense, in accordance with Section 22a-6 of the Connecticut General Statutes, pursuant to Section 53a-157b of the Connecticut General Statutes, and in accordance with any other applicable statute."

(f) Date of Filing

For purposes of this general permit, the date of filing with the Commissioner of any document is the date such document is received by the Commissioner. The word "day" as used in this general permit means the calendar day; if any date specified in the general permit falls on a Saturday, Sunday, or legal holiday, such deadline shall be the next business day.

(g) False Statements

Any false statement in any information submitted pursuant to this general permit may be punishable as a criminal offense, in accordance with Section 22a-6, under Section 53a-157b of the Connecticut General Statutes.

(h) Correction of Inaccuracies

Within fifteen days after the date the permittee becomes aware of a change in any information in any material submitted pursuant to this general permit, or becomes aware that any such information is inaccurate or misleading or that any relevant information has been omitted, the permittee shall correct the inaccurate or misleading information or supply the omitted information in writing to the Commissioner. Such information shall be filed in accordance with the certification requirements prescribed in Section 7(e) of this general permit.

(i) Other Applicable Law

Nothing in this general permit shall relieve the permittee of the obligation to comply with any other applicable federal, state and local law, including but not limited to the obligation to obtain any other authorizations required by such law.

(j) Other Rights

This general permit is subject to and does not derogate any present or future rights or powers of the State of Connecticut and conveys no rights in real or personal property nor any exclusive privileges, and is subject to all public and private rights and to any federal, state, and local laws pertinent to the property or activity affected by such general permit. In conducting any activity authorized hereunder, the permittee may not cause pollution, impairment, or destruction of the air, water, or other natural resources of this state. The issuance of this general permit shall not create any presumption that this general permit should or will be renewed.

Section 8. Commissioner's Powers

(a) *Abatement of Violations*

The Commissioner may take any action provided by law to abate a violation of this general permit, including but not limited to penalties of up to $25,000 per violation per day under Chapter 446k of the Connecticut General Statutes, for such violation. The Commissioner may, by summary proceedings or otherwise and for any reason provided by law, including violation of this general permit, revoke a permittee's authorization hereunder in accordance with Sections 22a-3a-2 through 22a-3a-6, inclusive, of the Regulations of Connecticut State Agencies. Nothing herein shall be construed to affect any remedy available to the Commissioner by law.

(b) *General Permit Revocation, Suspension, or Modification*

The Commissioner may, for any reason provided by law, by summary proceedings or otherwise, revoke or suspend this general permit or modify to establish any appropriate conditions, schedules of compliance, or other provisions which may be necessary to protect human health or the environment.

(c) *Filing of an Individual Application*

If the Commissioner notifies a permittee in writing that such permittee shall obtain an individual permit under Section 22a-430 of the Connecticut General Statutes if he wishes to continue lawfully conducting the authorized activity, the permittee shall file an application for an individual permit within thirty (30) days of receiving the Commissioner's notice, or at such other date as the Commissioner may allow. While such application is pending before the Commissioner, the permittee shall comply with the terms and conditions of this general permit and the subject approval of registration. If the Commissioner issues an individual permit to a permittee under this general permit, this general permit, as it applies to such permittee, shall automatically terminate on the date such individual permit is issued. Nothing herein shall affect the Commissioner's power to revoke a permittee's authorization under this general permit at any time.

Issued Date: January 9, 2004

ARTHUR J. ROCQUE, JR.
Commissioner

This is a true and accurate copy of the general permit executed on January 9, 2004 by the Commissioner of the Department of Environmental Protection.

Appendix A: Connecticut Towns with Urbanized Areas

Andover*	Ansonia	Avon
Beacon Falls	Berlin	Bethany
Bethel	Bloomfield	Bolton
Bozrah*	Branford	Bridgeport
Bristol	Brookfield	Burlington
Canterbury*	Canton	Cheshire
Chester	Clinton	Coventry*
Cromwell	Danbury	Darien
Deep River	Derby	Durham
East Granby	East Hampton*	East Hartford
East Haven	East Lyme	East Windsor
Easton	Ellington	Enfield
Essex	Fairfield	Farmington
Franklin*	Glastonbury	Granby
Greenwich	Griswold	Groton
Guilford	Haddam*	Hamden
Hartford	Hebron	Killingworth*
Ledyard	Lisbon	Litchfield*
Lyme*	Madison	Manchester
Marlborough	Meriden	Middlebury
Middlefield	Middletown	Milford
Monroe	Montville	Naugatuck
New Britain	New Canaan	New Fairfield
New Hartford*	New Haven	New London
New Milford	Newington	Newtown
North Branford	North Haven	Norwalk
Norwich	Old Lyme	Old Saybrook
Orange	Oxford	Plainfield*
Plainville	Plymouth	Portland
Preston*	Prospect	Putnam
Redding	Ridgefield	Rocky Hill
Salem*	Seymour	Shelton
Sherman*	Simsbury	Somers
South Windsor	Southbury	Southington
Sprague*	Stafford*	Stonington
Stratford	Suffield	Thomaston
Thompson	Tolland	Trumbull
Vernon	Wallingford	Washington*
Waterbury	Waterford	Watertown
West Hartford	West Haven	Westbrook
Weston	Westport	Wethersfield
Wilton	Windsor	Windsor Locks
Wolcott	Woodbridge	Woodbury
Woodstock*		

*Denotes town with population less than 1,000 in the Urbanized Area.

Massachusetts River and Stream Crossing Standards: Technical Guidelines

August 6, 2004

INTRODUCTION

As long and linear ecosystems, rivers and streams are very important for fish and other wildlife movements, but are also particularly vulnerable to fragmentation. In addition to natural barriers, a number of human activities can, to varying degrees, disrupt the continuity of river and stream ecosystems. The most familiar human-caused barriers are dams. However, there is growing concern about the role of river and stream crossings, and especially culverts, in disrupting river and stream continuity (see Appendix A.).

With funding from the Sweetwater Trust, the Massachusetts Watershed Initiative, and the Massachusetts Riverways Program, the University of Massachusetts–Amherst coordinated an effort to create river and stream crossing standards and a volunteer inventory program for culverts and other crossing structures to more effectively identify and address barriers to fish movement and river and stream continuity. Information was compiled about fish and wildlife passage requirements, culvert design standards, and methodologies for evaluating barriers to fish and wildlife passage. This information was used to develop design standards for culverts and other stream crossing structures.

The following standards were developed by the River and Stream Continuity Steering Committee including representatives from UMass-Amherst, MA Riverways Program, Massachusetts Watershed Initiative, Trout Unlimited, The Nature Conservancy, Mass Highway, and the Massachusetts Department of Environmental Protection. In developing the standards, the steering committee received advice from a Technical Advisory Committee that included representatives of the US Fish and Wildlife Service, USGS BRD, US EPA, US Army Corps of Engineers, MA Division of Fisheries and Wildlife, American Rivers, Connecticut River Watershed Council, Connecticut DEP, and a hydraulic engineering consultant. The standards are intended to serve as recommended standards for permanent crossings (highways, railways, roads, driveways, bike paths, etc) on fish-bearing streams and rivers, and as guidelines for upgrading existing crossings when possible. These standards seek to achieve, to varying degrees, three goals:

1. Fish and other Aquatic Organism Passage: Facilitate movement for most fish and other aquatic organism species, including relatively small, resident fish, aquatic amphibians & reptiles, and large invertebrates (e.g. crayfish, mussels).

2. River/stream continuity: Maintain continuity of the aquatic and benthic elements of river and stream ecosystems, generally through maintenance of appropriate substrates, water depths and flows. Maintenance of river and stream continuity is the most practical

strategy for facilitating movement of small, benthic organisms as well as some large, but weak-swimming species such as salamanders and crayfish.

3. Wildlife Passage: Facilitate movement of wildlife species including those primarily associated with river and stream ecosystems and others that may utilize riparian areas as movement corridors. Some species of wildlife such as muskrats and stream salamanders may benefit from river and stream continuity. Other species may require more open structures as well as dry passage along the banks or within the streambed at low flow.

This technical guidance adopts a "Stream Simulation" approach for crossing design in order to better protect river and stream ecosystems. Stream Simulation is a design approach that avoids flow constriction during normal conditions and creates a stream channel that maintains the diversity and complexity of the streambed through the crossing. Crossing structures that avoid channel constriction and maintain appropriate channel conditions within the structure should be able to accommodate most of the normal movements of aquatic organisms, and preserve (or restore) many ecosystem processes that maintain habitats and aquatic animal populations. The goal is to create crossings that present no more of an obstacle to movement than the natural channel and that are essentially "invisible" to aquatic organisms.

These guidelines are for general use to address issues of river and stream continuity, fish passage and wildlife movement. In some cases, site constraints may make strict adherence to the standards impractical or undesirable. For example, in some situations shallow bedrock may make it impractical to embed culverts. In other situations the road layout and surrounding landscape may make it impossible or impractical to achieve the recommended standards for height and openness. Site-specific information and good professional judgment should always be used to develop crossing designs that are both practical and effective.

Here are some important considerations to keep in mind when using these guidelines.

1. They are intended for permanent river and stream crossings. They were not intended for temporary crossings such as skid roads and temporary logging roads.
2. They are generally intended for fish-bearing streams. These guidelines are not recommended for those portions of intermittent streams that are not used by fish. However, these standards may be useful in areas where fish are not present but where protection of salamanders or other local wildlife species is desired. Further, the standards are not intended for drainage systems designed primarily for the conveyance of storm water or wastewater.
3. These technical guidelines have no regulatory standing. They are intended as technical guidelines that can be used to facilitate the preservation or restoration of river continuity and fish and wildlife movement. These guidelines may not be sufficient to address drainage or flood control issues that must also be considered during the permitting of permanent stream crossings.

STANDARDS FOR NEW CROSSINGS

There are two levels of standards (General and Optimum) to balance the cost and logistics of crossing design with the degree of river/stream continuity warranted in areas of different environmental significance.

General Standards:

***Goal*: Fish passage, river/stream continuity, some wildlife passage**

Application

Where permanent stream crossings are planned on fish bearing streams or rivers, they should at least meet general standards to pass most fish species, maintain river/stream continuity, and facilitate passage for some wildlife.

Fish bearing streams or rivers include rivers and streams that support one or more species of fish, including those portions of intermittent streams that are used seasonally by fish. These standards are also warranted where fish are not present, but where protection of salamanders or other local wildlife species is desired.

General standards call for open bottom structures or culverts that span the river/stream channel with natural bottom substrates that generally match upstream and downstream substrates. Stream depth and velocities in the crossing structure during low-flow conditions should approximate those in the natural river/stream channel. An openness ratio of 0.25 will pass some wildlife species but is unlikely to pass all the wildlife that would be accommodated by the optimum standards.

Standards

- Open bottom arch or bridge span preferred

  Site constraints may make the use of these structures impractical and in some cases well-designed culverts may actually perform better than bridges or open bottom arches. However, in areas where site constraints don't limit the usefulness of these structures, bridges and open-bottom arches are preferred over culverts.

- If a culvert, then it should be embedded $\geq$ 1 foot for box culverts and pipe arches, and at least 25 % for pipe culverts.

  In some cases site constraints may limit the degree to which a culvert can be embedded. In these cases pipe culverts should not be used and box culverts, pipe arches, open-bottom arches, or bridges should be considered instead.

- Natural bottom substrate within culvert (matching upstream and downstream substrates)

  Careful attention must be paid to the composition of the substrate within the culvert. The substrate within the structure should match the composition of the substrate in the natural stream channel at the time of construction and over time as the structure has had the opportunity to pass significant flood events. This substrate should either resist displacement during flood events or the structure should be designed to maintain an appropriate bottom through natural bed load transport.

- Spans channel width (a minimum of 1.2 times the bankfull width)

  A critical feature of stream simulation design is to avoid channel constriction during normal bankfull flows. Spanning an area 1.2 times the bankfull width will help prevent scouring within the structure or at the outlet during less frequent floods.

- Designed to provide water depths and velocities at low flow that are comparable to those found in upstream and downstream natural stream segments

  In order to provide water depths and velocities at low flow it is usually necessary to construct a low flow channel within the structure. Otherwise, the width of the structure needed to accommodate higher flows will create conditions that are too shallow at low flows. When constructing the channel special attention should be paid to the sizing and arrangement of materials within the structure. If only large material is used, without smaller material filling the voids, there is a risk that flows could go subsurface within the structure.

- Openness ratio $\geq$ 0.25

  Openness ratio is the cross-sectional area of a structure divided by its crossing length when measured in meters. For a box culvert, openness = (height x width)/ length.

Optimum Standards

***Goal*:** Fish passage, river/stream continuity, wildlife passage

Application

Where permanent stream crossings occur or are planned in areas of particular statewide or regional significance for their contribution to landscape level connectedness or river/stream ecosystems that provide important aquatic habitat for rare or endangered species, optimum standards should be applied in order to maintain river/stream continuity and facilitate passage for fish and wildlife.

Areas of particular statewide or regional significant for their contribution to landscape level connectedness include, but are not limited to, rivers/streams and associated riparian areas that serve as corridors or connecting habitat linking areas of significant habitat (>250 acres) in three or more towns. Optimum standards also should be applied to crossings that would adversely impact Biomap and Living Waters "core habitat" or areas providing linkages between "core habitats."

Important aquatic habitat for rare or endangered species includes, but is not limited to, those areas identified by the Natural Heritage and Endangered Species

Program (via the Living Waters project or regulatory review) that are considered important for protecting rare or endangered species.

Where permanent stream crossings occur or are planned in areas of high connectivity value – areas of particular statewide or regional significance for their contribution to landscape level connectedness – crossings should be designed to maintain river/stream continuity and facilitate passage for most fish and wildlife. The best designs for accomplishing this involve open bottom structures or bridges that not only span the river/stream channel, but also span one or both of the banks allowing dry passage for wildlife that move along the watercourse. Where the crossing involves high traffic volumes or physical barriers to wildlife movement, the crossing structure should be sized to pass most wildlife species (minimum height and openness requirements).

Standards

- Open bottom arch or bridge span

  Unless there are compelling reasons why a culvert would provide greater environmental benefits, only bridges or open-bottom arches should be used.

- Span the streambed and banks (allowing dry passage for wildlife ≥ 80% of the year)

  The structure span should be at least 1.2 times the bankfull width and provide banks on one or both sides with sufficient headroom to provide dry passage for semi-aquatic and terrestrial wildlife.

- Maintain a minimum height of 6 ft and openness ratio of 0.75 if conditions are present that significantly inhibit wildlife passage (high traffic volumes, steep embankments, fencing, Jersey barriers or other physical obstructions)

  Openness ratio is the cross-sectional area of a structure divided by its crossing length when measured in meters. For a box culvert, openness = (height x width)/ length.

- Otherwise, maintain a minimum height of 4 ft. and openness ratio of 0.5

STANDARDS FOR CULVERT REPLACEMENT

Given the number of culverts and other crossing structures that have been installed without consideration for ecosystem protection, it is important to assess what impact these crossings are having and what opportunities exist for mitigating those and future impacts. Culvert replacement or remediation are critical elements for the long-term protection of river and stream ecosystems.

Methods have been developed, and are continuing to be refined and adapted, for evaluating culverts and other crossing structures for their impacts on animal passage and other ecosystem processes. Along with these assessments there needs to be a process for prioritizing problem crossings for remediation. The process should take into account habitat quality in the river or stream and surrounding areas, upstream and downstream conditions, as well as the number of other crossings, discontinuities (channelized or piped sections), and barriers affecting the system. It is important to use a watershed-based approach to river and stream restoration in order to maximize positive outcomes and avoid unintended consequences.

Culvert upgrading requires careful planning and is not simply the replacement of a culvert with a larger structure. Even as undersized culverts block the movement of organisms and material, over time, rivers and streams adjust to the hydraulic and hydrological changes caused by these structures. Increasing the size of a crossing structure can cause head cutting – the progressive down-cutting of the stream channel – upstream of the crossing. Crossing replacement can result in the loss or degradation of wetlands that formed above the culvert as a consequence of constricted flow. In more developed watersheds, undersized culverts may play an important role in regulating storm flows and preventing flooding.

Before replacing a culvert or other crossing structure with a larger structure it is essential that replacement be evaluated for its impacts on:

- downstream flooding,
- upstream and downstream habitat (instream habitat, wetlands),
- potential for erosion and headcutting, and
- stream stability.

In most cases it will be necessary to conduct engineering analyses including longitudinal profiles of sufficient length to understand potential changes in channel characteristics. The replacement crossing will need to be carefully designed in order to maximize the benefits and minimize the potential for negative consequences resulting from the upgrade. In most cases these replacements will need to be reviewed and permitted by the local conservation commission.

Standards

- Whenever possible replacement culverts should meet the design guidelines for either general standards or optimal standards (see Standards for New Crossings above).
- If it is not possible or practical to meet all of the general or optimal standards, replacement crossings should be designed to at least meet general standards to the extent practical and to avoid or mitigate the following problems.

    → Orifice flows
    → Inlet drops
    → Outlet drops
    → Flow contraction that produces significant turbulence
    → Tailwater armoring
    → Tailwater scour pools
    → Physical barriers to fish passage

CONCLUSION

Given the large number of species that make up river and stream communities and the almost complete lack of information about swimming abilities and passage requirements for most organisms, it is impractical to use a species-based approach for designing road crossings to address the movement needs of aquatic organisms. A Stream Simulation approach is the most practical way to maintain viable populations of organisms that make up aquatic communities and maintain the fundamental integrity of river and stream ecosystems. Stream Simulation is an ecosystem-based approach that focuses on maintaining the variety and quality of habitats, the connectivity of river and stream ecosystems, and the essential ecological processes that shape and maintain these ecosystems over time.

Road networks and river systems share several things in common. Both are long, linear features of the landscape. Transporting materials (and organisms) is fundamental to how they function. Connectivity is key to the continued functioning of both systems. Ultimately, our goal should be to create a transportation infrastructure that does not fragment or undermine the essential ecological infrastructure of the land and its waterways.

GLOSSARY

→ **Bankfull Width** – Bankfull is amount of water that just fills the stream channel and where additional water would result in a rapid widening of the stream or overflow into the floodplain. Indicators of Bankfull width include:

- Abrupt transition from bank to floodplain. The change from a vertical bank to a horizontal surface is the best identifier of the floodplain and Bankfull stage, especially in low-gradient meandering streams.
- Top of pointbars. The pointbar consists of channel material deposited on the inside of meander bends. Set the top elevation of pointbars as the lowest possible Bankfull stage.
- Bank undercuts. Maximum heights of bank undercuts are useful indicators in steep channels lacking floodplains.
- Changes in bank material. Changes in soil particle size may indicate the operation of different processes. Changes in slope may also be associated with a change in particle size.
- Change in vegetation. Look for the low limit of perennial vegetation on the bank, or a sharp break in the density or type of vegetation.

→ **Culvert –** Round, elliptical or rectangular structures that are fully enclosed (contain a bottom) designed primarily for channeling water beneath a road, railroad or highway.

→ **Embedded Culvert –** A culvert that is installed in such a way that the bottom of the structure is below the stream bed and there is substrate in the culvert.

→ **Flow contraction** – When culvert is significantly smaller then stream width the converging flows creates a condition called “flow contraction.” The increased velocities and turbulence associated with flow contraction can block fish and wildlife passage.

→ **Inlet drop** – Where water level drops suddenly at an inlet, causing changes in water speed and turbulence. In addition to the higher velocities and turbulence, these jumps can be physical barriers to fish and other aquatic animals when they are swimming upstream and are unable to swim out of the culvert.

→ **Open Bottom Arch –** Arched crossing structures that span all or part of the stream bed, typically constructed on buried footings and without a bottom.

→ **Openness ratio –** Equals cross-sectional area of the structure divided by crossing length when measured in meters. For a box culvert, openness = (height x width)/ length.

→ **Orifice flows –** Flows that fill or nearly fill the entire culvert. These become problematic because there is no space within the culvert for wildlife passage and flows are typically too fast for the passage of fish and other aquatic animals.

→ **Outlet drop** – An outlet drop occurs when water drops off or cascades down from the outlet, usually into a receiving pool. This may be due to the original culvert placement or erosion of material at the downstream end of culvert. Outlet drops are barriers to fish and other aquatic animals that can’t jump to get up into the culvert.

→ **Physical barriers to fish and wildlife passage** – Any structure that physically blocks fish or wildlife movement as well as structures that would cause a culvert to become blocked. Beaver dams, debris jams, fences, sediment filling culvert, weirs, baffles, aprons, and gabions are examples of structures that might be or cause physical barriers. Weirs are short dams or fences in the stream that constrict water flow or fish movements. Baffles are structures within culverts that direct, constrict, or slow down water flow. Gabions are rectangular wire mesh baskets filled with rock that are used as retaining walls and erosion control structures.

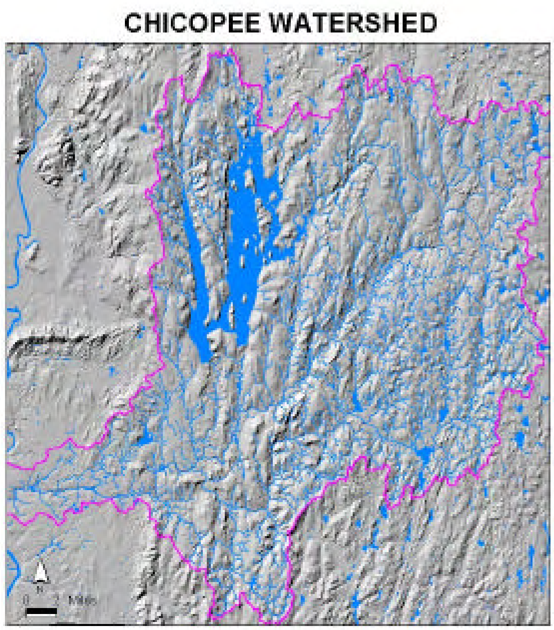
→ **Pipe Arch** – A pipe that has been factory deformed from a circular shape such that the width (or span) is larger that the vertical dimension (or rise), and forms a continuous circumference pipe that is not bottomless.

→ **Tailwater armoring –** Concrete aprons, plastic aprons, riprap or other structures added to culvert outlets to facilitate flow and prevent erosion.

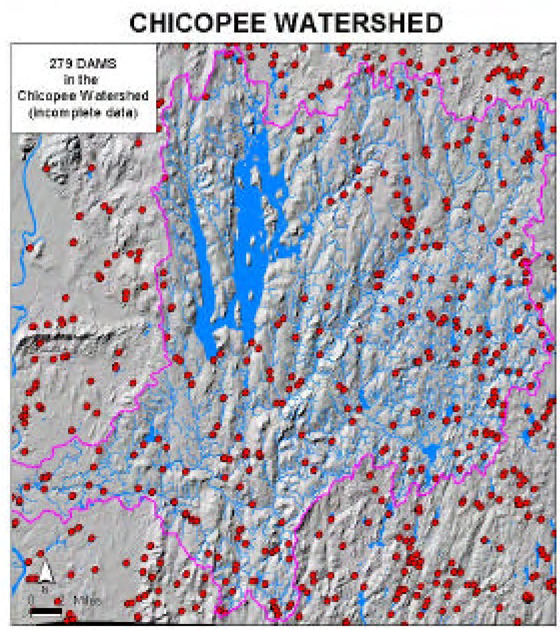
→ **Tailwater scour pool –** A pool created downstream from high flows exiting the culvert. The pool is wider than the stream channel and banks are eroded.

Appendix A.

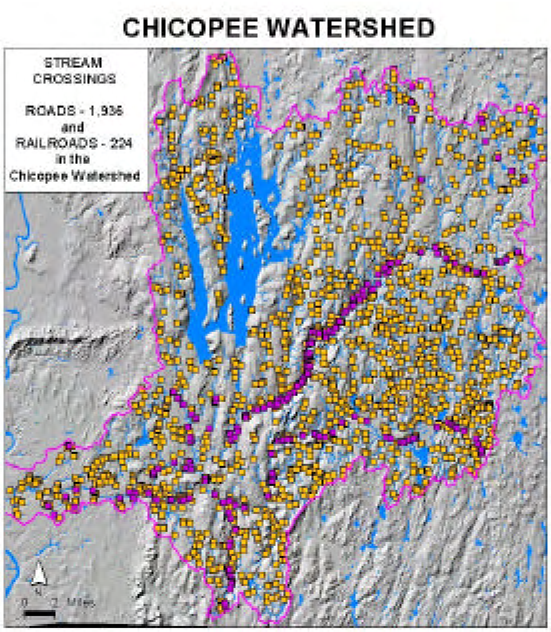
The Geographic Scope of River & Stream Fragmentation in Massachusetts (Courtesy of the Massachusetts Riverways Program)



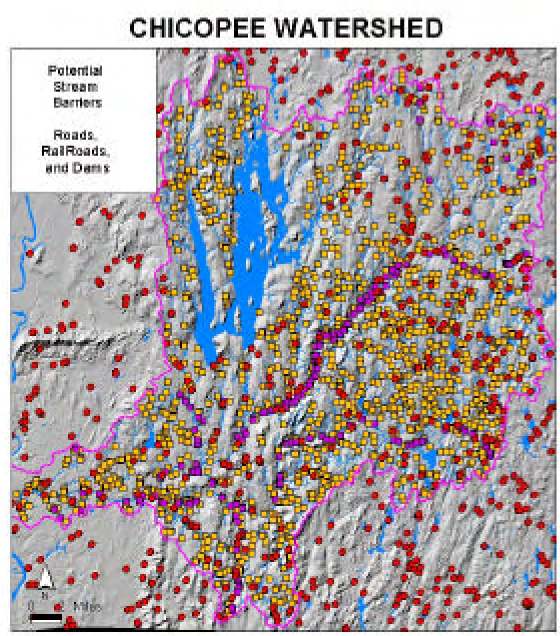
The 721 sq. mi. Chicopee River Watershed is a relatively rural watershed in Central Massachusetts.



A legacy of early American small-scale industrialization, there are at least 279 dams on the tributaries and mainstem of the Chicopee River.



The intersection of the stream network with roads and railroads results in an estimated 2,160 crossings.



The combination of crossings and dams raises serious concerns about the fragmentation of river and stream ecosystems in the Chicopee River watershed.

Appendix 10

Eightmile River Wild & Scenic Rivers Study Act of 2001

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

H.R.182

One Hundred Seventh Congress
of the
United States of America
AT THE FIRST SESSION

Begun and held at the City of Washington on Wednesday,

the third day of January, two thousand and one

An Act

To amend the Wild and Scenic Rivers Act to designate a segment of the Eightmile River in the State of Connecticut for study for potential addition to the National Wild and Scenic Rivers System, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the `Eightmile River Wild and Scenic River Study Act of 2001'.

SEC. 2. FINDINGS.

The Congress finds that--

(1) the Eightmile River in the State of Connecticut possesses important resource values, including wildlife, ecological, and scenic values, and historic sites and a cultural past important to America's heritage;

(2) there is strong support among State and local officials, area residents, and river users for a cooperative wild and scenic river study of the area; and

(3) there is a longstanding interest among State and local officials, area residents, and river users in undertaking a concerted cooperative effort to manage the river in a productive and meaningful way.

SEC. 3. DESIGNATION FOR STUDY.

Section 5(a) of the Wild and Scenic Rivers Act (16 U.S.C. 1276(a)) is amended by adding at the end the following new paragraph:

`(138) EIGHTMILE RIVER, CONNECTICUT- The segment from its headwaters downstream to its confluence with the Connecticut River.'.

SEC. 4. STUDY AND REPORT.

Appendix 11

Outreach and Education Documents, Eightmile Wild & Scenic Study

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

The Eightmile River Watershed

A Wild & Scenic Study Update

MAY 2004

Outstanding Resources Values of the Eightmile River Watershed Identified

The Eightmile River Wild & Scenic Study Committee has been working on a variety of efforts to identify and document the resource values that make the watershed and river system such a special place. During this phase of study, research has either been completed or is underway on vernal pools, natural communities, stream flows, and the cultural landscape. The outstanding resource values being considered for protection include:

Water Quantity – the amount of flow is often called the "master variable" protecting river resources since without adequate flow a river can not function well. Little impervious cover, the absence of dams or reservoirs, and only one water withdrawal all underscore a rare hydrologic system that is relatively intact and naturally functioning.

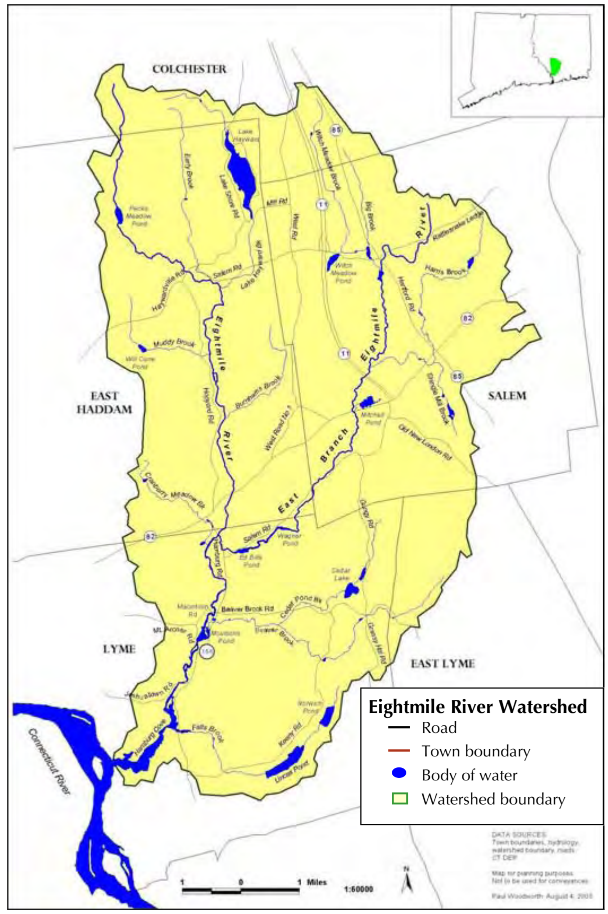
Rare and Diverse Species – the watershed is home to a host of unique plant species. Botanical field work reconfirmed two globally rare species and identified two other sites with globally rare natural communities. Nineteen new threatened, endangered, or special concern plant species, including 11 that are regionally rare, were also found in the watershed.

Geology – the point where present day North American and African continents broke apart is in the heart of the Eightmile River Watershed. The geology seen in the southern half of the watershed is the same geology seen in Morocco, a fairly unique situation in Connecticut!

River Ecosystem Quality – the watershed as a whole is a rare example of an intact, naturally functioning system. There are large unfragmented forest blocks, 85% forest cover, and numerous indicators of high habitat value, ranging from interior nesting birds to submerged aquatic vegetation and freshwater mussels.

Archaeology – a number of exceptional sites have been recognized in the watershed and placed on the National Register of Historic Places. Areas bordering the river have high potential for intact archaeological resources, and the proximity to the coast suggests the possibility that further significant resources will be identified.

Now that this phase of study is near complete, the Study Committee is gearing up to identify locally-led strategies to ensure long-term protection of these outstanding resource values. Community Forums held in May 2004 are the first in a number of opportunities for the community to discuss potential watershed management strategies and share ideas about how to protect the special nature of the Eightmile River watershed with the Study Committee.



Study Committee Reaches Out

The Eightmile River Wild and Scenic Study Committee held outreach meetings in the watershed towns of East Haddam, Lyme and Salem in Spring 2003 and 2004. Each of the sessions were very successful, with many participants and lots of good feedback.

Comments and questions were focused primarily on how watershed resources will be protected and how the study will be conducted. Comments about resource protection generally indicated strong community support for local land management and stewardship, protection of water quality/quantity. and better understanding local biodiversity. Questions about the study process focused on how best to protect private property values as well as leverage federal resources to achieve strong environmental protection. Lastly, an important concern voiced at each meeting was the desire for local land use decisions to remain under local control.

Input from these outreach meetings continues to be used by the Study Committee to understand the issues, concerns and priorities of the watershed community as a whole.

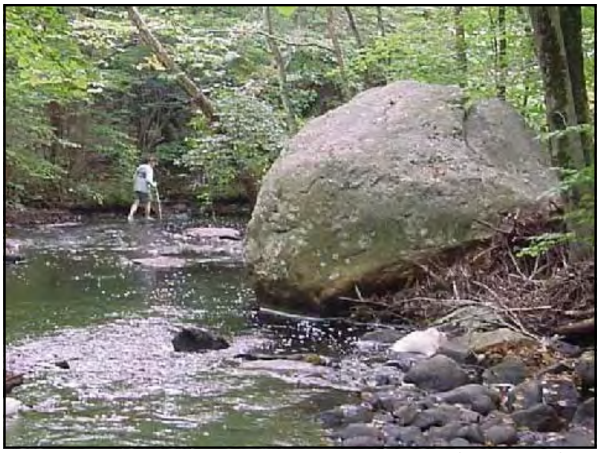


Photo: CRWP Archive

Chairman's Corner

The Eightmile River is the most outstanding river system within the Lower Connecticut River region — a region known as the "Tidelands" and named one of the 40 Last Great Places in the Western Hemisphere by The Nature Conservancy in 1993. As a riverine ecosystem, it is remarkably intact, free-flowing and virtually dam free. With excellent water quality and 85% forest cover, the river system is a haven for diverse and abundant fish populations, from native brook trout to blue back herring. This unusually robust river system contains globally rare species, an internationally recognized fresh water tidal marsh, and indicators of outstanding health such as native freshwater mussels. To top it all off, scenic beauty, historic character, and great fisheries flourish in this, the largest unfragmented forest region in coastal Connecticut.

Why does The Eightmile River need Protection?
The communities of East Haddam, Lyme and Salem make up 90% of the Eightmile River watershed. Over the last decade all three have experienced substantial development pressures. Incremental and poorly planned growth pose the greatest threat to the special qualities of the river system as highlighted above. Fragmenting forests and habitats, poorly managing stormwater runoff, and paving over important groundwater sources will all slowly degrade the features that make the watershed such a unique place. Growth can and will continue. With a Wild & Scenic designation, river communities will have the knowledge, tools and resources to ensure growth is approached in a way compatible with preserving the outstanding values of the Eightmile River.

Anthony Irving, Study Committee Chair
Ph. 860.434.2390
anthonyinlyme@aol.com

Stay Tuned!

Community leadership and involvement is critical for the study to be a success! The Eightmile River Wild & Scenic Education and Outreach Subcommittee is leading efforts to ensure the public is well informed about the study process and has ample opportunity to be involved. Community meetings and events will be held throughout the study, so . . .

Check the website for upcoming events!

The Eightmile Wild & Scenic Study Committee

Anthony Irving, Study Committee Chair
President, Lyme Land Conservation Trust

Randy Dill
Selectman & IWWC Chair, East Haddam

William Koch
First Selectman, Town of Lyme

Larry Reitz
First Selectman, Town of Salem

John Rozum
Member, P&Z Commission, East Haddam

David Tiffany
Chair, P&Z Commission, Lyme

Eric Belt
Member, IWWC, Salem

Susan Merrow
East Haddam Land Trust

David B. Bingham
President, Salem Land Trust

Nathan M. Frohling
Lower CT River Program Director, The Nature Conservancy

Linda Krause
Executive Director, CT River Estuary RPA

Walter Smith
Natural Resource Conservation Service (USDA)

Sally Snyder
Watersheds Coordinator, CT DEP

With support from the National Park Service
Jamie Fosburgh, Rivers Program Manager
Kevin Case, Study Project Manager

Study Committee Meetings are held in the Towns of East Haddam, Lyme, and Salem on a rotating basis on the 4th Monday of each month. Check the website for specific dates and schedules.

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www.eightmileriver.org

The Eightmile River Watershed

A Wild & Scenic Study Update

JUNE 2004

Community Forums Attract Over 160

This past May the Eightmile River Wild & Scenic Study Committee held community forums in the Towns of East Haddam, Lyme, and Salem. The forums, which drew over 160 attendees, were an opportunity to present the study findings to date and solicit input on potential strategies to manage and protect the Eightmile's special resources.

To kick off the evening Anthony Irving, Committee Chair, briefly explained the three steps of a Wild and Scenic Study; determining eligibility, developing management strategies, and demonstrating community support. The Committee has been diligently working through the study process, and the first step – determining eligibility through the identification of Outstanding Resource Values (ORVs) – is almost complete. Kevin Case, National Park Service Study Project Manager, then described the seven ORVs under consideration (see box below). From work completed to date it is clear that the Eightmile's natural and cultural resources are truly outstanding, therefore the river and its watershed are likely to be eligible for designation.

EIGHTMILE ORVs

- Archaeology
- Cultural Landscape
- Water Quality
- Water Quantity
- Geology
- Natural Communities
- Intact Ecosystem

The remainder of the evening focused on strategies available to protect the seven ORVs, including development of a locally supported watershed management plan. Nathan Frohling, Committee member and The Nature Conservancy Lower Connecticut River Program Director, emphasized that successful resource protection hinges on community involvement in developing acceptable management strategies, and a strong local commitment to implementation.

A watershed management plan is a toolbox that provides communities with strategies to protect resources over the

Photo: W. Goodfriend

Photo: S. Snyder

The Eightmile River Wild & Scenic Study Committee coordinated with the local communities to commission signs alerting travelers they are entering the Eightmile River watershed. Seven signs in all will be installed this summer on state roads including Route 11, 82, 85, 156 and Mount Parnassus. This effort will raise the general public's awareness of the location and beauty of the Eightmile River watershed

(Community Forums...continued)

long-term. In the Eightmile, the Committee has begun the first steps of plan development – identifying the major threats to, and current protections of, the seven identified ORVs. The next step is to determine the preferred level of resource protection, and assess if there are gaps between the desired and current levels of protection. Once these gaps are understood, a suite of action oriented recommendations can be developed that focus on achieving the desired levels of resource protection.

In general, public comments gathered during the forums suggest interest in employing an array of resource protection strategies. A number of possible management alternatives were mentioned, including improving stormwater treatment practices, strengthening local land use regulations, and enhancing river corridor protections.

The Committee will continue working with local community members, including land use commissions, watershed landowners, and the public, to develop a locally accepted resource management plan. This fall, the Committee will meet with the land use commissioners to solicit input and guidance on resource management alternatives.

Chairman's Corner

"To think that our little river here could be designated wild and scenic, not just here but for the United States, it's pretty amazing, really." *Bill Koch, Lyme First Selectman*

Think about it. It is truly amazing that a locally treasured resource, situated in a well preserved piece of Connecticut, the third smallest state in the union with the sixth highest population density, could receive national recognition. If the Eightmile is designated "Wild and Scenic" it will be one of only seven rivers in New England, and one hundred sixty rivers nationwide, to receive such recognition. And, while achieving such wide recognition is alluring, it also leads to the question – what would designation really mean to local watershed communities?

If designated the Eightmile River and its watershed will join the National Wild and Scenic Rivers System. As part of this system, federal funding and technical support will be available to a locally led coordinating council (with a membership similar to the Wild and Scenic Study Committee) to help implement a Watershed Management Plan. This plan is currently under development with considerable assistance and input from local community members. This locally created plan will be completed before the conclusion of the Wild and Scenic Study, and will be available for use even if the Eightmile does not receive designation.

In addition, designated rivers receive special protection from federally funded or permitted water resource projects. These projects generally include those requiring federal wetlands permits (under the jurisdiction of the Army Corps of Engineers). Once a river is designated, the National Park Service will review and comment on all federal permits and projects to avoid adverse impacts on the outstanding resource values identified during the Wild and Scenic Study.

So what does designation really mean? It means a great opportunity for local communities to obtain a broad array of resources focused on the long-term protection of their incredible local treasure — in this case — the Eightmile River watershed.

It is pretty amazing, really.

Anthony Irving, Study Committee Chair
Ph. 860.434.2390
anthonyinlyme@aol.com

Show your **WILD** support for the Eightmile!!!

Graciously designed by Marta Cone

To get a free limited edition bumper sticker contact Project Manager Kevin Case at 860.738.1092

The Eightmile Wild & Scenic Study Committee

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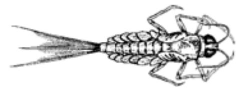
The Eightmile River Watershed
A Wild & Scenic Study Update
AUGUST 2004

EIGHTMILE OUTSTANDING RESOURCE VALUE: WATER QUALITY

(This is the first in a series of articles on the Outstanding Resource Values currently under study as part of the Wild & Scenic designation process)


Mayfly


Caddisfly


Dragonfly

Healthy river systems can support a myriad of sustainable uses. They provide habitat for unique plants and animals, serve as a drinking water supply, and offer recreational opportunities such as swimming, boating or fishing. The long term sustainability of a river as a resource is, however, strongly tied to the quality of the water flowing through it.

The Eightmile River and its tributaries form a strong and robust river system–and excellent water quality is one reason why. In fact, the Wild & Scenic Study Committee is considering water quality as one of the watershed's "Outstanding Resource Values." To meet federal standards for Wild & Scenic designation, the Study Committee is now working to show that water quality is not only locally outstanding, but is a unique, rare or exemplary resource for the state as a whole.

To determine just how outstanding the water is in the Eightmile two key factors are under consideration, chemical and biological conditions and current threats to water resources.

One indicator of chemical and biological water quality is the community of bottom-dwelling aquatic organisms known as *benthic macroinvertebrates*. Because the sensitivity of these organisms to water pollution and habitat change varies, the composition of species found living in a river or stream reflects long-term water quality of that resource.

Benthic macroinvertebrate surveys in the Eightmile indicate that ecological conditions are exemplary in the mainstem and very good in the East Branch. The data demonstrate that water quality and aquatic habitat in the Eightmile is not only locally exemplary, but as good as the best rivers studied in the state.

In addition to having outstanding water quality, major threats to water resources seen in other watersheds are almost nonexistent in the Eightmile. The two primary threats to water quality are *point source* and *nonpoint source pollution*. Currently, there are no point source discharges in the Eightmile watershed. Point sources are generally associated with discharge pipes from industrial uses such as wastewater treatment plants or factories.

Nonpoint source pollution (NPS), on the other hand, can come from any type of land use, including residential, agricultural, industrial and commercial properties. The most common types of NPS pollution are sediments, fertilizers, pesticides, oils and greases. Once contaminants accumulate on impervious surfaces (roads, parking lots, roofs), residential lawns and agricultural fields they are carried by stormwater runoff into wetlands, rivers, streams, lakes, and ponds. Because it is so prevalent, the EPA considers NPS to be a leading cause of river impairment.

EXAMPLE WATER QUALITY PRESERVATION ACTIONS

- Monitor water quality
- Minimize impervious surfaces
- Control NPS pollution
- Manage stormwater quality
- Limit new point sources
- Maintain healthy buffers
- Provide NPS education

One measure of NPS impairment is the amount of impervious cover. Scientific research suggests that in watersheds of up to 10 mi^2 stream quality can degrade when impervious cover is just 10% of the total area. For certain sensitive aquatic species, such as brook trout, impervious cover of as little as 4% can cause major population declines. Currently, impervious cover in the 88 Eightmile subwatersheds, the largest of which is 4.5 mi^2, ranges from 2% to 9%.

Based on the key indicators considered, it is clear that the Eightmile presently has exemplary water quality. Now the question is–how can we keep it that way? As part of the Wild & Scenic designation process the Study Committee is working to develop a Management Plan in cooperation with local land use officials and residents. The plan will include an overall water quality goal and recommended actions that can be implemented to meet that goal.

If the Eightmile is designated as a national Wild & Scenic River, a locally led Wild & Scenic Advisory Committee will promote use of the plan with support and funding from the National Park Service.



Photos: CRWP

Volunteers assess benthic macro-invertebrates in the Eightmile

Chairman's Corner

"Good water quality doesn't just happen." *anonymous*

As you'll read in the accompanying article, we are fortunate that the Eightmile has outstanding water quality. A strong conservation ethic and environmental stewardship, both now and in the past, are two of the reasons the Eightmile is such a tremendous asset. The challenge now is how best to preserve water quality and protect the Eightmile for the future.

One of the most important things we can do is maintain a healthy riparian corridor–or buffer–of trees, shrubs, and tall grasses along the rivers, streams, and brooks of the Eightmile watershed. Generally, a 100 foot buffer can act as a "living filter," trapping sediments, nutrients, and other soluble pollutants carried by rainfall or snow melt.

Buffers, especially if they have native trees and shrubs, also provide critical wildlife habitat and serve as migratory

Example of a riparian buffer in the Eightmile

corridors for many species. The leaves, logs, and branches that fall into the water provide important cover habitat for fish and help support the aquatic food chain. And along the banks, shade trees help moderate water temperature keeping conditions healthier for fish and other aquatic life.

Healthy trees and shrubs with strong root systems provide structural support to stream and river banks, holding soil in place. Sediment from eroding banks can cause significant turbidity and can bury critical aquatic habitat used by fish, insects, and other water dependent organisms.

Maintaining healthy vegetated buffers along local rivers and streams is a relatively simple and inexpensive stewardship practice that any riparian landowner can take on. By working together to protect and preserve riparian corridors we will keep the Eightmile a great place and preserve its outstanding water quality.

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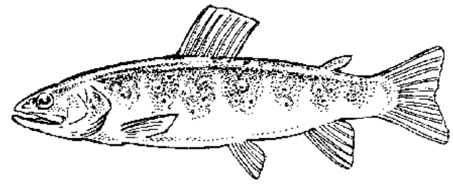

Brook Trout

WATERSHED FACTS

did you know . . .

In 1998 the Department of Environmental Protection and the USDA Natural Resources Conservation Service conducted a *Unified Watershed Assessment* to determine how our water resources measured up to state water quality goals. The Eightmile was one of only two major basins in the lower Connecticut River watershed to receive the "in need of protection" designation. This is significant considering that 70% of the state's major basins are designated "in need of restoration." Clearly, the Eightmile is a high quality resource that needs to be protected for future generations to enjoy.

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www.eightmileriver.org

Understanding Our Sense of Place: the Cultural Landscape of the Eightmile River Watershed

Barn on Rt. 156 in Lyme

J. Rozum (2002)

(This is the second in a series of articles on the Outstanding Resource Values currently under study as part of the Wild & Scenic designation process)

One of the most widely appreciated qualities of the Eightmile River Watershed is the special feeling of place it conveys to both residents and visitors. This emotional response to the Eightmile is one reason the public has taken such a keen interest in protecting the watershed. To better understand what it is that evokes such a strong sense of place, the Eightmile River Wild & Scenic Study Committee has undertaken an effort to document the cultural landscape features of the watershed.

Cultural landscapes are special places created by human interaction with the environment. They are comprised of the cultural and natural resources associated with historic events, activities, or persons, and serve to both define the current character of a community and reflect its past.

Quantifiable features of a cultural landscape include structures such as houses, churches, and public buildings as well as cemeteries, stone walls, views and vistas, vegetation and topography, and the distribution of transportation systems and land uses. Also considered is the spatial organization of features across the landscape, for example the location of hamlets such as the Eightmile's Millington Green or Hamburg.

To better understand how these types of features create the watershed's special sense of place the Study Committee retained researchers from the University of Massachusetts' Department of Landscape Architecture and Regional Planning to assess the significance of the watershed as a cultural landscape

The cultural landscape assessment will include a narrative of human settlement and the history of landscape change from Native Americans to the present day. It will also describe the features and characteristics of three distinct cultural landscape areas—an agricultural area, a town center, and an industrial center. And finally, it will comprehensively analyze the integrity and significance of the Eightmile cultural landscape as an outstanding resource value.

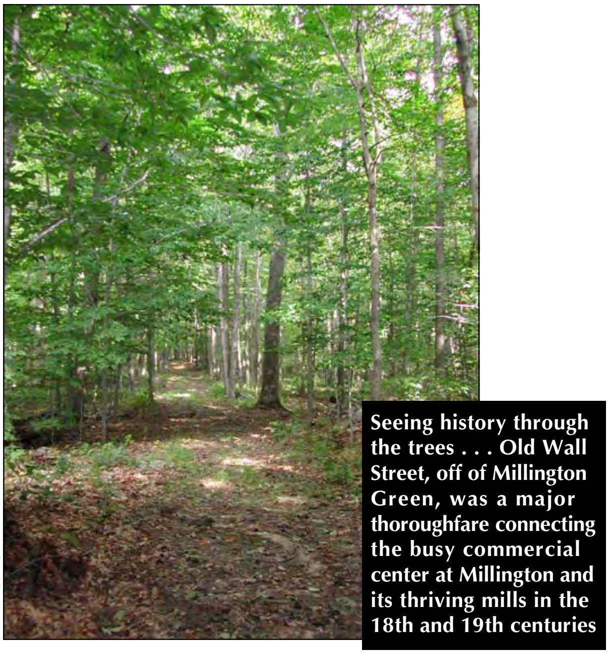
To determine if the Eightmile cultural landscape truly is outstanding a number of issues will be considered. These include the number and type of archaeological sites and intact historic buildings, the watershed's artistic history, and the effect that limited transportation hubs (no large harbors, ports, or railway lines) has had on development patterns. A comparative analysis will also be conducted to determine the statewide significance of the watershed as a cultural landscape.

Studying the Eightmile's cultural landscape will provide a tangible understanding of the widespread appreciation for the watershed's sense of place. It will also help to generate community support for the preservation of distinct cultural landscape areas and will be a valuable resource for residents and town officials when making future land management decisions.

Findings of cultural landscape assessment will be presented by University of Massachusetts researches at a public seminar scheduled for later this year.

"...Cultural landscapes reveal aspects of an area's origins and development. Through their form, features, and the ways they were used, cultural landscapes reveal much about human's evolving relationship with the natural world. They provide scenic, economic, ecological, social, recreational and educational opportunities... The ongoing preservation of cultural landscapes yields an improved quality of life for all and a sense of place for future generations."

The Cultural Landscape Foundation



L. Todd (2004)

Seeing history through the trees . . . Old Wall Street, off of Millington Green, was a major thoroughfare connecting the busy commercial center at Millington and its thriving mills in the 18th and 19th centuries

Chairman's Corner

A Wild & Scenic Study Committee member recently noted that while all the towns in the Eightmile River watershed are interested in protecting their "rural character," there is difficulty in defining exactly what that means.

Aspects of the watershed that call to mind "rural character" typically are not the natural resource values the Study Committee is focusing on. Driving down Hopyard Road in East Haddam you don't feel inspired because the river has a good selection of benthic macroinvertebrates or a natural flow regime, you respond to the twists and turns in the road, the canopy of trees overhead, and the stonework along the way. These features, which are part and parcel of the Eightmile's cultural landscape, are tangible signs of our current and past relationship to the land.

Many decades ago the agrarian way of life ended in the Eightmile River watershed, as it did in most of Connecticut. At the end of this period landscapes across the state began reverting to more primal forest types before evolving into suburban and exurban communities. This evolution led to substantial changes in the look and feel of many places, with new structures, transportation patterns, and landscapes replacing the old.

Unfortunately, it is often the more sublte features that collectively create the landscapes we value. It is only when these overlooked features are gone that we understand how important they really were. Straightening and adding new roads, cutting down canopy trees, removing or altering stone walls or historic buildings, for example, are outcomes of land use and landscape changes that can eventually diminish the special character of a place.

We are fortunate that the Eightmile has not yet succumb to the pressure of urbanization. Our cultural landscape still reflects patterns of the agrarian lifestyle and earlier – you just have to look through the trees to see it. The Wild & Scenic Study Committee recognizes that it is the cultural landscape, which some might call "rural character," that many of us subconsciously relate to. Because of this, the Study Committee is working to document the Eightmile's rural character and ensure its continued appreciation and preservation.

Understanding and celebrating the cultural landscape of the watershed will inspire us all to continue stewarding the special place we call the Eightmile. I hope you will join the Study Committee and our research team to learn about the Eightmile River Watershed Cultural Landscape Assessment.

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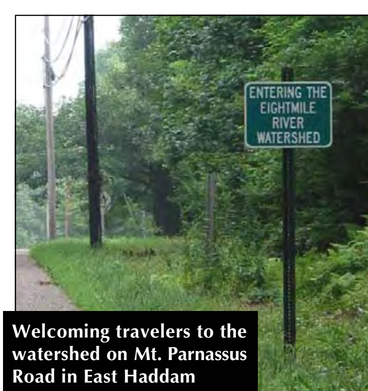


Welcoming travelers to the watershed on Mt. Parnassus Road in East Haddam

J. Rozum (2004)

The Eightmile River Watershed
A Wild & Scenic Study Update
MARCH 2005

Geology: The Foundation of the Eightmile River Watershed

Many aspects of the Eightmile River Watershed geology stand out as being regionally and locally significant. The following article is one of a series on the Eightmile's outstanding resource values. It describes some of the exceptional geologic features unique to the watershed. A glossary of select terms (in italics) is provided for your convenience below.

An Exceptional Assemblage of Bedrock

Bedrock is the solid rock that underlies soil or other unconsolidated surface material. In 1966, Lundgren described the bedrock of the Eightmile River Watershed as "an exceptionally varied suite of rocks that includes representatives of nearly all of the major *stratigraphic* and *granitic* units known in eastern Connecticut."

The exceptional variation in the Eightmile watershed's bedrock assemblage has its origin in New England's plate tectonic history. This history includes the closing of the Iapetos Ocean between 480 and 250 million years ago when the African and North American *tectonic plates* converged and ultimately collided. Eleven bedrock units representing the remnants of the Iapetos Ocean were crushed together with units that were once part of western Morocco (North Africa). Heating and metamorphosis then formed what is now the bedrock foundation of the Eightmile.

For most of New England the closing of the Iapetos Ocean resulted in a general north-south alignment of *terrane* boundaries and their attendant bedrock units. This is not the case for a small area of Southeastern Connecticut, including the Eightmile. In this region, a small crinkle in the bedrock fabric produced an anomalous east-west alignment. As a result, rocks from two major players in the New England-wide plate tectonic history are found in the watershed. The east-west trending Honey Hill fault is a terrane boundary that delineates the contact of oceanic affinity Iapetos Terrane bedrock units to the north, and African affinity Avalonian Terrane bedrock units to the south.

Also unique to the Eightmile is the occurrence of basic or "sweet" soils. Most *metamorphic* bedrock in Connecticut is acidic, which over time breaks down (weathers) to acidic soil. Five of the eleven metamorphic bedrock units underlying the Eightmile have basic, calc-silicate or marble members. Mapped in the Eightmile near Cedar Lake and at the south end of Moulsons Pond, basic bedrock members will likely weather to basic soils. These basic soils are ecologically significant in a region generally dominated by acidic soils.

Atypical Local Topography

Stream erosion over the past 250 million years coupled with the erosive power of two known Pleistocene glaciations has sculpted the bedrock surface into New England's rolling, north-south oriented topography. This landscape pattern in Connecticut was caused by selective weathering of less

A portion of the Honey Hill Fault runs through the north end of the Fox Hopyard Golf Course in East Haddam

resistant bedrock units as well as north-south aligned fault/fracture zones that developed when rifting formed the Atlantic Ocean. North-south running ridge systems drained by south-flowing streams are typical in most of Southern New England – except for a small area in and around the Eightmile. (*article continued on back* ⇨)

GLOSSARY

ge·ol·o·gy (jē-ŏl'ə-jē) ***n.***
The scientific study of the origin, history, and structure of the earth, a specific region of the earth's crust, or the solid matter of a celestial body.

gran·ite (grăn'ĭt) ***n.***
A common, coarse-grained, light-colored, hard igneous rock consisting chiefly of quartz, orthoclase or microcline, and mica, used in monuments and for building.

met·a·mor·phic (mĕt'ə-môr'fĭk) ***adj.***
Changed in structure or composition as a result of metamorphism, a process by which rocks are altered in composition, texture, or internal structure by extreme heat, pressure, and the introduction of new chemical substances.

roche mou·ton·née (rôsh' mūt'n-ā', mū'tô-nā') ***n.***
An elongate mound of bedrock worn smooth and round by glacial abrasion.

stra·tig·ra·phy (strə-tĭg'rə-fē) ***n***
The study of rock strata, especially the distribution, deposition, and age of sedimentary rocks.

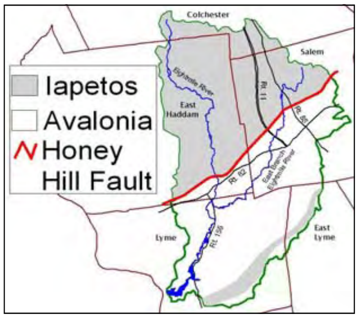
stri·a·tion (strī-ā'shən) ***n.***
One of a number of parallel lines or scratches on the surface of a rock that were inscribed by rock fragments embedded in the base of a glacier as it moved across the rock.

tectonic plates (tek-TON-ik) ***n.***
The dozen or so plates that are about 30 miles thick that makes up the surface of the Earth. Their motion is studied in the field of plate tectonics. The plates are not the same as the continents. The North American plate, for example, extends from the middle of the Atlantic Ocean to the west coast of the United States and Canada.

ter·rane also ter·rain (tə-rān', tĕr'ān) ***n.***
A series of related rock formations.

Chairman's Corner

Geology of the Eightmile—More Than Meets the Eye



Have you ever dreamed of going to Africa? Well if you have, but haven't the means to get there, you can find a little bit of Africa right here in the Eightmile. It isn't the plants, it isn't the birds, and it isn't the wildlife – it is the rocks right beneath your feet! You might find it hard to believe but the geology in the southern half of the Eightmile River Watershed is the same as that in Africa.

Most of us don't think much about geology in our daily lives unless we are admiring the beauty of a bedrock cut while driving down the highway, or are annoyed by yet another stone to pull out of the garden. In the Eightmile there is more to geology than meets the eye, or for that matter, the spade. Geology is truly the foundation upon which everything else is built.

As the Wild & Scenic Study moves forward and we look deeper at the tremendous resources the Eightmile offers one thing is for sure, the watershed's outstanding resources are greatly influenced by its geology. For example, the direction that streams flow in the watershed is determined by the underlying geology. Due to an unusual configuration of the area's bedrock, some of the streams in the Eightmile (such as Beaver Brook and Fall Brook) actually flow in an east-to-west direction – an anomaly in New England.

How much water is in each stream depends on the interaction between surface and ground waters – and this interaction is greatly influenced by geology. How steep streams are and what kinds of type of habitats they offer, such as runs, riffles and pools, is also driven by geology.

Beyond the streams, the character of the surrounding upland habitat depends on the aspect, slope, soils and climate present – all which are influenced by geology. In Devil's Hopyard for example, the talus slopes produce a variety of microclimates, and these distinct microclimates foster the establishment of unique plant species.

The geology of the Eightmile is an important reason that the watershed is such an outstanding place. With that a given, how can we manage this outstanding – yet somewhat unmanageable – resource? While some geology cannot be altered, for example the effects of continental drift, plate tectonics and glaciations, other aspects surely can. The geology that maintain stream flows, water levels and habitat values should be understood and recognized as key part of the Eightmile's outstanding intact ecosystem. ■

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(Geology: The Foundation of the Eightmile River Watershed...continued)

The anomalous alignment of bedrock units in the Eightmile creates a series of east-west trending strike ridges (bedrock alignments) which are cut by valleys that mirror the regional pattern of north-south fractures. The result is a rectangular or "blocky" local topography that is uncharacteristic in Connecticut and the region as a whole. The drainage pattern of the Eightmile River and its tributaries reflects the east-west bias of the strike ridges and the north-south bias of the crosscutting fractures.

Glacial Evidence Remains

The pattern of glacial deposition in the Eightmile is similar to other areas of Southern New England that are underlain by metamorphic bedrock. Blanketed by thin till, uplands are punctuated by patches of thicker till, drumlins and bedrock outcrops. Associated with exposed upland bedrock are *striations*, polished surfaces, *rouche moutonnée* and evidence of relict glacial spillways. The valleys in the Eightmile are filled with stratified drift deposits of sands, gravels and lake/pond deposits left by the last glacier during its northward retreat. Five former ice positions are marked by ice-contact stratified drift deposits that lie in the valley between Hamburg Cove and Route 82. Eskers and Kettles occur in several locations, and there are exemplary examples of these passive ice features in the Pleasant Valley Preserve. Open fields just north of Hamburg Cove, in the Pleasant Valley area, and in the North Plains area are nice example of an "eggs in basket" topography that compelled the Scottish to invent the very popular game of golf. ■

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The Eightmile River
Wild & Scenic Study Committee

The Eightmile River Watershed
Wild & Scenic Study Update

Summer 2005

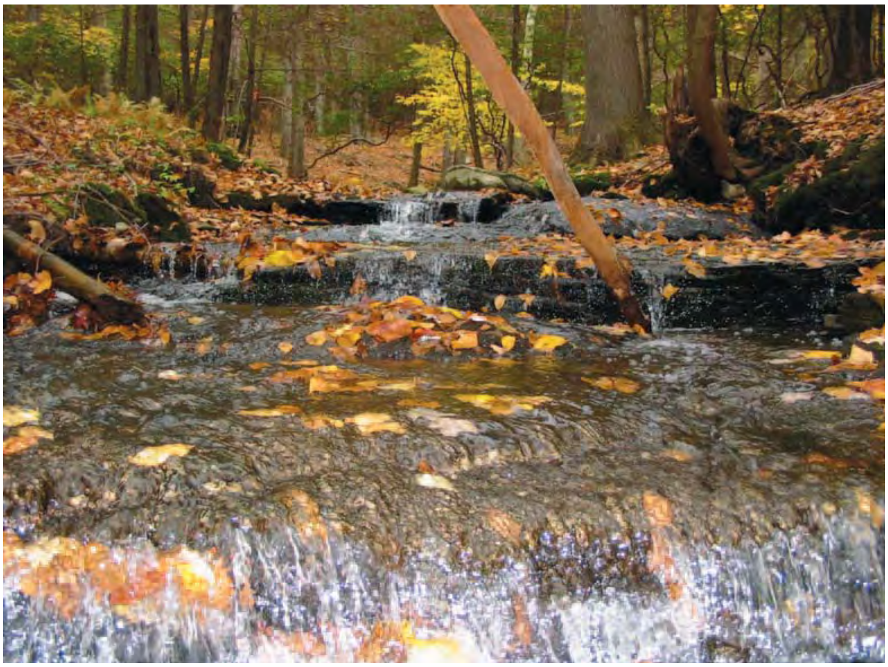

Photo courtesy of John Rozum.

Chairman's Column

For some of us living in and near the Eightmile River Watershed, the concept of a "Wild & Scenic" river might be new. If that is the case, the first question asked might be whether Wild & Scenic designation is more than just a name on a piece of paper. The answer to that question is yes. A Wild & Scenic designation offers river communities many tangible benefits.

An Eightmile designation likely means access to consistent, long-term funding from the National Park Service (NPS) to help our local communities protect and manage the watershed's outstanding resource values. It could also mean a paid technical staff person to help all three communities implement tasks identified in a watershed management plan.

NPS funding and technical support has helped jump start resource protection efforts for many Wild & Scenic rivers. In New Hampshire $650,000 of NPS funds were used to leverage $5.6 million to protect 1,437 acres, including six miles of riparian habitat in the Lamprey River Watershed.

(continues on pg. 2)

Wild & Scenic Study Enters Final Phase

With the Eightmile River Wild & Scenic Study nearing completion, the Study Committee is working diligently to wrap up three major tasks. First, prove what is special about the Eightmile River Watershed. Second, develop a watershed management plan that will facilitate the protection and enhancement of these special values. And, third, demonstrate that community members, local land use decision makers, the State of Connecticut and other watershed stakeholders support Wild & Scenic designation of the Eightmile River Watershed. The Study Committee has successfully completed the first task and made significant progress on the remaining two tasks. The Study Committee is planning to complete of all three major tasks by December 2005.

Proving the Eightmile Watershed is Special

The first task the Study Committee tackled was proving the Eightmile is special. Local and regional specialists determined that there are six features of the watershed – referred to as Outstanding Resource Values (ORVs) – that each make the Eightmile exceptional. These include the cultural landscape, geology, water quality, hydrology, unique species and natural communities, and the watershed ecosystem. Study reports detailing the ORVs are available at ***www.eightmileriver.org***.

(continues on pg. 2)

In This Issue

Wild & Scenic Study Enters Final Phase

Developing the Management Plan

Communities to Vote on Support for Designation

You Still Have a Critical Role

Many Benefits of Wild & Scenic Designation

(Chairman's Column continued)

On the Farmington River, currently Connecticut's only Wild & Scenic River, $10,000 of NPS funds were used to leverage an additional $80,000 to help rebuild a failing river bank threatening water quality, aquatic habitat, and a town road.

Also on the Farmington River, NPS funds were used to create informational kiosks at popular river access points, initiate a water quality monitoring program, and establish resource protection small grants. The small grants program has already distributed nearly $40,000 to local land trusts, schools, Boy Scout troops and other community organizations for resource protection activities.

Beyond actual dollars, Wild & Scenic designation means additional technical review of federally permitted or funded projects to ensure the identified Wild & Scenic outstanding resources will not be adversely impacted. As an example, if the Eightmile is designated Wild & Scenic, NPS staff will evaluate all proposed projects requiring a federal wetland permit under the Clean Water Act Section 404. They will also provide a review on any federally funded projects in the watershed.

Maintaining the high water quality, habitat, natural flow, biodiversity, and cultural qualities of the Eightmile River Watershed won't happen by accident. It will take energy and attention from many different collaborating partners to make sure the watershed's outstanding resource values are protected and enhanced, for generations to come. Wild & Scenic designation of the Eightmile River Watershed can provide the catalyst communities of East Haddam, Lyme and Salem, the state, and other stakeholders need to keep working towards successfully protecting our cherished watershed.

To me, that is the true benefit.

Anthony Irving

(continued from pg. 1)

Developing the Management Plan

The second task, developing a watershed management plan, is entering a critical stage. A Wild & Scenic Study subcommittee completed an extensive exercise to identify the threats to each ORV. The subcommittee then evaluated the extent that each threat was being addressed at either the local or state level. Through this process, the subcommittee discovered that all three towns have already expended a substantial amount of effort on open space conservation and land use planning. While these efforts will go a long way to protect and enhance the Eightmile's ORVs, some fundamental management challenges remain. Like most other watersheds, key management issues in the Eightmile include protecting riparian corridors, maintaining large unfragmented habitat blocks, keeping impervious cover low, and minimizing the impacts of stormwater runoff.

In March 2005 the Study Committee held a first-ever Eightmile Land Use Commissioner Summit. Over 40 local land use decision makers from the Planning, Zoning, Inland Wetlands and Conservation Commissions of the three major watershed towns (East Haddam, Lyme and Salem) attended the Summit. This unique get-together was an opportunity for Study Committee members and local land use decision makers to exchange ideas and share information. Study Committee members explained the process involved in developing the watershed management plan, and reviewed significant management issues they have identified to date. Commission members then offered critical feedback on the planning process, opinions on the identified management issues, and preferences for how to move forward to complete a draft plan.

Over the next few months the subcommittee will work closely with local land use decision makers and State agency representatives to develop a draft plan addressing identified management issues. Once there is agreement by all partners, the Study Committee will hold a community meeting to explain the draft plan and gather feedback. This meeting will be on **Thursday, October 13th, 2005.**

Communities to Vote on Support for Designation

The Study Committee's third task is demonstrating to the U.S. Congress local support for Wild & Scenic designation and a commitment by all partners to actively participate in implementing the watershed management plan. In the spring of 2005, the Connecticut General Assembly unanimously passed a bill declaring the State's support for designation. At the local level, demonstrating support for designation will occur at town meetings where residents will be asked to vote on a motion supporting Wild & Scenic designation of the Eightmile River Watershed. The Study Committee is hopeful that these votes will all take place by December 2005.

State of CT Supports Designation

Gov. M. Jodi Rell recently visited the Eightmile River Watershed to sign into law Public Act 05-18 An Act Concerning Designation of the Eightmile River Watershed within the National Wild & Scenic River System. This Act proclaims the state's support for designation and a commitment to participate in implementation of the watershed management plan. Thanks to the leadership of Rep. Linda Orange and Sen. Andrea Stillman the bill passed both the House and Senate unanimously. Other helpful bill co-sponsors include Sen. Eileen Daily and Rep. Ed Jutila. Joining the Governor at the bill signing was U.S. Congressman Rob Simmons, CT DEP Commissioner Gina McCarthy, and the First Selectmen of the three Eightmile River Watershed towns.

Dignitaries at the Eightmile River Bill Signing Include:

First Row (L to R) – State Sen. Andrea Stillman, Nathan Frohling of The Nature Conservancy, Gov. M. Jodi Rell, State Rep. Linda Orange, CT DEP Commissioner Gina McCarthy.

Second Row (L to R) – State Rep. Ed Jutila, U.S. Congressman Rob Simmons, Salem Land Trust President Sandra Kozlowski, Salem 1st Selectman Larry Reitz, Lyme 1st Selectman Bill Koch.

Third row (L to R) – Annie Bingham, Eightmile Study Committee Member David Bingham, Eightmile Study Committee Chairman Anthony Irving, Salem Planning & Zoning Alternate Carl Fontneau. Photo courtesy of Linda Bireley.

On the Homestretch

Once all three major tasks are complete, the Study Committee's last responsibility will be to make a final recommendation on designation to the National Park Service. If there is strong local support and a clear commitment from all partners to participate in implementing the watershed management plan, the Study Committee will make a favorable recommendation for designation.

At that point the Study Committee's work will be done. The National Park Service will be responsible for producing a final study report document and soliciting final public comments. Then, the U.S. Congress needs to pass a designation bill to be signed by the President before the Eightmile River Watershed can formally join the national Wild & Scenic Rivers System.

You Still Have a Critical Role

Over the last three years there has been a vast effort to understand the Eightmile's outstanding resources and cultivate ideas for their preservation. And while the Study Committee is clearly on the homestretch, you still have an important role. Please join us at the upcoming Wild & Scenic community meeting on **Thursday, October 13th** at the **Fox Hopyard Golf Club** in **East Haddam, Connecticut,** and share your thoughts, ideas and opinions on protecting the Eightmile. For more information on the Wild & Scenic Study, including details on upcoming meetings and events, please visit ***www.eightmileriver.org.***

Benefit of Wild & Scenic Designation

Keeping impervious cover low

The amount of impervious cover in a watershed affects the hydrology of streams, rivers, ponds, lakes and wetlands. Impervious surfaces, including rooftops, roads, driveways and parking lots, inhibit infiltration of rainfall and snowmelt. As the amount of impervious cover grows, surface runoff increases and groundwater recharge decreases, altering the natural hydrology of the watershed. This can lead to a number of changes, including higher runoff velocity and peak flows, increased frequency and severity of flooding, and diminished base flow conditions, possibly to the point that streams become intermittent or dry.

Impervious cover not only alters the natural hydrologic cycle but can increase the amount of polluted runoff as well. Studies have found that as little as 4-5% impervious cover watershed-wide can degrade aquatic life and habitat quality. It is estimated that 3% of the Eightmile River Watershed is currently impervious. Depending on how the Eightmile watershed develops, impervious cover could potentially reach 12%. Wild & Scenic designation can help provide resources for local communities to support efforts to keep impervious cover low, not only benefiting the Eightmile's outstanding resource values, but the quality of all the watershed towns as well.

Maintaining woodlands and natural land cover protects stream hydrology and local water quality.
Photo courtesy of John Rozum.

March '05 — *Study Committee holds Eightmile Land Use Commissioner Summit*

August '05 — *Draft Eightmile River Watershed Management Plan Completed*

September '05 — *Land Use Commissions Review and Vote on Endorsement of Draft Watershed Management Plan*

October '05 — *On Thursday, October 13th, Study Committee Holds Community Meeting to Present Draft Watershed Management Plan and Solicit Input from the Public*

December '05 — *Town Meetings to Vote on Support of Wild & Scenic Designation*

Eightmile River Downstream of Moulson Pond in Lyme.
Photo courtesy of David Bingham.

Benefit of Wild & Scenic Designation

Minimizing the impacts of stormwater

One of the greatest detriments to water quality is pollution carried by stormwater runoff (often referred to as Nonpoint Source Pollution). When rainfall or snowmelt can no longer infiltrate into the soil it begins to flow overland, becoming stormwater runoff. This runoff can pick up pollutants such as sediments, heavy metals, and oils that build up on impervious surfaces and deposit them into nearby receiving waters. Nutrients and bacteria attached to sediment particles can be carried with stormwater runoff, as can fertilizers and pesticides improperly applied to lawns and landscapes. According to the State's 2004 Water Quality Report to Congress, one-quarter of Connecticut's assessed river miles are impaired, not fully supporting aquatic life or contact recreation (e.g., swimming, boating). A primary cause of this impairment is polluted stormwater runoff. In fact, polluted stormwater runoff is such a problem that it is the focus of a recent CT DEP technical guidance document – the 2004 Connecticut Stormwater Quality Manual.

Through a combination of efforts, including education, reduction of imperious surfaces, better site planning and design, and stormwater quality treatment, the amount of polluted stormwater runoff in a watershed can be reduced. Technical assistance on how best to minimize the impacts of stormwater is one of the benefits that Wild & Scenic designation would bring to each Eightmile community, and the watershed as a whole.

January '06

Eightmile Study Committee Completes Study Process and Makes Recommendation to National Park Service

January-March '06

National Park Service Completes Draft Study Report, Solicits Final Pubic Comments and Makes Recommendation to U.S. Congress

Public Input and Involvement is Critical to the Wild & Scenic Study Process

The Eightmile River Wild & Scenic Study Committee continues to actively seek the opinions and input of landowners, town officials, river users and regional and state agencies. The Study Committee is interested in all forms of input on subjects ranging from the study process, to natural and cultural features, to the development of the Watershed Management Plan. If you have questions, would like to provide input or want to be involved please contact:

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Additional Resources

For information on the Study or The National Wild & Scenic Rivers Program, please visit:

www.eightmileriver.org
www.nps.gov/pwsr

The Many Benefits of Wild & Scenic Designation

Protecting riparian corridors

Riparian Corridors are upland areas with a biological, hydrological and physical connection to adjacent streams or rivers. Riparian corridors have many important functions, including filtering pollutants from stormwater runoff and providing storage during seasonal flooding events. Trees and shrubs along streams and rivers stabilize banks and provide shade that helps keep water temperatures low and dissolved oxygen levels high. Riparian corridors are exceptionally productive and provide food and habitat to a wide variety of aquatic and terrestrial plants and animals.

Altering the natural condition of the riparian corridor (e.g., disturbing the soils, slopes or vegetation) can quickly degrade the important functions described above. Protecting these functions by preserving intact riparian corridors is of vital importance to all watersheds, including the Eightmile. Assistance with riparian resource protection strategies such as voluntary land conservation programs and landowner outreach is just one of the benefits that Wild & Scenic designation would bring to the entire Eightmile watershed.

*Purple Milkweed**

Maintaining large unfragmented habitat blocks

Large contiguous blocks of unfragmented habitat are important to conserving biological diversity and naturally functioning ecosystems. Fragmentation occurs when large blocks of habitat are divided into multiple smaller habitat patches, typically when land is converted from one use to another. For example, if a road is built cutting across a single, large, intact forest block what remains is two smaller disconnected forest patches. This reduction in habitat area can force species to migrate to larger, more suitable habitats. It can also cause populations to become isolated and potentially decline in size and quality. Fragmented habitats have a greater ratio of edge to interior, which can cause shifts in the composition of species, the physical microclimate and levels of competition or predation. Currently, there are a significant number of large, unfragmented (roadless) blocks in the Eightmile River Watershed. A total of 5% of roadless blocks wholly or partially within the Eightmile are greater than 2,500 acres; 15% are greater than 1,000 acres; and 26% are greater than 500 acres. A locally-based watershed management plan developed during the Wild & Scenic Study process will include tools to help conserve the current low level of habitat fragmentation. This advisory plan will benefit all three watershed towns with guidance for protecting the high level of biological diversity and ecosystem function integral to the outstanding values of the Eightmile.

Benefits of Wild & Scenic Designation

USDA-NRCS PLANTS Database / Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 3: 26.

***Harvester Butterfly** at Walden Preserve, Salem. Photo courtesy of David Bingham.*

Eightmile River Wild & Scenic Study Committee Members

Eric Belt
Member Salem Inland Wetlands Commission

David B. Bingham
Vice-President
Salem Land Trust

Randy Dill
Chairman, East Haddam Inland Wetlands Commission and Selectman, Town of East Haddam

Nathan Frohling
Director Lower CT River Program, The Nature Conservancy

Anthony Irving
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First Selectman, Town of East Haddam

Larry Reitz
First Selectman, Town of Salem

John Rozum
Liaison to the East Haddam Planning & Zoning Commission, and CT NEMO Coordinator (UCONN CES)

Walter Smith
U.S. Dept. of Agriculture, Natural Resources Conservation Service

Sally Snyder
CT River Watershed Coordinator, CT Dept. of Environmental Protection

** There are only 8 known occurrences of purple milkweed in New England – two are located in the Eightmile River Watershed. Photo Courtesy of: Thomas G. Barnes @ USDA-NRCS PLANTS Database / Barnes, T.G. & S.W. Francis. 2004. Wildflowers and ferns of Kentucky. University Press of KY.*

Quick Facts about the Eightmile River Watershed

A watershed is an area of land that drains to a single common outlet such as a stream, pond, or wetland. The Eightmile River Watershed's 40,000 acres are situated primarily in the towns of East Haddam, Lyme and Salem.

Over 150 miles of streams feed the mainstem of the Eightmile River, which ultimately drains into Hamburg Cove and then the Connecticut River.

There are five globally rare species in the watershed including two plants, Estuary Beggar's Tick and Parker's Pipewort; a butterfly, the Frosted Elfin; a damselfly, the Little Bluet; and a dragonfly, the Skillet Clubtail.

Some of the most common fish in the Eightmile River Watershed include American Eel, White Sucker, Common Shiner, Tessellated Darter, Fall Fish, Blacknose Dace and Longnose Dace.

Currently 28% of the watershed is considered permanently protected open space.

Only 7% of the watershed is considered developed, while nearly 80% is forested.

Between 1985 and 2002 the three towns of East Haddam, Lyme and Salem lost 2,425 acres of forest and gained 729 acres of developed land.

Wood Frogs rely on vernal pools for successful breeding. Photo courtesy of Carol Giese.

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Conservation District, Inc.
dekoven House Community Center
27 Washington Street
Middletown, CT 06457

Eightmile Wild & Scenic Study Enters Final Phase

Community Meeting on Thursday, October 13th, 2005

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Appendix 12

Municipal Regulation and Policy Review of East Haddam, Lyme and Salem , CT

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

Eightmile River Wild & Scenic Study

Municipal Regulatory Review – Towns of East Haddam, Lyme and Salem

Short Version

FINAL DRAFT – December 14, 2004

By U.S. Dept. of Agriculture Natural Resource Conservation Service for the Eightmile River Wild & Scenic Study Committee

Eight Mile River Regulations Review

Wild and Scenic River Study

Introduction

In the fall of 2001 a study of the Eightmile River for possible inclusion in the National Wild & Scenic Rivers System was authorized by Congress. Congressman Rob Simmons and Senator Chris Dodd, in response to letters from town boards, residents, area land trusts, and river-fronting landowners, sponsored a study bill that the entire Connecticut congressional delegation supported. The bill ultimately was passed and signed into law as Public Law No. 107-65.

The study, being conducted by the locally led Eightmile River Wild & Scenic Study Committee, with support from the National Park Service, has three primary components: determining if the river is eligible for inclusion in the Wild & Scenic Rivers System by demonstrating what makes it so special; establishing if the river is suitable for Wild & Scenic designation by substantiating local support and commitment to designation; and, developing a locally supported watershed protection and management plan. This municipal regulatory review is an improtant first step in the management plan development process as it provides a current understanding of natural and cultural resource management approaches currently in place.

The purpose of this inventory is to present the existing municipal regulations and programs to identify the controls, policies, and plans that favor protection and enhancement of the natural and cultural resources in the Eightmile River Watershed. Recognizing growth can and will continue, the communities of this area can use this review to evaluate the similarities and differences between the plans, policies, and regulations of the municipalities in the watershed. The table below presents the regulations, policies, and plans each town has established to address natural resources issues and help protect the Outstanding Resource Values (ORVs) of water quality, water quantity, habitat quality and intactness, cultural and historic resources, and scenic resources.

The following regulations and programs were reviewed for the Towns of East Haddam, Lyme, and Salem. Commentary is also included for the Town of Colchester and Salem each of which has a small portion of its Town area located in the Eightmile River Watershed. Information for the Towns of Colchester and Salem is based on interviews conducted with appropriate Town staff and any materials provided by Town staff.

<u>Policies, Plans and Regulations Reviewed</u>

Policies and Plans

Policies and plans adopted by a municipality provide overall guidance to achieve the future vision for the community. Existing municipal documents were reviewed for the presence of policies and plans that relate to environmental protection.

Plan of Conservation and) Development (p.16)

Municipalities in Connecticut are required to have a Plan of Conservation and Development that outlines the overall vision of a community, and to update these plans every 10 years. The review of these plans looked at how current the plans are and the extent that they include policies, strategies, and implementation recommendations for protection of the natural and cultural resources.

Open Space Plans (p.16)

Open space plans set up goals and objectives in town policy to dedicate a certain amount and, in some cases, certain types of land for permanent open space. The intent is typically to help protect ecosystem functions and significant natural features, and retain community character. Policies were reviewed to determine if an open space plan existed and, if so, to what extent that plan outlines the amount and types of land the community is seeking to protect.

Greenway Provisions (p.16)

A greenway is an undeveloped corridor of open space land that connects two or more parcels of open space and or park land. The objective of the review for greenway provisions was to determine the extent municipal policy or regulations encourage or require greenway considerations in the land development review process.

Economic Development Plan (p.16)

Economic development plans propose ways in which a town can encourage economic growth and development. A review was conducted for any economic development plans to determine how the subject communities are intending to manage continued growth along with natural and cultural resources management.

Eightmile River Compact (p.16)

The compact is a non-binding cooperative agreement between East Haddam, Lyme, and Salem stating the Towns' commitment to work together to protect their natural and cultural heritage. Documents were reviewed to see if any of the Towns referenced the compact.

Natural Resources Inventory (p.16)

A Natural Resources Inventory is a data gathering process to identify and summarize the natural resources within a community. A review was conducted to determine if any such inventories had occurred and, if so, what natural resources each community identified, how they relate to the Outstanding Resource Values, and what protection measures are being suggested and implemented.

Build Out Plan (p.17)

Build out plans are intended to show the potential growth and development patterns that could result based on existing zoning and subdivision regulations. A review was conducted to determine if any of the communities had conducted such a plan and to identify the assumptions made developing the plan as well as any recommendations for managing growth through the municipal regulatory process.

Historic Districts (p.17)

Historic districts are areas or zones within a town established to maintain the integrity historic and cultural character of the community. Municipal documents were reviewed to determine if any historic districts had been created, what constitutes an historic district, and how each community is addressing the protection of such districts.

Regulations

Municipal regulations can be considered as rules that address specific planning actions and activities. Municipalities generally categorize regulations based on zoning, subdivision, and wetland activities. Regulations were reviewed to determine what methods the towns are using and to what extent to address and approach natural resources protection as part of their planning process.

Zoning Regulations

Zoning regulations of each municipality essentially determine the current and future land use. Different land uses affect the environment in different ways and to varying degrees. Zoning regulations for each municipality were reviewed to identify the controls, policies, and plans that favor protection and enhancement of the region.

Subdivision Regulations

Subdivision regulations provide details on the process for subdividing land in each municipality. A subdivision refers to the division of a parcel of land into smaller parcels for sale or building development. Subdivision regulations were reviewed to identify whether or not they contained provisions that could influence the amount and concentration of non-point source pollution contributed by a subdivision, water quantity, the preservation of habitat quality and intactness, the preservation of cultural and historic resources, and the protection of viewsheds.

Inland Wetland Regulations

Inland Wetland Regulations are regulations adopted by the municipalities in accordance with the Connecticut Inland Wetlands and Watercourses Act codified in Section 22a-36 and 22a-45 of the Connecticut General Statutes. The regulations make provisions for the protection, preservation, maintenance and use of the inland wetlands and watercourses by minimizing their disturbance and pollution. The regulations were reviewed to determine the presence/absence of buffer or setback requirements.

Wetland Upland Review/Buffer/Setback Areas (p.18)

Wetland agencies implement the Wetland Act through regulations which must conform to the statutes and DEP regulations. Many of Connecticut's wetland agencies have adopted regulations governing construction activities located in upland areas surrounding wetlands and watercourses. These regulations are known as upland review area, buffer, or setback regulations depending on the town. The linear distance from a wetland or watercourse that is considered within the regulated area under the municipal inland wetlands and watercourses regulations. It is generally expressed as "The regulated area shall extend for a distance of ___ feet from wetlands, and ___ feet from the edge of a watercourse."

Public Health (p.19)

Documents were evaluated for any regulations designed to ensure the protection of public health. These included and were not limited to water quality, septic and sewer, and aquifer and groundwater protection.

Tidal Wetlands (p.20)

Regulations specifically intended to address issues associated with activities affecting areas of tidal wetlands.

Design Review (p.22)

Design review regulations enable municipal commissions to comment on plans throughout or at various times during the process of site development. The opportunity to review plans and comment facilitates better communication between developer and town commissions.

Flood Plain Management (p.23)

Flood plains are the relatively flat areas adjoining rivers, streams and coastal areas that can flood and when built upon are a hazardous place for life and property. Municipal documents were reviewed to determine the extent that they protect flood plains for their natural function of receiving flood water and dispersing its energy while allowing compatible land uses for both economic potential and protection of natural resources.

Overlay/Buffer Zones (p.24)

Overlay zones are areas that are designated to preserve and enhance an area, typically through additional regulations or design standards. Buffer zones are areas of land without structures that are left in their natural state or landscaped to serve as visual or natural barriers between different land uses. Overlay and buffer zones are tools designed to protect and preserve natural areas and, in some cases, provide quality habitat and intactness.

Aquifer Protection (p.25)

An aquifer is a geological unit that is capable of yielding usable amounts of potable water.

Resources Extraction (p.26)

Resources extraction refers to the excavation and or removal of earth materials from a parcel of land. The removal of material includes sand and gravel as well as timber resources. Zoning regulations were reviewed to identify any permit requirements for the removal of earth materials including sand and gravel mining.

Storm Water Management (p.27)

Storm water management refers to the combination of practices or actions taken to control the quantity, rate of flow, and quality of surface water runoff resulting from rainfall. Storm water management is the planned control of storm water runoff to prevent flooding, erosion and sedimentation, and water quality degradation; and to promote groundwater recharge and minimize the impact of developments on adjacent or downstream land and watercourses.

Erosion & Sediment Control Plans (p.29)

An erosion and sediment control plan contains the proper provisions to adequately control erosion and sedimentation and to reduce the potential damage from storm water runoff from a subdivision.

Alternative Developments (open space, cluster subdivision, conservation subdivision) (p.30)

Alternative developments are non-traditional developments that will assure conservation of land and accomplish some of the following purposes: preserve land for park and recreation purposes; preserve and protect natural areas; preserve wetlands, marshlands or land with other natural values; and protect streams, rivers and ponds. Alternative developments (sometimes called conservation developments, cluster subdivisions, or open space subdivisions) may allow an increase in density in part of a parcel in order to protect other more sensitive land.

Density Bonus (p.31)

In some instances municipalities provide incentive to developers to develop a larger number of homes than would otherwise be allowed for the existing zoning as long as a certain percentage of those homes are designated affordable housing. This practice enables a community to concentrate development.

Vernal Pools (p.32)

Vernal pools are temporary bodies of water, typically containing standing water during the spring and drying out during most years. The pools generally occur in confined basins or shallow swales and lack outlet stream. While fish populations are not supported, vernal pools do support the life cycle of characteristic species. The support of the life cycle of characteristic species (species that need the habitat of the vernal pool) is what makes the pools important to protect and to maintain their integrity.

Ridgelines (p.33)

Ridgelines form the apex between two hillsides. They are prized for their aesthetic value, the viewshed they offer, and the habitat they provide for flora and fauna.

Water Supply Watersheds (p.34)

Water supply watersheds are drainage basins that are used to provide water for public water systems. Public water systems in Connecticut are those that serve 15 or more water service connections or 25 or more people.

Net Buildable/Soils Based Zoning (p.35)

Net buildable regulations require a minimum amount of land be available within each parcel in order to construct a building. Certain criteria are established for what will and will not be considered as 'buildable' land. Soils based zoning relies on the characteristics a sites soils as the way to evaluate what type and amount of development is permissible on a parcel or in a subdivision. These types of regulations are intended to manage the amount and type of development based on the natural resources found at a site.

Regional Consideration (p. 36)

Each of the 169 municipalities in Connecticut determines its own rules, regulations, and policies to manage growth and development. Regulations considering resources management from a regional perspective create an opportunity to manage resources less from political boundaries and more from resources needs.

Construction Phasing (p.37)

Phasing the development of a site is a way to minimize the impact on natural resources and to protect against potential problems associated with erosion and sedimentation, vegetation removal, stormwater management, among others.

Vegetation Restoration/Preservation (p.38)

Are any regulations in place that require developers to evaluate existing vegetation and make provisions for to protect any of it considered to be important. What measures do the towns have in place to require the restoration of vegetation that is removed or damaged as part of the site development?

Mixed Land Use (p.39)

Mixed land use is zoning that encourages the blending of conventionally designated land use categories, including but not limited to residential, commercial, and industrial. The theory behind mixed land use is to create more liveable communities by collocating services with residents.

Septic System Location and Design (p.40)

Properly located and designed septic systems minimize the potential for system failure and future water quality problems

Slopes (p.41)

Steep slopes may be considered a limiting factor, or constraint, for development. The purpose is to prohibit or limit development on steeply sloped areas that would require extensive engineering, present potential problems with septic system management, might result in erosion and sedimentation problems, along with other natural resources concerns.

Interior Lots (p.42)

Interior lots are generally considered lots that have no road frontage.

Bonding (p.43)

Requiring bonding is a way for a municipality to ensure that money will be available to cover costs for any for site management or proper construction that the developer is not able to provide.

Archaeology (p.44)

The presence of indigenous populations for thousands of years prior to the settlement of Connecticut roughly 350 years ago has left a rich archeological history of the people who have occupied this land. Protection of those sites and artifacts is an important method to preserve the history and cultural

Watershed Approach (p.45)

Watershed planning is a way to address resource needs based on the geographic delineation of water resources distribution. Water quality and water quantity issues are often addressed through watershed planning. It is also considered a way to address natural resources concerns using geographic rather than political boundaries.

Open Space Set Asides (p.46)

Open space dedication refers to requirements in regulations or town policy to set aside a certain amount of land for permanent open space as part of the subdivision plan approval process.

Open Space Funding (p.47)

Regulations were examined to assess if any town has measures in place to ensure that bonding is in place to assure that open space set asides are put in place.

Fees in Lieu of Open Space (p.48)

In certain cases it may not be feasible, for a variety of reasons, to establish open space set asides. An alternative is for the developer to pay a fee in lieu of creation of open space. The money can be used by the town to purchase and create acceptable open space another part of town.

Transfer of Development Rights (p.49)

This planning technique allows permits transfer of development rights from one property to another property. Transferring the rights creates a means for moving proposed development from a less suitable area to a more suitable site. This acts as a mechanism to preserve important natural features, farmland, open space, etc…

Planned Residential Development (p.50)

Planned Residential Developments promote variety, innovation, and flexibility in development by allowing variation in lot size, dwelling types, and design requirements. The intent is to encourage efficient use of land, to preserve natural features, and to create a living atmosphere that enhances quality of life.

Narrative Summary of Rules and Regulations

The following are concise summaries condensing the findings of the rules and regulations inventory. The purpose of this summary is to
1.) create an understanding of the overall regulatory approach each individual community has adopted to address natural resources concerns
2.) create a perspective of the similarities and dissimilarities in the environmental policies, rules, and regulations of the three municipalities.
3.) create a tool to examine the rules, regulations, and policies in relation to the ORVs under consideration as part of the Eightmile River Watershed Study.

As a result, it will be possible for a person using this document to draw some conclusions about potential regional issues which are important to all the municipalities as well as areas of municipal regulation which might warrant further discussion on a regional level in order to develop more consistency.

Town of East Haddam

The Town of East Haddam is currently in the process of updating its Plan of Conservation and Development (POCD). As part of the POCD the Town is conducting a build out analysis that will be based on new regulations being developed. Though the new POCD and new regulations are not yet available, the existing municipal regulations and policies demonstrate East Haddam's commitment to protecting the ORVs of the community's natural resources. Using stormwater management as the centerpiece to its regulations, East Haddam is addressing water quantity and water quality issues. Various other measures are in place requiring developers evaluate the natural resources on a sit e and to provide measures to maintain habitat quality. The community is encouraged to provide insight as to how resources that might be affected by development. Several special zones have been established in Town intended to protect cultural and historic resources along with natural resources. These regulations translate into a means for maintaining the scenic and rural character of the Town.

Wetlands Regulations

The Town has adopted standard State model wetland regulations with a 100 foot setback for watercourses and wetlands for regulated areas and activities.

Public Health

Although no regulations specifically categorized under public health were found, several regulations state the protection of public health as a complementary purpose to achieve.

Tidal Wetlands

No regulations were found specifically focused on tidal wetlands.

Design Review

Although there are no regulations identified under the heading Design Review, the Town has a standard procedure outlined for subdivision applications. The procedure requires the applicant to include pertinent information about subdivision layout, location of buildings, presence of natural resources features, and appropriate timing and routing of application materials, among other elements. In addition, East Haddam regulations cite that public information should be sought by the Planning and Zoning Commission to provide as much detail as possible about a site prior to its development. Also, under wetlands regulations developers are required to provide alternatives for the site development and an explanation as to why they chose the option they chose.

Flood Plains

The Town has the standard State model regulations.

Overlay/Buffer Areas

East Haddam has created a Conservation Zone. Additional regulations are in place to establish streambelt reservations, rural and agricultural buffer areas, as well as residential buffers intended to separate different zoning areas and types of neighborhoods. The developer is responsible for the establishment of the buffer and the individual property owner is responsible for the maintenance of the buffer.

Aquifers

The regulations make no direct reference to aquifer protection.

Resources Extraction
East Haddam has standard regulations for sand and gravel operations, including five (5) acres limitation for total area being excavated at any one time. The Town also has extensive governing timber harvesting, including aspects such as but not limited to vegetative restoration, size of area to be harvested, procedures for implementation of activities, and a 100 foot setback from adjoining properties.

Stormwater Management (includes detention and retention, road design, impervious surfaces limits, curbs and swales, parking, and maintenance)
Stormwater management regulations have become central to East Haddam's effort to direct the type of future development as well as the way in which future development occurs. By requiring developers to meet stringent stormwater quality and quantity standards the Town has eliminated the use of conservation easements as a means of enforcement and has moved away from the use of soils based zoning. The regulations strongly encourage developers to use the CT Department of Environmental Protection's Stormwater Design Manual (published in 2002) as the guideline to direct subdivision and lot designs. Regulations address use techniques such as detention and retention basins, use of pervious materials in appropriate circumstances, road and driveway design criteria, along with other measures to minimize impact from stormwater runoff on ground water and surface water.

Erosion and Sediment Control
The Town uses the standard regulations based on the Erosion and Sediment Control Guidelines set forth by the State of Connecticut, Section 22a-329 of the General Statutes.

Alternative Developments (e.g. open space, cluster, conservation subdivisions)
Some form of alternative development is supported through the municipal regulations. Developers are to propose both a conventional subdivision plan and an alternative development plan for the P&Z Commission to review. The Commission has the authority to decide which plan is most appropriate.

Vernal Pools
East Haddam has taken a progressive stand on vernal pools. A 400 foot setback has been established. In addition, applicants are required to provide extensive documentation regarding vernal pools. The Town has developed a Vernal Pool Obligate Species list, criteria for vernal pool identification, a vernal pool inventory worksheet, and a vernal pool impact worksheet for applicants to use.

Ridgelines
Ridges and ridge tops are considered scenic resources to be preserved, conserved, and protected, particularly when considering areas for open space.

Water Supply Watersheds
Other than applicants being required to notify water supply companies if development is proposed on water supply land that had not been mapped with the Town, the Town does not have specific regulations regarding water supply watersheds.

Net Buildable/Soil Based Zoning
Regulations for the establishment of Net Buildable Areas have been developed and will be incorporated into the new Town regulations.

Regional Consideration
Regional consideration appears to be limited to the standard notification to adjoining communities when an activity that may affect traffic, watercourses, septic or sewage will be occurring within 500 feet of the municipal boundary.

Construction Phasing
Some construction phasing is incorporated through the erosion and sedimentation regulations.

Mixed Land Use
The Town has established a mixed land use district. The intent is to build on an existing area and the regulations do not encourage expansion of the district or creation of similar districts in other parts of Town.

Vegetation Restoration/Preservation
Standard regulations are in place requiring planting of vegetation on any disturbed land. Timber harvesting regulations set guidelines as well for restoring and protecting vegetation.

Septic System Location and Design
Applicants are required to provide a sanitary waste disposal plan that includes soils information and meets CT Department of Public Health codes.

Slopes
Numerous regulations are in place establishing guidelines for slopes created as part of site restoration activities. The Town also uses 20% slopes as a limiting factor as part of its design criteria for minimum buildable areas for lots and subdivisions.

Interior Lots
The Town does not permit interior lots.

Bonding
Various bonding measures are in place. For subdivisions there is a two (2) year timeframe that can be extended, and as part of Earth Moving Operations the amount of the bond is to be determined by the Commission.

Archaeology (Cultural, Historical, Viewsheds)
As part of the effort to protect and preserve cultural and historic resources, the Town has established Conservation Areas, Conservation Zones, Historic Parks, and Sensitive Areas. Included in these areas are cemeteries; stonewalls; foundations; unique natural features; historic parks; the Lower Connecticut River area; historical, town, and architectural character and scenic roads. Views and vistas have also been identified as resources to preserve, enhance, and restore.

Watershed Approach (Regulations by Major Watersheds)
No regulations were found addressing resources or planning on a watershed basis. The POCD does, however, acknowledges East Haddam as part of the Eightmile River Watershed. The Eightmile River compact has been signed by the municipality and there is recognition of the municipality as part of a larger watershed community.

Open Space Set Asides
Open space set asides are in place. The size and location of open space area to be set aside is a site specific determination. The minimum amount to be set aside is 15% of the total area of the site. Numerous methods of disposition are possible. Natural resources and features are to be considered when determining what areas should be set aside as open space

Open Space Funding (Bonding)
Enforcement bonding is in place to assure for open space set asides.

Fees in Lieu
Payment in lieu of open space is permitted. Not more than 10% of the fair market value of the land shall be paid. A developer is exempt if 20% or more of the subdivision will be used for affordable housing.

Transfer of Development Rights
No regulations were found.

Planned Residential Development
Floating Zone Regulations exist that make provisions for Planned Residential and Planned Recreational Developments. Special standards are in place regarding approved land uses and parcel sizes in the PRDs.

Town of Lyme

In 2001 the Town of Lyme completed it most recent revision of its POCD. Since the mide-1960's, when the first POCD was written, the community has recognized the value and importance of natural and cultural/historic resources to the Town. Over the last 40 years Lyme has worked to ensure that these resources are preserved. The permanent preservation of land has been, and as noted in the current POCD, will continue to be a primary strategy to accomplish this goal. As part of that approach the Town has noted that it should consider large tracts of land and habitat that promotes healthy biodiversity, encourage open space preservation with tax incentives, use municipal regulations to assess open space subdivisions as well as buffer and no-development areas. Other actions complimenting land preservation include reviewing local land use regulations to ensure that all available and appropriate tools are in place, encouraging the maintenance of early successional habitats (old fields and meadows), encouraging continuation of agriculture and preservation of agricultural lands, and the preservation of cultural and historic sites and features among others. The POCD also suggests that municipal regulations can be used to control residential development through minimum buildable areas, accessory residential uses, viewshed requirements, and size requirements. Additional recommendations include restrictions on mixed use zoning, sewer avoidance, and stormwater management. For Lyme, preservation of open space is the way to ensure that the protection of the outstanding resource values of the community.

The current body of municipal rules, regulations, and policies reflect the focus on land preservation as the preferred method for land management. The overall tenor of the municipal codes focuses more on controlling the potential for growth in Lyme rather than managing for future growth.

Wetlands Regulations

The Town has adopted the standard State model wetland regulations with a 100 foot setback for watercourses and wetlands. A special 200 foot setback has been established for the location of subsurface waste disposal systems near specifically identified waterbodies, and 150 feet for all remaining waterbodies.

Public Health

Although no regulations specifically categorized under public health were found, several regulations state the protection of public health as a complementary purpose to achieve.

Tidal Wetlands

The Town has both 100 and 200 foot buffer zones depending on the zoning designation.

Design Review

No regulations were found specifically addressing design review other than the standard submittal and review of a subdivision application.

Flood Plains

The Town has the standard State model regulations. The regulations are particular to subdivisions of five (5) acres or 50 lots, require that no increases greater than one (1) foot occur in flood level, and identify minimum lot size and lot width in the flood plain district.

Overlay/Buffer Areas

The Town has an established Conservation Zone. Conservation is identified as Lyme's primary method for protection of resources. Certain uses are prohibited in the Conservation Zone and other uses require special permits.

Aquifers

Aquifers are mentioned in the Subdivision Regulations as a natural resource to be conserved and protected under its Open Space requirements.

Resources Extraction

The Town has standard regulations for sand and gravel operations, and has a 200 foot setback in place for operations. Appendix A outlines standards for timber harvesting including stream protection, logging roads, aesthetics, harvest methods, wildlife and regeneration.

Stormwater Management ((includes detention and retention, road design, impervious surfaces limits, curbs and swales, parking, and maintenance)

Overall, the stormwater management regulations are minimal. Requirements are in place for surface drainage and subsurface drainage. No references were found concerning detention or retention of stormwater, road design and stormwater, impervious surfaces, parking, or maintenance of stormwater management measures and practices. The Town has attempted to minimize the potential impact from development and, therefore, has not developed significant stormwater management regulations

Erosion and Sediment Control

The Town uses the standard regulations based on the Erosion and Sediment Control Guidelines set forth by the State of Connecticut, Section 22a-329 of the General Statutes. The Town applies these standards to land disturbances of one half acre or more.

Alternative Developments (e.g. open space, cluster, conservation subdivisions)

The Planning and Zoning Commission has the authority to subdivide land as a cluster subdivision. The area is not to be less than 15 acres and the Commission will use a formula to determine the number of lots.

Vernal Pools

No regulations were found addressing vernal pools.

Ridgelines

Ridges and ridge tops are considered scenic resources to be preserved, conserved, and protected, particularly when considering areas for open space.

Water Supply Watersheds

No regulations were found addressing water supply watersheds.

Net Buildable/Soil Based Zoning

Minimum net buildable areas have been established for residential zones

Regional Consideration

Regional consideration appears to be limited to the standard notification to adjoining communities when an activity that may affect traffic, watercourses, septic or sewage will be occurring within 500 feet of the municipal boundary.

Construction Phasing

No regulations were found addressing construction phasing.

Mixed Land Use

Though the regulations allow for one (1) family dwelling unit per lot in Commercial Districts, the POCD discourages the development of mixed land uses.

Vegetation Restoration/Preservation

Identify on site plan significant vegetation (functions for erosion control, wildlife habitat, historical, aesthetic, ecological, or recreational purpose). Building locations need to be such that youngest and healthiest trees, bushes, and plants are protected. Planting plans needed for new developments to show that solar energy access is not impaired.

Septic System Location and Design

Requirements are in place to show location of septic and sanitary systems. Location and design must demonstrate no impairment or contamination will occur during flood events.

Slopes

Grading plans require that no finished or bank exceed 1:3 slope, and ADA requirements are met for assisted living facilities.

Interior Lots
Interior lot defined as "A lot other than a corner lot or through lot". Regulations state that all lots shall have frontage on streets.

Bonding
Various bonding measures are in place.

Archaeology
The Town has designated Conservation Zones as a way to preserve natural, cultural, and archeological features, as well as unique scenic, ecological, scientific, and historic areas of value. In addition to natural features such as wetlands and watercourses, particular vegetation, unusual topography, ledges, consideration should be given to stonewalls, scenic vistas and views, cemeteries, and trails.

Watershed Approach (Regulations by Major Watersheds)
No regulations were found addressing resources or planning on a watershed basis. The POCD does, however, acknowledge Lyme as part of the Eightmile River Watershed. The Eightmile River compact has been signed by the municipality and there is recognition of the municipality as part of a larger watershed community.

Open Space Set Asides
Open space requirements. The minimum amount to be set aside is 15% of the total area of the site. Numerous methods of disposition are possible. Natural resources and features are to be considered when determining what areas should be set aside as open space.

Open Space Funding
No regulations were found.

Fees in Lieu
Regulations allow for payment in lieu of land if insufficient or unsuitable land is all that is available. Not more than 10% of the fair market value of the land shall be paid

Transfer of Development Rights
No regulations were found.

Planned Residential Development
No regulations were found.

Town of Salem
The Town of Salem adopted its current POCD in 2002. Recognizing the Town is facing growth and development pressures, the POCD strives to layout strategies to enable Salem to balance the preservation of the rural character of the Town with impending commercial, industrial, and residential growth. Contained within the plan are recommendations that blend actions intended to preserve the rural and natural elements of the Town while creating a framework in which other land uses can be developed.

Salem has pursued several avenues to assess and address the development pressures facing the community. The Town conducted a build out analysis, is investigating soils based zoning or net buildable area zoning, examined the possibility of using cluster subdivisions, and developed an open space plan. These studies and approaches have been designed to evaluate potential impacts and recommend potential methods for addressing the natural and cultural resources needs of the community along with the expressed need to diversify the Town's tax base through industrial and commercial growth. The regulations outlined below are indicative of Salem's desire to use varied methods for guarding against potentially detrimental impacts to the Town's outstanding resource values. Developers need to consider and present alternative types of developments as well as alternative methods of development, innovative techniques for stormwater management are encouraged, net buildable area is being used to minimize and control impact from future development, and cluster housing is being investigated, along with other measures. The existing municipal regulations mirror this approach.

Wetlands Regulations
The Town has adopted the standard State model wetland regulations with a 75 foot setback for watercourses and wetlands. The Town has also established regulations setting a minimum amount of land required should wetlands be on a site or if accessory apartments are present, as well as for Planned Residential Developments.

Public Health
The regulations state that no lot shall be subdivided should it pose a threat to health or public safety.

Tidal Wetlands
No regulations were found.

Design Review
Along with standard procedures for subdivision application review, the regulations state that specific attention should be paid to natural resources for subdivision layout and the plan should look to preserve natural resources. Also, under wetlands regulations developers are required to provide alternatives for the site development and an explanation as to why they chose the option they chose.

Flood Plains
The Town has the standard State model regulations. The regulations are particular to subdivisions of five (5) acres or 50 lots.

Overlay/Buffer Areas
The Town has created a Seasonal Residential Zone and a Commercial Recreation Zone, which serves as a preserve around Gardner Lake. In addition, regulations are in place requiring visual buffer strips for commercial and industrial sites. Screen planting plans may be required for campground sites.

Aquifers
Applicants must provide information about and show they are taking into account aquifers as part of the environmental management report that is necessary for a Planned Recreation/Residential Community.

Resources Extraction
The Town has standard regulations for sand and gravel operations. A minimum land requirement is set for an operation in industrial zoned areas.

Stormwater Management ((includes detention and retention, road design, impervious surfaces limits, curbs and swales, parking, and maintenance)
A broad range of stormwater regulations are in place. They are intended to protect the property being developed as well as adjacent and adjoining properties. The town uses the 25 year storm as the design criteria. A 13% maximum limit is set for impervious area in PRDs. Treatment measures such as swales, detention basins and ponds are cited as potential measures to control stormwater runoff. Regulations are in place to assure control of stormwater for protection of groundwater. Control of stormwater is established for roads and parking areas, and the Town favors traditional designs criteria requiring use of bituminous materials and curbing.

Erosion and Sediment Control
The Town uses the standard regulations based on the Erosion and Sediment Control Guidelines set forth by the State of Connecticut, Section 22a-329 of the General Statutes. The Town applies these standards to land disturbances of one half acre or more.

Alternative Developments (e.g. open space, cluster, conservation subdivisions)
The Town has established regulations allowing a developer to propose an alternative type development for the purpose of increasing residential choices, preserving open spaces, and preserving natural areas and scenic vistas.

Vernal Pools
No regulations were found.

Ridgelines
Applicants are required to show "rock ridges" on pre-application sketches.

Water Supply Watersheds
Information and considerations need to be given in the environmental management plan for the area associated with the golf course.

Net Buildable/Soil Based Zoning
Regulations have been established using net buildable area as a means for regulating development. NBA is required for each new lot created after December 1, 2003.

Regional Consideration
Regional consideration appears to be limited to the standard notification to adjoining communities when an activity that may affect traffic, watercourses, septic or sewage will be occurring within 500 feet of the municipal boundary.

Construction Phasing
No regulations were found addressing construction phasing.

Mixed Land Use
Mixed land uses are permitted in Town. Regulations are minimal, however, allowing for residential uses on a limited basis in commercial districts.

Vegetation Restoration/Preservation
Standard regulations are in place requiring planting of vegetation on any disturbed land. In addition, a landscaping plan showing vegetation is necessary for all stormwater management practices.

Septic System Location and Design
Applicants are required to provide a sanitary waste disposal plan that includes soils information and meets CT Department of Public Health codes. Location and design must demonstrate no impairment or contamination will occur during flood events.

Slopes
Regulations are in place setting design criteria as well as recognizing the potential impact from development on steep sloped areas.

Interior Lots
Interior lots are permitted in certain zones under certain condition. Certain lot sizes have also been set.

Bonding
Various bonding measures are in place.

Archaeology
The Town requires applicants to provide a detailed "Cultural and Historic Resources" study for a Planned Recreational/Residential Community Development and a "Mitigation Plan" related to protecting community and site historic, cultural, and natural resource features.

Watershed Approach (Regulations by Major Watersheds)
No regulations were found addressing resources or planning on a watershed basis. The POCD does, however, acknowledge Lyme as part of the Eightmile River Watershed. The Eightmile River compact has been signed by the municipality and there is recognition of the municipality as part of a larger watershed community.

Open Space Set Asides
Open space requirements are contained in the regulations. It is stated that the land to be deemed for open space shall be an amount necessary to achieve the stated purpose(s). This flexibility gives the Planning and Zoning Commission authority to determine open space requirements.

Open Space Funding
No regulations were found.

Fees in Lieu
No regulations were found.

Transfer of Development Rights
No regulations were found.

Planned Residential Development
Extensive regulations are in place for the existing PRD associated with the golf course. The regulations are comprehensive, accounting for stormwater, wildlife, natural resources along with other planning and design requirements.

Watershed-wide Summary
The municipal regulatory approach of East Haddam, Lyme, and Salem are similar in that each Town has adopted a set of basic regulations designed to protect the natural, cultural, and historic features of the community. Each of the Towns has incorporated conventional flood plain management regulations and erosion and sedimentation control regulations. All three communities have established overlay or buffer areas in an effort to ensure that natural, cultural, and historic resources are identified and measures are implemented to protect those resources. Resources extraction regulations, state model wetland regulations, septic system location and design, ridgelines, and vegetation restoration/preservation regulations are a part of each Town's collection of regulatory tools, as are basic bonding requirements. Each of these seems to be part of a foundation of standard methods for regulating growth and development.

Development and growth regulations that seem to be used minimally by the Towns' or not used at all include Transfer of Development Rights, Density Bonuses, Construction Phasing, Regional Consideration and Coordination, Water Supply watershed, and Watershed Approach to management. The use of these techniques may present an opportunity for the communities to investigate to work in conjunction with existing regulatory tools. It should be noted that although none of the Towns has any watershed approach or regional consideration/coordination written regulations, the fact that all three have signed the Eightmile River compact and that all have incorporated the ideas of the Greenway Provisions into their regulations is indicative of the fact the communities do recognize that the natural resources of the area extend beyond municipal boundaries. Furthermore, it suggests that there is a willingness to work jointly to achieve common goals.

Areas where the communities have developed somewhat different approaches include stormwater management, alternative developments, mixed land use provisions, open space set asides, vernal pools, net buildable zoning. Also, the details for wetland review areas and for resource extraction operations vary between the Towns. The primary differences here lie in the degree to which each community stresses a particular regulatory method. East Haddam, for example, has developed strong stormwater management codes to manage growth and the potential impacts from development. In contrast, Lyme has very few stormwater management regulations because the emphasis is on preservation of open space. With extensive open space requirements and str5ong efforts to remove land from future development, the reliance on management techniques is lessened for Lyme. Salem falls between the other two Towns regarding stormwater management. Unlike its neighbors, Salem is pursuing a more vigorous net buildable area regulatory approach to address growth and development issues. East Haddam and Salem are looking toward alternative type developments (e.g. . cluster subdivision, low impact developments, etc…) as a way to integrate continued development into their communities and minimize potential impacts from that development. Each community has established different setback distances for wetland areas, and East Haddam and Lyme have developed detailed timber harvesting regulations.

Essentially, it is clear that East Haddam, Lyme, and Salem share in the belief that the natural, cultural, and historic resources in their communities need to protected, preserved, conserved, and maintained. The different approaches toward achieving those ends present an opportunity for the three Towns to learn from one another.

Other Towns in the Watershed

Roughly ten percent (10%) of the land in the Eightmile River watershed is located in the Towns of Colchester and East Lyme. Because of this relatively small proportion the regulations of these municipalities were not evaluated in the dame detail as the Towns of East Haddam, Lyme, and Salem.

The area of land in Colchester located within the Eightmile watershed already has plans for subdivision approved. Colchester in general is working to incorporate natural resources planning as part of its planning process for other parts of town. The Town has conducted a build out analysis and has developed an open space plan in an effort to minimize potential impacts from future development. Information about these approaches was obtained from an interview with Town staff.

The area of land in East Lyme located within the Eightmile watershed is State protected land. Consequently, that portion of the watershed is protected.

Enforcement of Regulations

East Haddam

Based on discussion with a representative from East Haddam, the Town uses a proactive approach toward enforcement. The objective is to work with the developers and builders early on and throughout the process to ensure that regulatory requirements are being met. Limited staff requires establishing a cyclical period of site inspection for residential properties. Siting issues and failure to obtain necessary permits seem to be the predominant enforcement concerns. Moreover, the Town has shown its willingness to pursue legal actions in order to enforce its regulations.

Lyme

Based on discussion with a representative from Lyme, the Town is currently considering ways to increase its ability to enforce environmental regulations. The Town takes a proactive approach with new development and works with the developers and builders early on and throughout the process to ensure that regulatory requirements are being met. Enforcement issues seem to arise most often regarding riparian areas and viewsheds. Often existing homes have stipulations governing viewsheds and riparian areas. When a new homeowner purchases the home increased access to water or improvement of views are desired and the new homeowner proceeds to clear areas that are protected. The only way the Town is aware of the activity is if a complaint is filed and the response has been to impose a cease a desist order. Some discussion has taken place in Town regarding the use of fines as an enforcement tool.

Salem

No interview was conducted with the Town.

Policies/ Plans/ Regulations	Comments
Plan of Conservation and Development	
East Haddam	• POCD is currently under revision
Lyme	• Inclusive vision of the community that incorporates recommendations for planning tools and strategies to preserve, maintain, conserve, and protect the community's cultural and natural character. Primary method for maintaining the character of the Town is preservation of open space.
Salem	• Inclusive vision of the community that incorporates recommendations for planning tools and strategies to preserve, maintain, conserve, and protect the community's cultural and natural character. Community recognizes the pressure from growth that is facing Salem and the competition between different land uses. A variety of methods are suggested as ways to balance the desire for protecting the rural character of the Town while allowing it to grow.
Open Space Plan	
East Haddam	• No Plan was found.
Lyme	• No Plan was found.
Salem	• No Plan was found.
Greenway Plan	
East Haddam	• No Plan was found.
Lyme	• No Plan was found.
Salem	• Currently pursuing a Greenway Development Plan for Route 11 area. Parcels are being investigated for possible purchase.
Economic Development Plan	
East Haddam	• No Plan was found.
Lyme	• No Plan was found.
Salem	• No Plan was found.
	•
Eightmile River Compact	• The Town signed the compact
East Haddam	• The Town signed the compact
Lyme	• The Town signed the compact
Salem	
Natural Resource Inventory	
East Haddam	• No Plan was found.
Lyme	• No Plan was found.
Salem	• No Plan was found.

Build Out	
East Haddam	• No Plan was found.
Lyme	• No Plan was found.
Salem	• A build out has been conducted.
Historic Districts	
East Haddam	• Although no separate document specific to historic districts was found, regulations in place for protecting historical resources and preserving historic character of Town
Lyme	• Although no separate document specific to historic districts was found, regulations in place for protecting historical resources and preserving historic character of Town
Salem	

Inland Wetlands/Upland Review Areas	
East Haddam	• Standard State model regulations are in place for regulated uses, non-regulated uses, and uses of right. • 100 foot setback in place for activity or use from wetland or watercourses • 400 foot setback in place for activity or use from vernal pool • Subdivision Plan requires approval from Wetlands Commission • **Regulated Activity** defined as any operation within or use of a wetland or watercourse involving removal or deposition of material, or any obstruction, construction, or alteration or pollution, of such wetland or watercourses.
Lyme	• Standard State model regulations are in place for regulated uses, non-regulated uses, and uses of right. Town has included "compaction and artificial illumination" to definition of what is considered regulated activity. • 100 foot setback established for activity or use for all wetlands or watercourse (inland and tidal) • 200 foot setback established for septic system installation for specifically identified waterbodies • 150 foot setback established for septic system installation for all other waterbodies.
Salem	• Standard State model regulations are in place for regulated uses, non-regulated uses, and uses of right. Town has included clearing, grubbing, filling, grading, paving, excavating, constructing, depositing, removing of material, and discharge of stormwater to definition of what is considered regulated activity. • 75 foot established for Upland Review Area • Watercourse or wetland itself is defined as place for Regulated Area/Regulated Activity (no setback as in East Haddam or Lyme) • Minimum lot size necessary if wetlands are on site • Specific regulations for lot use dependent on the presence of wetlands.

Public Health	
East Haddam	• Not specifically mentioned in Regulations.
Lyme	• Not specifically mentioned in Regulations.
Salem	• Regulation state no land shall be subdivided for building purposes if it poses a danger to health or the public safety.

Tidal Wetlands	
East Haddam	• Not specifically mentioned in Regulations
Lyme	• 100 foot setback established that restricts use of land adjoining tidal wetlands, including no grading, excavation, deposition, construction, non-commercial cutting or alteration is permitted unless plan is submitted and approved. Plan must show that any such development will not cause any filling in of the tidal wetlands. • Different frontage requirements in place for different districts.
Salem	• Not specifically mentioned in Regulations

CT River Gateway	
East Haddam	• Town representatives noted that the existing regulations are in line with the Gateway Commission recommendations.
Lyme	• Town representatives noted that the existing regulations are in line with the Gateway Commission recommendations.
Salem	• Town representatives noted that the existing regulations are in line with the Gateway Commission recommendations.

Design Review	
East Haddam	• Preliminary Layout review including information such as environmental, historical, and archeological factors that may assist the Commission and applicant in decision making process. Public input is encouraged.
Lyme	• Not specifically mentioned in Regulations
Salem	• Site plans are required. Serves as a way to assess potential impact to natural resources and ecological communities and to help developer deal with potential impacts.

Flood Plains	
East Haddam	• General provisions are in place requiring for protection against flood damage for new construction.
Lyme	• Requirements are in place to ensure safety for development in flood prone areas. • Size of 5 acre or 50 lots specified as minimum for flood plain requirements to be used • No increase in flood levels permitted
Salem	• Size of 5 acre or 50 lots specified as minimum for flood plain requirements to be used • Regulations are designed to minimize impact from development and to ensure implementation of safety measures. • Town has designated a Special Flood Hazard Area

Overlay/Buffer Areas/(prohibitive vs. review)	
East Haddam	• Town has designated certain areas as Conservation Zone and for Streambank Reservations. • Have regulations requiring buffers for residential, agricultural, and rural areas.
Lyme	• Town has established a Conservation Zone and has a set of regulations guiding types of acceptable activities in the area.
Salem	• Town has established a Seasonal Residential Zone (around Lake Gardner) and a Commercial Recreation Zone (to preserve area fronting Gardner Lake for water oriented activities). • Buffer requirements are in place for commercial, industrial, and campground sites.

Aquifer Protection	
East Haddam	• Not specifically mentioned in Regulations
Lyme	• Aquifers are one of numerous resources mentioned as a reason for open space protection
Salem	• Specific groundwater protection regulations are in place. Designed to protect health and safety of community • Specific regulations are in place for Planned Residential Development

Resource Extraction (e.g. Sand, Gravel, Rock, Timber)	
East Haddam	• Contradictory statements in subsequent regulations -- Filling, removal, or excavation of earth materials is permitted in all zones with the exception of land designated as the "Conservation Zone" (Filling, removal, or excavation activities permitted in all zones including Conservation Zone without special exception provided no permanent damage is done to landscape.) • Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc… • 100 foot buffer from property line established • Disturbed may not exceed five acres • No permit necessary where building permit granted as long as activities not to exceed 300 cubic yards of materials • Slopes are to be 1:3 for restoration of site • <u>Timber harvesting regulations in place</u>. Overall intention to mitigate impact to species, wildlife, specific tree species/specimens, and vegetation • Avoid linear cutting bounds to soften edges and to replicate natural conditions. • Timber harvesting permitted in Conservation Zone by special exception only • 100 foot setback from watercourses • Only 50 percent of measurable volume of timber to be removed • Regrading not to exceed 10% and not be less than 2% • Disturbed may not exceed five acres
Lyme	• Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc… • 200 foot setback from property line for resource extraction activities. • Disturbed may not exceed five acres • <u>Timber harvesting regulations include:</u> • a 100 foot buffer for stream protection • Only 50 percent of measurable volume of timber to be removed • Disturbed may not exceed five acres
Salem	• Basic regulations in established governing operation of gravel extraction, including requirements for drainage, grading, noise, traffic,, revegetation, etc… • No pit deeper than 4 foot unless safe access and egress • Slopes for drainage to be 1:2 • Excavation by special permit required in certain zones • Minimum of 40 acres required for manufacturing and processing of material and 500 foot setback from Rural or Residential zone • No timber harvesting regulations in place.

Stormwater Management	
East Haddam	• Extensive regulations in place to minimize stormwater runoff. • Recommend use of *DEP Stormwater Design Manual* as guidance for developers. Stormwater management practices to be designed to meet criteria established in manual. • Hotspot is defined as an "area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater." • Structural BMP's are to be able to remove 80% of post development Total Suspended Solids (TSS). • No direct discharges into watercourses or wetlands. • Basic notion behind regulations is to minimize stormwater flow and pollutant impact on water resources and use of non-structural measures is encouraged in the regulations.
Lyme	• Minimal regulations are in place for stormwater management and regulations are fairly broad in • All subdivision plans shall make proper provision form sanitary and stormwater drainage. • Adequate subsurface stormwater drainage required unless deemed otherwise by Commission. • No water courses shall be altered or obstructed in way that reduces natural run-off capacity.
Salem	• 25 year storm is used as standard for design for drainage improvements. • Specific regulations are in place for Golf Course Planned Residential Development. • Adequate provision to be made for disposal of surface and stormwater. • Groundwater storm drainage regulations in place to minimize potential for pollutants to be conveyed (e.g. dumpster/waste receptacles to be covered, impervious areas to contain spillage, etc…)
Stormwater Management - Detention/Retention/Vortex, etc.	
East Haddam	• Regulations are in place that support the use of detention and retention basins to the greatest extent possible for filtering of stormwater. • Detention and retention are one of several methods identified as stormwater management techniques that can be used.
Lyme	• Not specifically mentioned in Regulations
Salem	• Detention ponds/basins are mentioned as a method that can be used for stormwater management.
Stormwater Management - Road design	
East Haddam	• Provisions are made to prevent stormwater flow onto Town roads from driveways and private roads. • Alternative porous pavements are permitted for new residential street design with approval of Commission.
Lyme	• Not specifically mentioned in Regulations
Salem	• Provision for storm drainage shall be made in all paved areas. • PRD roads serving less than 10 units are required to be paved, curbed, or provided with storm drains unless otherwise determined by Board of Selectmen.
Stormwater Management - Impervious surface limits (Direct/Indirect limits)	
East Haddam	• All Stormwater Management plans shall disclose all assumptions made in regard to future land clearing and regarding, creation of impervious

	surfaces, along with impact from other development activities. • All site designs should establish management practices to control stormwater flows, and pervious surfaces are recommended as method to accomplish this goal (both for water quantity and water quality).
Lyme	• Not specifically mentioned in regulations.
Salem	• Impervious coverage of total development for PRD Golf Course shall not exceed 13%.
Stormwater Management - Curbs/Swales	
East Haddam	• Swales are noted in regulations as one of several methods that can be used to moderate stormwater discharges. In this respect swales are part of a larger effort within regulations to use management techniques to address water quality and water quantity issues. • Site plans are required to show locations of existing and proposed conveyance systems. • Driveway design criteria recommends use of swales as one of several methods.
Lyme	• Not specifically mentioned in regulations.
Salem	• Groundwater Protection Regulations require that: the Commission may require swales, among other potential practices, to treat stormwater runoff, contain pollution, control peak flows, and/or allow for clean water infiltration into the ground. • Bituminous concrete curbing or similar quality curbing shall be used on all parking areas and access roads where necessary for drainage.
Stormwater Management - Parking Requirements	
East Haddam	• Not specifically mentioned in regulations.
Lyme	• Not specifically mentioned in regulations.
Salem	• Requirement in place to cover the surface of all parking areas with a durable, dustless surface. The Commission may waive the paving/use of durable, dustless surface for any parking lot that will be used in whole or in part only for irregular and infrequent events and/or where a non-paved and /or non-durable and non-dustless surface would substantially enhance environmental quality and will be maintained to satisfaction of Commission
Stormwater Management - Maintenance	
East Haddam	• Applicant must submit maintenance plan for all stormwater BMPs. Plan will include description of maintenance tasks with recommended implementation schedule, and description of access and safety issues. • Owner is responsible for maintenance for private drainage ways and roadways. • To ensure maintenance no Certificate of Use/Compliance shall be issued until approved deed restriction approved by P&Z is filed.
Lyme	• Not specifically mentioned in regulations.
Salem	• Golf course PRD Stormwater Management Plan and Water Management Budget are required along with provisions for maintenance of all stormwater management system components. • Pervious parking areas required to be maintained to satisfaction of Commission.
Stormwater Management - Culvert replacement	
East Haddam	• Not specifically mentioned in regulations.
Lyme	• Not specifically mentioned in regulations.
Salem	• Not specifically mentioned in regulations.

Erosion & Sediment Control	
East Haddam	• E&S plan required that is consistent with CT Council on Soil and Water Conservation publication *2002 CT Guidelines for E&S Control*. • Plan required for developments ½ acre or larger. • Phases of operation/conservation practices/vegetation/maintenance/costs, etc… required • Site development cannot begin until plan is certified • P&Z representative is responsible for review and evaluate the plan • Preservation and protection of shade trees is encouraged • Flexibility permitted to address site specific needs and measurements.
Lyme	• E&S plan required for subdivision plans – ½ acre or more in size. • E&S plan required for Gateway Conservation Zone regardless of size of disturbance. • Plan must meet *2002 CT Guidelines for E&S Control.* • Phases of operation/conservation practices/vegetation/maintenance/costs, etc… required • P&Z Board responsible for approval or denial of E&S plan. • Overall goal is to minimize erosion and sedimentation during construction and ensure protection and stability of site after completion of work.
Salem	• E&S plan required to control erosion and sedimentation during and after construction. • The E&S plan shall be based on the *CT Guidelines for Soil Erosion and Sediment Control*. • A Planned Recreational/Residential Community applicant must submit an Erosion and Sediment Control Plan for the entire development parcel

Alternative Developments (Open Space, Cluster, Conservation subdivisions, etc…	
East Haddam	• Commission has a temporary limited moratorium on subdivision applications while it studies and reviews regulations governing alternative developments. Commission is looking to find way to will allow the most effective and environmentally sensitive division of land that will enhance the prospects for the conservation of natural resources and preservation of open space for the welfare of all East Haddam residents and landowners. • Floating Zones are permitted in Town and can be used to have a zone change. • Cluster housing can be established for single family detached dwellings in R-2 and R-4 zones where parcels are ≥ 30 acres (greater than or equal to). • Development of parcels must be consistent with general requirements.
Lyme	• Planning and Zoning Commission has the authority to subdivide land as a cluster development • Area not to be less than 15 acres. • All other subdivision regulations to apply so long as not inconsistent with these regulations.
Salem	• Rural Cluster Development (RCD) is permitted in regulations – means a building pattern which concentrates dwellings and accessory building on a particular portion of a parcel so that at least 70 percent of the parcel remains as open space to be used exclusively for recreational, conservation, and agricultural purposes. • Interior streets and driveways shall be designed to eliminate through traffic, reduce traffic speeds, and provide for adequate circulation within the RCD and to its related facilities and open space. Walkways, courts and paths shall provide pedestrian access to and between residential structures, supporting facilities and open space areas and shall be separated from vehicular traffic wherever reasonably possible.

Density Bonus	
East Haddam	• Not specifically mentioned in regulations.
Lyme	• Not specifically mentioned in regulations.
Salem	• Not specifically mentioned in regulations.

Vernal Pools	
East Haddam	• Extensive regulations are in place to protect vernal pools • 400 foot buffer established for any activity that would constitute a regulated activity. • Vernal pool inventory required for an area that has or may have a pool. • On site determination required for confirmation of location of vernal pools • Criteria have been established for vernal pool identification. • Vernal pool inventory worksheet developed and to be used. • Vernal pool impact worksheet developed and to be used. • Obligate vernal pool species sheet in appendix.
Lyme	• Not specifically mentioned in the regulations.
Salem	• Not specifically mentioned in the regulations.

Ridgelines	
East Haddam	• Ridges to be considered in disposition of open space or recreation areas. • Wireless telecommunication facilities to be kept below visually prominent ridges.
Lyme	• Ridgetops to be considered as part of preservation of rural character and maintenance of the scenic resources of Lyme.
Salem	• Pre-application sketch plan should show all major site features, including rock ridges, among others

Water Supply Watersheds	
East Haddam	• Water company is to be notified of any subdivision within watershed of water company land.
Lyme	• Not specifically mentioned in regulations.
Salem	• Golf Course Planned Residential Development –if public water supply is to be provided the applicant shall submit a plan to the Commission as part of the Environmental Management Report.

Net Buildable/Soil Based Zoning	
East Haddam	• Regulations for net buildable area have been approved and are being incorporated in to the regulations.
Lyme	• Net buidlable lot area is defined as area of contiguous real estate required by regulations for the purpose of obtaining Town permission to build keeping in mind protection of public health and safety and to maintain quality of surface and ground waters and open space character of the Town. Percentage allowances are outlined based on soil classifications for on-site sewage, wetland and watercourses, flood hazard areas, and exposed ledge. • Minimum net buildable areas set at 42,000 sq. ft. for RU-120 district; 48,000 sq. ft for RU-80 district; 14,000 sq. ft for RU-40 district.
Salem	• Each new lot created after Dec. 1, 2003 shall contain "Net Buildable Area", all of which must be located in Salem. This NBA will not apply to the first subdivision or first resubdivision of three or fewer new lots by owner(s) of record on effective date of this regulation. • Desirability of NBA to moderate impact on water quality and upland review areas – protects on site potable water and on site subsurface sewage; reduction of adverse effects of erosion and storm water drainage; reduction in long-term degradation of groundwater; minimizes likelihood of incursions in environmentally sensitive Upland Review Areas.

Regional Consideration/Coordination	
East Haddam	• Standard regulations in place requiring notification to adjoining municipalities for activities within 500 feet of Town boundaries (including sewer, water drainage, traffic, etc…)
Lyme	• Not specifically mentioned in regulations
Salem	• Standard regulations in place requiring notification to adjoining municipalities for activities within 500 feet of Town boundaries (including sewer, water drainage, traffic, etc…).

Construction Phasing	
East Haddam	• Broad regulations in place requiring general provisions to protect site development. Includes measures to protect against erosion, protect wildlife, etc.. Nothing specifically mentioning phasing of construction operations, however.
Lyme	• Not specifically mentioned in the regulations.
Salem	• Not specifically mentioned in the regulations.

Vegetation Restoration/Preservation	
East Haddam	• Purpose of enhancement of property values and erosion control, the preservation and protection of shade trees throughout subdivision shall be encouraged, except where they interfere with roads and utilities. • Basic regulations for planting of vegetation for stabilization of disturbed areas, and to ensure revegetation of streambanks and prevent erosion.
Lyme	• Wetland regulations prohibiting disturbance of vegetation, among other elements, in wetlands and watercourses. • Solar Access Protection, Vegetation Siting – (a) Existing vegetation – in order to protect as much existing vegetation as possible and still allow for solar access, buildings should be located in that location which protects and ensures long life to the youngest and healthiest trees, bushes and plants. (b) Planting plans for new development shall be submitted which ensure that no new vegetation (e.g. street trees) denies new building solar access
Salem	• Environmental Mgmt. Report for a Planned Recreational/Residential Community requires inclusion of a "vegetation inventory" study and report, a "Revegetation/Landscape plan" for the entire development parcel, and a "Habitat/Vegetation Enhancement Monitoring Plan" shall contain input from the DEP on how to conserve endangered, rare, or species of special concern, and incorporate such input into practices to be adhered to in the Plan. • On commercial site plans, a separate landscaping plan shall be presented identifying the location, size, and species of trees and shrubs proposed. • General landscaping plan required in general. • All stormwater management practices must have a landscaping plan detailing the vegetation to be planted.

Mixed Land Use Provisions	
East Haddam	• Purpose of IG District is to allow a diverse center where unlike uses can be combined.
Lyme	• Allowance for one family dwelling units per lot are permitted in Commercial Districts. May be attached or detached from other buildings. • Plan of Conservation and Development discourages residential development in commercially zoned areas as means of assuring commercial zoning remaining available for future commercial development.
Salem	• Residence of the owner or caretaker of a permitted non-residential use allowed by right or special exception may be located within same building in business or commercial district. Residence must contain at least 650 square feet and meet other requirements.

Septic Systems Location and Design	
East Haddam	• Standard requirements for septic systems – soil testing, assure no damage if area is flooded, meet health codes, etc… • System to be certified by an engineer or sanitarian. • No building is permitted on lots with very poorly drained, poorly drained, alluvial, or floodplain or soil with significant limitations (specific soils listed in regulations). • Required to inform adjacent towns if sewerage will affect the other town(s). • Variances and special exceptions require the posting of a Bond. • 75 foot setback from wetlands, watercourses, and surface bodies of water.
Lyme	• Setback established – 200 feet from specifically identified waterbodies; 150 feet from all other waterbodies. • Notice to adjoining municipalities is required if other town will be affected. • Standard regulations in place governing septic systems, meet health codes, etc….
Salem	• Each dwelling or other permitted use shall have its own water supply and sewage disposal system located on the same lot as the dwelling or other permitted us is situated. • Rural Zone A permits by Special Exception Sewage treatment facilities or power plants. • Where an on-lot or community sewage disposal system is to be used for golf course Planned Residential Development, the applicant shall submit to the Commission a report endorsed in writing by the Town Sanitarian indicating that conditions are satisfactory for each such system. • Approval of site by Town Sanitarian • Standards: The applicant shall provide verification from a Certified Soils Scientist that the areas of the development to be used for subsurface sewage disposal are underlain by soils classified by the US Soil Conservation Service in the Soil Survey for New London County (1983) as having "slight" or "moderate" limitations for the operation of septic tank absorption fields. • Notice to adjoining municipalities is required if other town will be affected.

Slopes	
East Haddam	• Steep slopes defined as 20% or greater • Developers are required to show steep slopes on subdivision plans • Slope criteria established for road and driveway design.
Lyme	• Grading plan to show area to be excavated and proposed contours for the area after operation. No finished slopes or banks should exceed 1 foot of vertical rise to 3 feet of horizontal run. (Amended 6/22/92 Effective 7/1/92).
Salem	• The plan shall provide for proper drainage of the area of the operation after completion and no bank shall exceed a slope of one foot of vertical rise in two feet of horizontal rise. • The site area accessible to residents shall have no slope greater than 5% which bring compliance to the Americans with Disabilities Act (ADA) requirements. • As part of Site Plan Standards: Grading of all drives shall provide minimum slope of one percent and maximum of eight percent.

Interior Lots	
East Haddam	• No interior lots are permitted. (From discussion with East Haddam Town Staff)
Lyme	• Interior lot defined as "A lot other than a corner lot or through lot". • All lots shall have frontage on streets.
Salem	• Rear lots containing single or two family residences or agricultural uses are permitted in RU-A, RU-B, and R-A zones. Conditions to be met include Rear lots shall be at least twice the minimum lot size required for the district in which they are proposed,; no more than two tiers of rear lot permitted behind lots fronting a road; 50 foot setback from boundaries for buildings for rear lots; among others. • Rear lots permitted in HC and B zones without increase in lot size, however.

Bonding	
East Haddam	• Performance bond required for Earth Material Moving operations and for approval of Floating Zones. Amount to be determined by Planning and Zoning Commission. • Performance bond shall have two (2) year timeframe that may be extended. • Prior to release of Performance Bond, subdivider shall present Maintenance Bond equal to ten (10%) percent of Performance Bond. Bond shall be for one year period
Lyme	• Bond required for a subdivision plan to receive final approval. Board of Selectman and Commissioner to determine amount and terms that are satisfactory.
Salem	• Bond is required before issuance of Certificate of Occupancy. Commission shall determine amount of bond. • Bonding for Excavation activities. Bond shall be sufficient to cover cost of any required access, drainage, or safety improvements and costs of regarding disturbed areas, covering with topsoil, and seeding. • Commission may require posting of bond for seasonal campground facilities in amount adequate to cover costs of improvements. • Bond may be required by Commission prior to approval of subdivision.

Archaeology	
East Haddam	• Conservation Areas limited to regulatory jurisdiction include cultural features such as historic and archeological sites. • Public is encouraged to provide information about archeological factors that may assist the Commission and applicant in the decision making process. • Commission may request investigation or review in for sites where significant historical impact may be involved. Where possible, goal is to leave significant sites undisturbed. Able to consider those areas as open space. • All cemeteries within proposed subdivision shall be deeded to the Town, an existing cemetery association, a homeowners association, or other responsible party, along with a twenty foot protective buffer • Subdivisions to be laid out to preserve significant cultural resources. • In all subdivisions 20 acres or greater applicants will make written inquiry to State Archaeologist to determine if there is evidence of archaeological significance -- assessment shall be based on (a) the proximity to identified cemeteries, human burials, archaeological sites, historic sites and/or (b) the natural terrain features such as proximity to wetlands or watercourses, soils, slope, aspect s of rock shelters, where factors reflect scientifically documented settlement patterns preferred by Native Americans or European Colonist. • Management Plan is required for cultural resources consisting of (a) a written investigative report prepared by a professional archaeologist, (b) an evaluation of impact of the proposed subdivision; (c) a description of measures to be undertaken by the applicant to mitigate adverse impacts of construction activities, and (d) copies of all investigative reports and management plans shall be submitted to the Office of State Archaeology and State Historic Preservation Officer for review and comment prior to any P&Z public hearing. • Stonewalls and foundations considered significant man made features important to the character of the community. Proposed street, utility and future building shall be designed to preserve stonewalls and foundations to the maximum extent possible. The Commission may require conservation easements along stonewalls and foundations to ensure their future protection. The Commission may require the reconstruction of significant stonewalls and foundations by the subdivider where their preservation is not possible
Lyme	• Preservation of historic and cultural resources in an appropriate setting, including historic and archaeological sites, stone walls, cemeteries, trails and the like considered as part of open space land needs. • Subdivisions shall be laid out to preserve and enhance cultural and archaeological features, along with existing natural features • If there is notice of archaeological features, or the Commission so requests, the applicant shall make written inquiry of the State Archaeologist to determine if there is evidence of sites of archaeological significance. Any significant sites shall, where possible, be left undisturbed and may be considered in meeting the Open Space requirements. • All cemeteries within a proposed subdivision shall be deeded to the Town of Lyme, along with a 30 foot protective buffer.
Salem	• For Planned Recreational/Residential Community an Environmental Mgmt Report is required and shall include a "Cultural and Historic Resources" study. Also required is a "Mitigation Plan(s)" related to protecting community and site historic, cultural, and natural resource features" study .

Watershed Approach - planning/regs by major watersheds?	
East Haddam	• Not specifically mentioned in regulations.
Lyme	• Not specifically mentioned in regulations.
Salem	• Not specifically mentioned in regulations.

Open Space Set Asides	
East Haddam	• Open space to show location and rough dimensions of proposed open space. • Open space areas to be left in natural, undisturbed state; agricultural land for which development rights have been assigned or otherwise alienated in perpetuity; areas and facilities for non-commercial, non-profit recreation; and similar areas for wildlife habitat, passive and active recreation, groundwater recharge, scenic preservation, and the like. Commission shall consider Plan of Conservation objectives, map designations, and subject sites characteristics for uses such as conservation and protection of wildlife and natural or scenic resources including lakes, ponds, streams, streambelts, inland wetlands, aquifers, significant woodlands, ridges, ravines, ledge outcroppings, other unusual physical features, protection of historic or archeological sites, expansion of exiting open space and recreational areas and the meeting of neighborhood and/or community-wide recreational needs. Commission may consider proximity to or potential for combining proposed open space with existing or proposed open space on adjoining properties owned by public or private institution. • Disposition of land will be based on site specific conditions – including size of area, type of land, etc… • Required open space and or recreation areas shall not be less than 15% of the property under consideration. Commission may consider tract(s) of land to be subdivided as well as any other adjacent tract(s) owned, controlled, or under agreement to buy or optioned by the subdivider. This Section applies to subdivisions of more than 5 (five) lots or 15 acre parcels. • Open space typically to be left undisturbed if not being used for active recreation.
Lyme	• Open Space definition includes but shall not be limited to land left in its natural undisturbed state for conservation; agricultural land where development rights have been assigned or otherwise alienated in perpetuity; land areas and facilities for non-commercial, non-profit recreation; for parks or playgrounds; and similar land areas for wildlife habitat, passive and active recreation, groundwater recharge, scenic preservation, and the like. • Requirements for Open Space, Purpose – Conservation and protection of natural resources including: ledge outcroppings, ravines, significant woodlands, stands of unique or scenic trees, unusual trees, wetlands, watercourses, aquifers, retention of natural drainage ways, wildlife habitat, and other unusual environmental, ecological, topographical and physical features. • Objective is to provide balance of open space types throughout Town. Disposition of open space dependent upon site specific conditions. Commission may require variety of landforms, habitat, and vegetation. • Dedication of open space Commission shall be guided by, but not limited to standard of 15% of the land area of the subdivision with minimum reservation of one acre. Commission may require additional open space based on unique qualities of particular location. Commission may also determine lesser area is sufficient or that reservation of land not feasible due to quality and location of land within particular subdivision. • Open space land shall not be subject to introduction of non-indigenous species, fertilization, herbicides, pesticides and may not be used by domestic animals.
Salem	• Subdivision plan map shall contain layouts of open space reserved for parks, playgrounds or other common separate uses. • Open spaces are areas containing important natural resources (e.g. wetlands, watercourses, steep slopes, wildlife corridors…)Open space may also protect scenic view or enhance features in a subdivision. • Commission determines the disposition of open space. • Open space locations shall be determined by the features they are intended to protect or enhance. • Land for open space shall be the amount necessary to achieve the purposes described in Section

Open Space Funding (i.e. Bonding)	
East Haddam	• Enforcement Bonding -- Subdivider required to post performance bond in an amount and with terms acceptable to Commission. All required improvement of open space/recreation area to be completed prior to occupancy of fifty (50%) percent of dwellings within subdivision unless modified by Commission in accordance with Subdivision Regulations Section 3.04g.
Lyme	• Not specifically mentioned in regulations.
Salem	• Not specifically mentioned in regulations.

Fees in Lieu of Open Space	
East Haddam	• Commission may authorize subdivider to pay a fee to the town in lieu of disposition of land when, "in its sole discretion", it determines there are no adequate area on the subdivision which merit preservation by one of methods set forth, or where there are other areas where preservation would be more beneficial to public health, safety, and welfare. Such payment or combination of payment and the fair market value of land transferred shall be equal to not more than ten (10%) percent of the fair market value of the land to be subdivided prior to the approval of the subdivision. • Exemption from Fee in lieu for the transfer of land in a subdivision of less than five (5) lots is to parent, child, brother, sister, grandparent, grandchild, aunt, uncle, or first cousin of the property owner for no consideration or if the subdivision is to contain affordable equal to twenty (20%) percent or more of the total housing to be constructed in the subdivision.
Lyme	• If insufficient or unsuitable land for reservation of open space the Commission may require the provision of a fee to the Town or combination of fee and transfer of land in lieu of requirement to provide open space. Combination of payment plus fair market value of the land transferred shall not be more than ten percent of the fair market value of the total amount of land to be subdivided prior to approval of subdivision.
Salem	• Not specifically mentioned in regulations.

Transfer of Development Rights	
East Haddam	• Not specifically mentioned in regulations.
Lyme	• Not specifically mentioned in regulations.
Salem	• Not specifically mentioned in regulations.

Planned Residential Development	
East Haddam	• A Planned Recreational Development (PRD) shall be subject to the approval of the Planning and Zoning Commission. • PRD's can be created in Floating Zones. • Recreational Uses: Recreational uses for which application may be made in the PRD-RD Zones are as follows: golf courses, equestrian complexes, and nature preserves and centers.
Lyme	• Not specifically mentioned in regulations.
Salem	• Planned Recreations/Residential Community permitted by Special Exception in Rural Zone A. Golf course shall be principal use, development shall have area not less than 300 contiguous acres, traffic study and environmental management report shall be part of application/site plan, as well as compliance with all zoning, subdivision, road ordinances, and wetlands regulations as applicable. • At least 50% of total development parcel shall be reserved a permanent open space. Golf course fairways and wetlands may be included in calculation of open space. • Dwellings within golf course residential zone may be grouped as way to retain significant open space areas and preserve and protect natural area and scenic vistas • All utility lines for PRD serving more than four dwelling units shall be underground except where excavation and placement poses a significant environmental risk, affecting large trees, wetlands, steep slopes, ledge outcroppings.

NOTES – Special Considerations
East Haddam – * section 1.09 Penalty for failure to comply -- violation of subdivision approval Commission may void subdivision for any lots not yet conveyed, call bonds, direct Zoning Officer to withhold Certificate of Zoning Compliance…require corrective actions….p.6 (subdivision regs) * Section 1.10 Adoption of a Temporary Moratorium -- to meet goals of POCD Policy A - "Encourage Residential Growth at a Slow Rate" -- protect against fragmentation of forest and loss of important habitats. Limited moratorium on subdivision applications and approvals. Effective Nov. 13, 2002 for 6 month period. Amendment May 1, 2003 to extend for additional 4 months. Previously granted subdivisions grandfathered in, moratorium subdivision comprised of more than 4 lots. p.7 (subdivision regs) * Sect. 4.08 Passive Solar Energy Techniques – Applicant shall demonstrate to Commission they have considered use of passive solar energy techniques – includes house orientation, street and lot layout, vegetation, natural and man-made topographical features, and protection of solar access within the development. **Lyme –** **Zoning** * Section 3.26 outlines a series of standards and regulations for development in the Coastal Boundary of the Town. * Section 17.9.3 Impact on Environment under Special Exceptions states that the location and size of such use, nature and intensity of operations, and site layout and development will not have negative impact on any environmental and natural resource areas on or adjacent to the site or within neighborhood. **Subdivision** * Section 4.5 character of land to be subdivided be of such character that it can be used for the purposes intended without danger to health safety and welfare. Lands subject to flooding or with inadequate means of sanitary sewage disposal or sedimentation control, or that fail to meet criteria of non-commercial cutting plan, or criteria of the minimum net buildable lot area shall net be subdivided for residential purposes. * Section 4.12 – Passive Solar Energy – Applicant shall demonstrate to Commission consideration has been given to use of passive solar techniques in Plan * Appendix A – Details the minimum requirements and regulations for cutting of timber, including stream protection, logging roads and trails, aesthetic considerations, harvest methods, wildlife considerations, regeneration, and fir control considerations. **Salem –** **Zoning** * Section 4.1.14 states Nature Preserves managed by a Land Trust for passive recreation allowed in Rural Zone A. * Section 5.1.15 states Nature Preserves managed by a Land Trust for passive recreation allowed in Rural Zone B. * Section 5A.2.9 states Nature Preserves managed by a Land Trust for passive recreation allowed in Seasonal Residential Zone. * Section 6.1.10 states Nature Preserves managed by a Land Trust for passive recreation allowed in Residential Zone A. * Section 23 – Wind Energy Conversion System Regulations – permitted in any zone by Special Exception, on lot of at least 40,000 square feet * Section 29.5.1(l) As part of Special Exception application for wireless tower -- visual analysis showing areas form which the tower would be visible. Includes simulation to assist Commission in assessing appearance during winter months from furthest extent of tower's visibility at the five foot height and from distance of 1,000 feet. **Subdivision** * Section 6.5.3 states subdivider shall demonstrate to Commission use of solar energy techniques have been considered.

Appendix 13

Assessment of the Archaeological Resources of the Eightmile River Watershed

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

Assessment of the Eight Mile River's Archaeological Resources

Cultural resources and research design

Nearly 300 archaeological[1] and historic architectural sites have been identified for the towns and villages within the Eight Mile River watershed, 23 of these are located within ¼ mile of the Eight Mile River and the East Branch. The historic sites[2] include many existing buildings, bridges, mills and dams, cemeteries and wharfs, a number of which are listed on the National Register of Historic Places. Historic Districts are found in Salem, Lyme and East Haddam. The prehistoric sites[3] (Native American), spanning at least 8,000 years (Middle Archaic - Historic Periods), have been identified by artifacts found during surficial and subsurface surveys and through information provided by collectors. These archaeology sites document the region's progress from settlements of hunters-gatherers to colonial agriculturalists whose industrial and commercial adaptations during the Industrial Revolution ushered them into the world of industrial capitalism. Several of these archaeological sites have outstanding resource value.

Given the time and space constraints of the present assessment and the vast archaeological resources that exist in proximity to the Eight Mile River, the approach taken for the present study has been to compile a list of known archaeology sites, and then to present a summary of the archaeological resources, highlighting the more significant sites and presenting a general synopsis of the known sites and their potential resource value. This information also provides a basis for predicting where additional, presently unknown and most likely buried sites may be found. Site data for the towns within the Eight Mile River Watershed were gathered through an extensive review of the site files and maps at the Office of State Archaeology (Storrs), the State Historic Preservation Office (Hartford) and the Public Archaeology Survey Team, Inc. (Mansfield). The review included manuscripts and survey reports pertaining to the archaeology of the Eight Mile River area and prehistoric subsistence and settlement patterns in Connecticut and southern New England. Historic references and maps were examined for information pertaining to Native American groups following European contact.

Important Sites and Surveys within the Eight Mile River Watershed

In addition to local historic districts which include Hadlyme Ferry (Lyme), East Haddam, Haddam Center and Salem, four sites within the Eight Mile River Watershed are listed on the National Register of Historic Places. The National Register of Historic Places includes "cultural resources of state, local as well as national significance in order to ensure future generations an opportunity to appreciate and enjoy the nation's heritage" (Poirier 1987:7). The following extract

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[1] Archaeology sites are places where human occupations and/or activities have taken place. Associated artifacts, structures, and features provide clues to the nature of these sites.
[2] Historic archaeological sites are those that post date European contact, c.1500.
[3] Prehistoric archaeological sites are those that predate European contact. Prior to this time Native American groups in southern New England relied on oral tradition as a means of recording their past.

from the *Environmental Review Primer for Connecticut's Archaeological Resources* outlines the National Register criteria.

> "The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:
>
> A. that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> B. that are associated with the lives of persons significant in out past; or
>
> C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. that have yielded, or may be likely to yield, information important in prehistory or history (Poirier 1987: 7)."

Clearly, National Register sites in the Eight Mile River Watershed hold "outstanding resource value". The descriptions of these properties have been excerpted from their National Register of Historic Places - Nomination Forms:

Simon Tiffany House in Salem is a typical 19th century Federal Period construction. This gambrel roofed, two-story, center chimney house was built c.1799. The Tiffanys were among the early settlers in Salem and farmed the land during the 19th century. The property provides insight into the rural/farming period in Salem's history.

The **Hamburg Bridge Historic District** located in Lyme includes the three arched concrete bridge (1936) that crosses the Eight Mile River two miles above its confluence with the Connecticut River, c.18 parcels of land, and 10 houses and a series of wharfs. The Colonial, Georgian, Greek Revival, Eastlake and vernacular style houses with a single exception date from the 18th- through 19th-centuries and functioned in conjunction with the wharfs that were used for boat traffic and early commercial activities such as lumber shipping from 1800 to 1824 when the river was dredged and the focus of activities shifted to the center of Hamburg.

The **Salem Historic District** consists of white framed buildings along the Salem green (northern zone). These include an array of public and private buildings that provide a window into 18th century and early 19th century life in southern New England: the Congregational Church c.1840, the Grange Hall moved to Salem in 1831, the Salem Town House built in 1840 and used for general meetings and several 18th- and 19th-century houses. The southern zone includes the Methodist Tavern c.1720, a Federal Style house c.1820 (Rev. John Whittlesey Home) and a barn used for the Music Vale Seminary which was the first degree granting school of music in the United States (1835).

The Bingham Farm in Salem

The Bingham Farm in Salem holds tremendous archaeological potential and has been under consideration for the National Register. The title chain for the property can be followed to its purchase from a Niantic Sachem in 1664 through its 20th century purchase by Hiram Bingham who discovered Macchu Picchu, an important archaeological site, in the Peruvian Andes (Office of State Archaeology manuscript 1997). The property contains three of the Valley's earliest houses, an 18th century barn, and possible slave quarters and burials. The latter sites provide an opportunity to increase our understanding about the life of African Americans in colonial southern New England. A section of the Governor's Highway also passed through the property. Given the criteria outlined above, Bingham's twentieth century home built on the property also appears to be eligible for the National Register (N. Bellantoni, personal communication 2004).

18th Century Foundations in the Millington Section of East Haddam

Early foundations still visible in Millington hold the potential to reveal details about life in East Haddam during the mid- and late-18th century. These ruins include the foundations of Revolutionary War General Joshua Spencer's home and general store. Artifacts associated with these latter structures have been recovered from the wooded front yard of Mrs. Anita Sherman (N. Bellantoni; D.Poirier personal communications 2004). More detailed information on this site can be obtained at the Office of State Archaeology.

Archaeological surveys conducted during the early 1980s by the Public Archaeology Survey Team, Inc. under the direction of Dr. Kevin McBride resulted in creation of **The Lower Connecticut River Valley Woodland Period Archaeological Thematic Resource**. During these surveys over 350 prehistoric sites were located, 36 of these represent the Roaring Brook (A.D.1-750) and the Selden Creek (A.D. 750-1500) prehistoric cultural phases in the lower Connecticut Valley. Fourteen of these sites are listed on the National Register of Historic Places as part of the "lower Connecticut River Valley Woodland Period Archaeological Thematic Resource" nomination. Two additional sites were determined by the National Park Service to be eligible for listing, but were not listed due to owner objection (D. Poirier, personal communication 2004). The survey included the towns of East Haddam, Haddam, Lyme and Old Lyme. Archaeological data obtained from these sites reflects subsistence and settlement changes that were occurring during these Woodland Period phases. Together these sites are designated a "thematic resource" as they presently provide our total understanding of Native American life along the lower portion of the Connecticut River during the Late Woodland Period. The archaeological assemblages indicate a greater riverine focus possibly tied to resources associated with advancing tidal marshes. Although upland resources continued to be exploited, large seasonal camps once found in the interior were being replaced by smaller temporary camps and task specific sites that were components of large base camps close to the rivers. An increasing reliance on non-local lithic materials suggests a greater interaction with other Native American groups throughout the region was also occurring during these phases. The **Hamburg Cove Site** (75-7) located near the confluence of the Eight Mile and Connecticut Rivers dates mid-way between the two phases. Large quantities of deer bone recovered from the faunal assemblage suggest that "longer-term" hunting activities occurred at this site (National Register Form 1986). It is logical that because of its proximity to the lower Connecticut River, its limited archaeological investigation, and the relatively undeveloped landscape of the Eight Mile River that known and presently unknown sites along this waterway need to be considered as part of this thematic resource.

Unrecorded sites

Information regarding a number of known but as yet uninvestigated historic and prehistoric sites within the Eight Mile River Watershed was provided by State Archaeologist Dr. Nicholas Bellantoni, Mary Harper, Director of the Public Archaeology Survey Team, Inc. and Dr. David Poirier, Staff Archaeologist for the State Historic Preservation Office. These highly sensitive archaeological sites, not presently recorded at the Office of State Archaeology include:

- The Bingham Property, located along the East Branch in Salem includes stone features, foundations and stone piles related to farm activities.
- A dam and mill remains at the west end of Ed Bills Pond (N.Lyme).
- An 18th century cellar hole west of an abandoned road (Baker Lane) (N.Lyme).
- A cellar hole west of intersection of RT. 82 and Hopyard Rd. (E.Haddam). Lithic materials were reported on what is now a golf course.
- The North Plain Cemetery which contains both Native American and European burials. Native American artifacts were also collected a short distance northeast of the cemetery on the east side of Eight Mile River (E.Haddam).
- Mill ruins and a dam along Muddy Brook near Devil's Hopyard (East Haddam).
- A Native American site near the north end of Hopyard Road (east side)(E.Haddam).
- A foundation near the intersection of Eight Mile River and Haywardville Road (E.Haddam).
- An abandoned community in East Lyme.
- An abandoned stone arch bridge located near Route 82 near Woodbridge Road (Salem).

Prehistoric site/settlement models

A number of archaeological studies have focused on the development of models for predicting site locations (Banks and Lavin 2003). These studies have shown repeatedly that archaeology sites are firmly associated with specific physical environments and landforms. Thornbahn's studies of several hundred sites in southeastern New England showed that prehistoric sites clustered within 300 meters of low-ranking streams and large wetlands (Thornbahn *et al.* 1980; Thornbahn 1982). Casjen's (1979) study of prehistoric settlement patterning in the Concord River Valley concluded that 80% of the valley's prehistoric sites were located within 200 meters of fresh water. Mulholland's (1984) doctoral dissertation on southern New England prehistory and McBride's (1984) doctoral dissertation on lower Connecticut Valley prehistory both confirm a strong Native American preference for settlements overlooking interior wetlands, lakes, rivers and streams. McBride and Soulsby's (1989) survey of the proposed corridor for Route 6/I-84 in eastern Connecticut found that 94% of the discovered sites were situated within 150 meters of freshwater; their average distance was 42 meters from a wetland or watercourse. Such environments sustain concentrated varieties of animal and plant food sources that would have been attractive to Native American peoples. Several of these surveys also noted the importance of well-drained, sandy terraces and knolls (e.g., Thornbahn *et al.* 1980; Thornbahn 1982; McBride 1984). During the mid-1990s, survey work across the McLean Game Refuge in the Farmington Valley Watershed demonstrated that Native American groups sometimes located themselves along landforms "too small to be discerned on standard USGS, 7.5 minute, 1:24,000 topographic maps (Feder 2001:19)". A relationship was also identified between Native American sites and glacial features such as kettle holes and eskers that offered resource and hunting opportunities (Feder and Banks 1996). The most commonly occurring site soils were those representative of the moderately and well-drained Charlton, Hinckley, Hollis and Merrimac soil types (McBride and Soulsby 1989).

A recent study of the known Native American sites from the nearby Connecticut Valley Towns of Middletown and Cromwell indicates that Native Americans also preferred certain elevations and slope as well (Reeve and Lavin 2001:27, Table 1). Among these sites, the average site elevation was 120.26 feet; 90% were below 280.17 feet in elevation. Most of the prehistoric sites were located in relatively level settings. In total, 73.7 percent of prehistoric sites are in areas of 0 to 5 percent slopes; 21.0% were located in areas of 5-15% slope, while only 5.3% were located at 15-25% slope. No sites were located within an area of over 25% slope. As in the surveys discussed above, the Middletown/Cromwell sites show a preference for proximity to freshwater. Their average distance to fresh water was 249.37 feet (ca. 76 meters); 95% percent of the prehistoric sites were located 492 feet (ca. 150 meters) or less from a fresh water source, including rivers, streams and wetlands. All but one of the prehistoric sites in the steeper settings (5-25%) were rock shelters associated with bedrock outcrops. Additionally, prehistoric sites were identified in association with a wide range of landforms including river and stream terraces (52.6 percent of sites), knolls (10.5 percent of sites), upland flats and benches (21 percent of sites), and slopes (15.8 percent of sites). The diversity of landforms probably reflects the diversity of seasonal subsistence resources and habitats exploited by prehistoric hunter-gatherers and horticulturists.

Twenty five of the 278 recorded sites located in the towns encompassing the present assessment are located in the immediate vicinity of the Eight Mile River and its East Branch. Twenty of the twenty five sites are Native American. Many of the other sites represent different aspects of the same settlement systems. Native American subsistence was based on the exploitation of a wide variety of resources. Some of these resources were obtained from ecological zones away from the river. Many of these resources are seasonal and Native groups relocated across the landscape accordingly to take advantage of these resources. Consequently, sites along the river and those away from the river are components of the same Native American subsistence-settlement system and must be examined together to fully understand Native economy and social organization.

Native American sites close to the Eight Mile River and the East Branch display similar characteristics in terms of elevation, slope and distance to water sources to sites from the nearby Middletown Cromwell study. **Table 1** is a summary of the recorded archaeological sites near the Eight Mile River or the East Branch. Diagnostic artifacts from some of them indicate a

Native American presence dating from the Middle Archaic Period (c.6, 000-4,000 BC) through European Contact (c.1500 AD). The sites have been listed in order of their potential importance based on their site integrity as assessed on the site forms. Sites designated as having good or fair site integrity should be considered archaeological sensitive and merit investigation should they be threatened by development. Twenty three of the twenty five sites are within ¼ mile (the buffer proposed this study) of these water sources. Although disturbances have limited the data available from some of the sites and development has impacted others since the time they were reported, the locations of these sites differ little from surrounding areas that have not been investigated. Thus, the potential for intact archaeological resources within the study area remains high.

Eight Mile River: Archaeological Potential

A wide range of habitats within the drainage supported many plant and animal resources that Native Americans relied on and the river provided transportation and trade possibilities. The Eight Mile River also provided access to coastal resources not readily available to Native American groups living in other parts of Connecticut. In addition, the topography, past land uses and delayed land development near the Eight Mile River sets it aside from other rivers in Connecticut and increase the potential for intact archaeological sites. Early archaeological surveys were often subjective and focused on certain landforms where sites were likely to be found and excluded others thought unlikely to have sites. These surveys sampled only a small percentage of the land area within the drainage. Sites located by collectors are also those with greater archaeological visibility (i.e., cleared and plowed land), the number of archaeology sites across the river drainage is certainly much greater and the entire drainage possesses a moderate to high degree of sensitivity for archaeological resources. Known and potential sites within the Eight Mile River watershed can increase our understanding of Late Woodland Period Native Americans and should also be included as part of the Woodland Period Archaeological Thematic Resource described above.

Historic Native American Groups within the Watershed

Nineteenth and twentieth century histories record the rich Native American history within the vicinity of the Eight Mile River as of European Contact. These groups include the Wangunks (AKA Mattebessett; Machemoodus) around modern day Middletown, the Western Nehantics (AKA Niantics) from the Connecticut River to the Niantic River, the Pequots from the Niantic River east to within 10 miles east of the Pawcatuck River, and the Mohegans (whose first sachem was the well-known Uncas) north of the Pequots (DeForest 1852, Trumbull 1898; Roberts 1906; Harwood 1932). Alleged Native American territorial boundaries c. 1625 are depicted in Mathias Spiess's *Map of the State of Connecticut showing Indian Trails, Villages, & Sachemdoms* (**Figure 1**).

Criteria for determining archaeological sensitivity

In addition to the known sites along the Eight Mile River, various surveys of 100s of archaeology sites have shown that physiographic and other factors indicate sensitivity for unknown sites. These factors are discussed in the next section. A recent archaeological site sensitivity analysis in Simsbury outlined the criteria for determining the degree of sensitivity an area possesses for archaeological resources (Banks and Lavin 2002).

- Areas with known prehistoric and historic archaeology sites (including historic districts) are designated as highly sensitive, adjacent properties also have a moderate to high potential for archaeological resources.
- Areas possessing topography and environmental settings generally associated with prehistoric archaeology sites should be considered to have a high sensitivity. The major settings delineated by archaeologists have been floodplains, terraces overlooking water sources and uplands near plant, animal lithic resources (Feder 1981; McBride and Dewar 1981). Glacial and small topographic features were locations also selected by Native Americans during prehistory (Feder and Banks 1996; Feder 2001).
- Properties with relatively undeveloped/undisturbed landscapes should be considered to have minimally a moderate degree of sensitivity because of their potential for intact archaeological resources
- Conversely, land with a high degree of disturbance/modification is much less likely to have intact archaeological resources and thus is categorized as having low or no archaeological sensitivity
- Other areas included as having low or no archaeological sensitivity are properties with excess slopes or that are low-lying and wet.

Management of Eight Mile River Archaeological Resources

The Eight Mile River Watershed offers an important opportunity to examine Native American subsistence and settlement systems that differ from those found elsewhere in southern New England owing to access to both interior and coastal resources. A topography void of broad floodplains reduced the areas suitable for intensive agriculture increasing the potential for intact archaeological resources. The delayed development of properties has also helped preserve the integrity of the watershed's archaeology.

Since Native American settlement systems include a variety of site types across the landscape (i.e., seasonal camps, temporary camps, task specific sites) across the landscape, the entire Eight Mile River Watershed is a most suitable unit when trying to understand a Native group's entire subsistence system and settlement system. Sites located near the Eight Mile River are essential components of these systems. Only by identifying the relationship between these sites and those in the uplands can this be obtained. The first step in such an endeavor would be the adoption of archaeological regulations that require an archaeological assessment and/or reconnaissance survey prior to new development. Such regulations provide an opportunity to identify archaeological resources that may be present within a given project area so that an informed decision can be made regarding development plans. Efforts should be made to protect known sites and to require testing of areas deemed to have a moderate to high archaeological sensitivity. Ideally, the towns within the watershed should establish uniform regulations through their Planning and Zoning and Inland Wetland boards for the reasons stated above. Every attempt also should be made to document and photograph buildings, wharf remains, cellar holes, mill ruins and other unrecorded cultural features that exist within the watershed. These sites can add to our understanding of the history associated with the Eight Mile River and also how they related to contemporary events across Connecticut.

Overview/ Resource Value of the Eight Mile River

The locations of known sites along the Eight Mile River are reflection of biases due to archaeological visibility, methodology and subjectivity of past testing and surface collecting. The paucity of archaeology sites along East Branch is due to a lack of archaeological testing. During early surveys emphasis was placed on particular landforms and others thought to be marginal (i.e., slopes greater than 5 or 10%) were overlooked. Although these oversights have been corrected to some extent, time and financial considerations continue to place limitations on the sample sizes of surveys. The area sampled across the Lower Connecticut River Valley during surveys by the Public Archaeology Survey Team, Inc. in the late 1970s and early 1980s was considerably less than 10 percent of the total land area (M. Harper; D. Forrest, personal communication 2004). Unquestionably, many more archaeology sites have yet to be identified along the Eight Mile River.

The Eight Mile River represents an outstanding resource value on several levels.

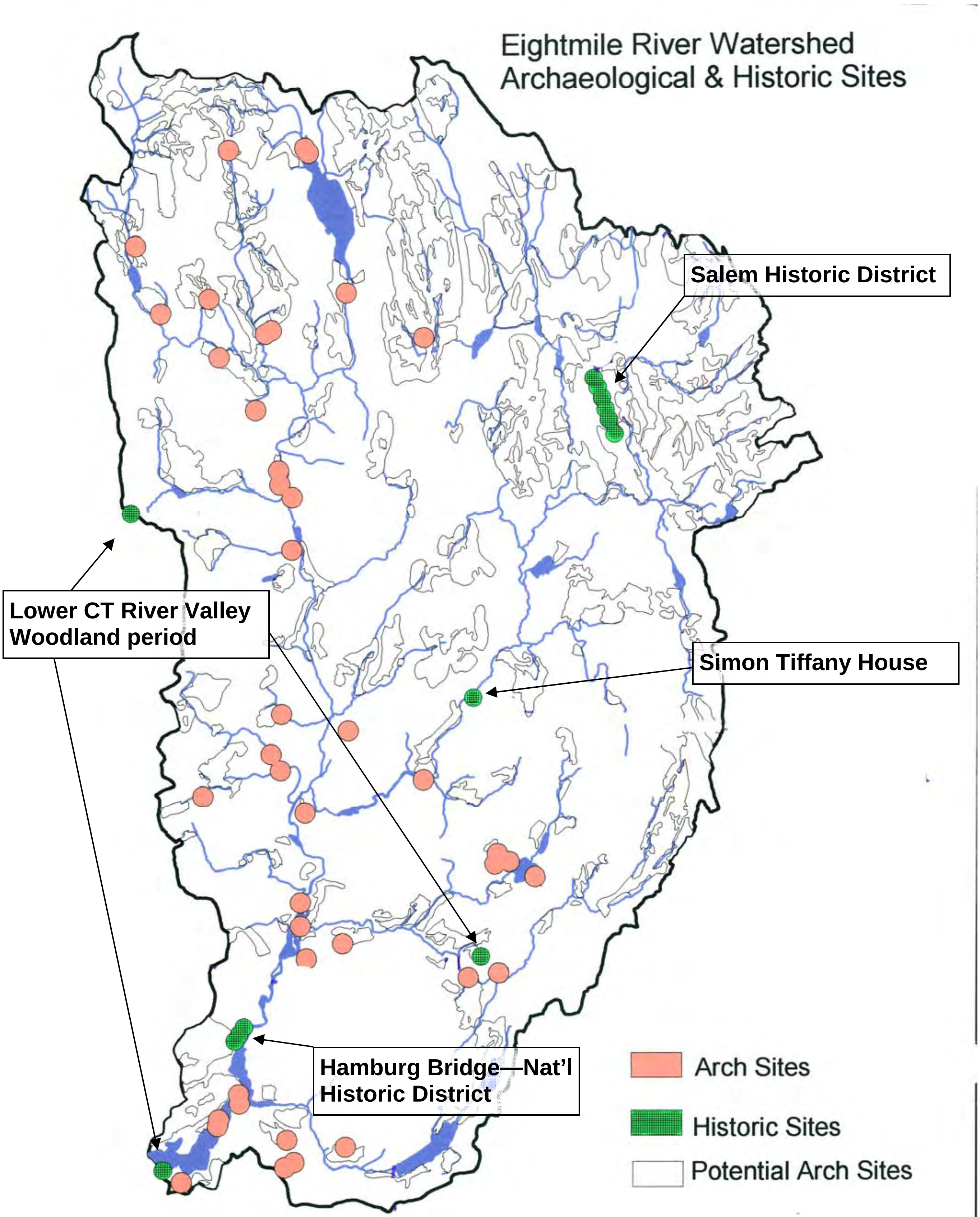
- First, a number of exceptional historic and prehistoric sites have already been recognized and placed on the National Register of Historic Places.
- Secondly, the land bordering the river has a high potential for intact archaeological resources, as the landscape has been less impacted by historic activities and development, although rapid development of more marginal land is now taking place. The potential for intact sites strongly suggests the possibility of other, presently unknown, archaeology sites that possess outstanding resource value.
- Thirdly, the proximity of watershed to coastal resources is another major difference. Access to the coast also provided opportunities for contact with other Native American groups, trade and the exchange of ideas. Such influences might be discernable in the archaeological record. This is also true for the Euro-American, Historic period cultures. Just as house placement during historic times seems to resemble patterns seen in Rhode Island (further from roadways) rather than that typically seen in Connecticut (close to the road) (M. Harper, personal communication 2004), it would not be unexpected that Native American subsistence and settlement patterns were to some

degree influenced in a similar manner. Understanding how subsistence and settlement differed and the relationships between the groups living near the Eight Mile River and elsewhere in Connecticut would be an important contribution to our knowledge of the region's prehistory.

Table 1. Reported data for archaeological sites adjacent to the Eight Mile River

MA=Middle Archaic LA=Late Archaic
WL=Woodland na=not available

Site #	Name	Locale	Age	Site Type	Size	Slope (%)	Elevation	Soil Type	Nearest Water Source	Distance (m)
41-06	Duck Mill Pond	riverine	19th cen.	mill	2 acres	15-25	300'	Hollis-	Eight Mile River	0
								Charlton		
41-05	Lake Hayward	knoll	LA	camp	1 arcre	15-25	370'	Hinckley-	Lake Hayward	125
								Manchester		
41-37	Dobbia Hill Road		unknown	hunting/	c.40x20 m	5-15	100'	na	Eight Mile River	12
				fishing						
41-28	Devil's Rock		contact	rockshelter				Hincley-	Eight Mile River	200
			other					Manchester		
41-29	Devil's Hopyard									
	Rockshelter		prehistoric	rockshelter		15-25	250'	na	Eight Mile River	100
41-82	Chapman Falls	terrace	LA & WL		3 acres	na	180	65B	Eight Mile River	20-0
41-119	Devil's Hopyard		archaic	undetermined			100'	na	Eight Mile River	c.60
75-35	Cricklewood Field		Archaic/	na	unknown	0-5	50'	na	Eight Mile River	50
			Woodland							
75-31	Macintosh		unknown	unknown		na	100'	na	trib. Eight Mile River	100
75-36	Sisson Cemetery		LA	seasonal	2500 sq. m	0-5	130	na	East Branch	50
				camp						
75-19	no name		unknown	lithic	unknown	05	20'	sand,silt	Hamburg Cove	100
				scatter						
75-20	no name		unknown	na	not determined	0-5	50	sand,silt	Eight Mile River	50
75-21	Costa's Cove		contact	camp/	25-50 sq. m	5-15	50	sand,silt	Hamburg Cove	70
				rockshelter						
75-47	Jewitt		unknown	unknown	na	0-5	50'	sand,silt	Hamburg Cove	10
75-50	Gerber		MA	unknown	unknown	na	100'	na	Eight Mile River	100
75-56	Cooper's Boat House		LA	find spot	unknown	na	40'	sand,silt	Hamburg Cove	50
			WL							
75-57	Matson		WL			0-5	20'	silt	Eight Mile River	c.20
121-38	New Salem Plantation/	Bingham Family							wetland	na
	Elm Grove Cem.		1800-1870	Bingham Family						


Eightmile River Watershed
Archaeological & Historic Sites
Salem Historic District
Lower CT River Valley Woodland period
Simon Tiffany House
Hamburg Bridge—Nat'l Historic District
Arch Sites
Historic Sites
Potential Arch Sites

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Appendix 14

Eightmile River Watershed Project - Land Resources Inventory and Data Analysis

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

EIGHTMILE RIVER WATERSHED PROJECT
Land Resources Inventory & Data Analysis

GOAL: TO PROTECT AND ENHANCE RURAL LANDSCAPES THROUGHOUT THE WATERSHED

1. To provide habitat for a full range of native wildlife and plant communities
2. To protect the quality and quantity of water resources
3. To ensure a sustainable supply of wood and other forest products and benefits for future generations

METHODOLOGY: There were two basic steps in the analysis:

I. IDENTIFY LARGE UNDEVELOPED, UNFRAGMENTED AREAS AND THEIR RESOURCE ATTRIBUTES.

A. Boundaries were drawn between all currently developed land and open space areas using satellite landcover data.
B. Watershed committee members identified all roads and power lines of significant size and use that they constituted fragmentation boundaries between open space areas.
C. RESULT: Sixteen separate unfragmented open space areas ranging in size from 286 to 4,081 acres.
D. Data were generated on the percentage of each unfragmented area that is:
   - permanently protected open space
   - forested vs. farmland
   - prime farm or productive forest soils
   - wetlands or water

POTENTIAL DATAUSE: Large unfragmented areas have the greatest potential for sustaining a full range of biological diversity (Goal 1). If protected, those with significant amounts of productive soils and water resources also have the greatest potential for fulfilling Goals 2 & 3.

Locating these areas on a watershed map, determining what percentage of each area is currently protected from development, and overlaying the individual parcel map can assist the community in creating priorities and geographically focusing open space protection efforts.

II. IDENTIFY THE PLANT COMMUNITIES AND SOIL TYPES THAT OCCUR IN THE WATERSHED, THEIR RELATIVE ABUNDANCE AND THE CURRENT LEVEL OF PROTECTION FOR EACH.

A. All soils in the watershed were grouped into 7 "Natural Soils Group" categories as defined by the Natural Resource Conservation Service. Total acreage and the percent currently protected were calculated for each.
B. Fourteen species-specific land uses and/or forest types were identified from the satellite data. Total acreage and the percent currently protected were calculated for each.
C. All known occurrences of rare, endangered or special concern species were located on the watershed map.

POTENTIAL DATA USE: Fulfilling Goal 1. The full range of native flora and fauna can only be sustained if the full range of soils and sites upon which they develop are retained. These data show the community which soil types are least common and/or have the least level of protection.

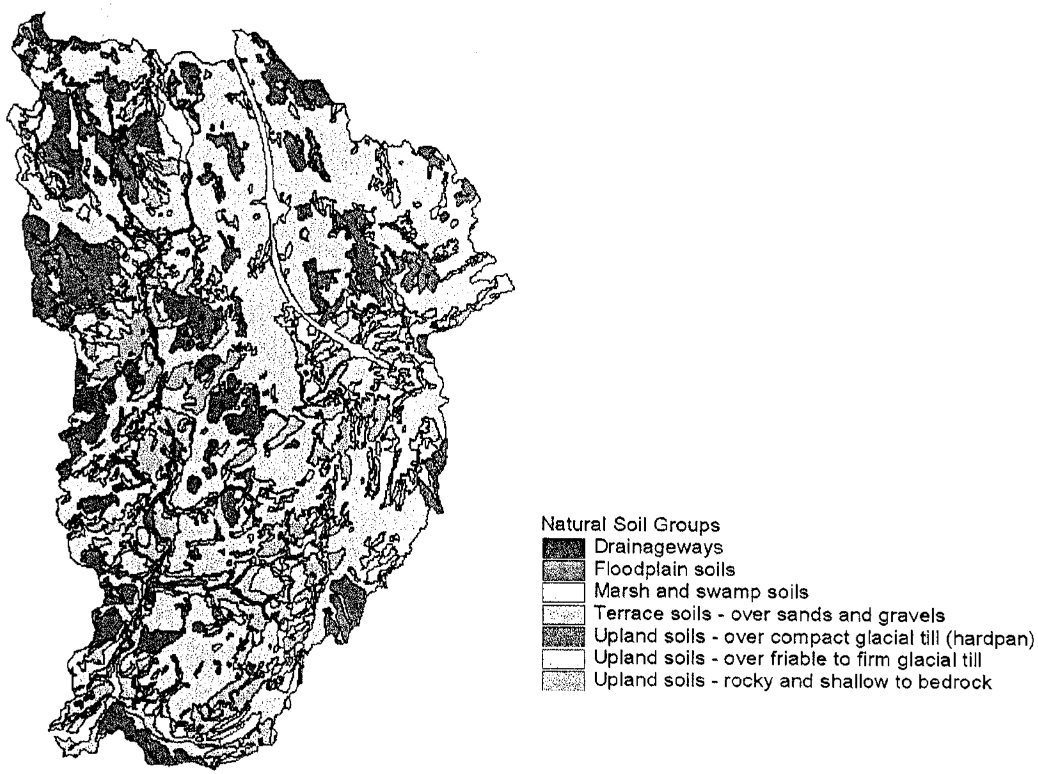
They also show which forest types are least common and/or have the least level of protection.

These factors can be additional criteria used in creating priorities and geographically focusing open space protection efforts.

FUTURE REFINEMENT: This analysis was done using information available in map form from databases at the University of Connecticut. As long-term land use plans and decisions are developed, it can and should be augmented with additional data that, while important, cannot be obtained from existing maps or satellite images. Such additional data can only come from community members familiar with the watershed and could include:

- Unique plant communities not identified above;
- Vernal pools;
- Active farmlands;
- Significant rock outcrops and scenic vistas;
- Occurrences of rare, endangered or special concern species not identified above.

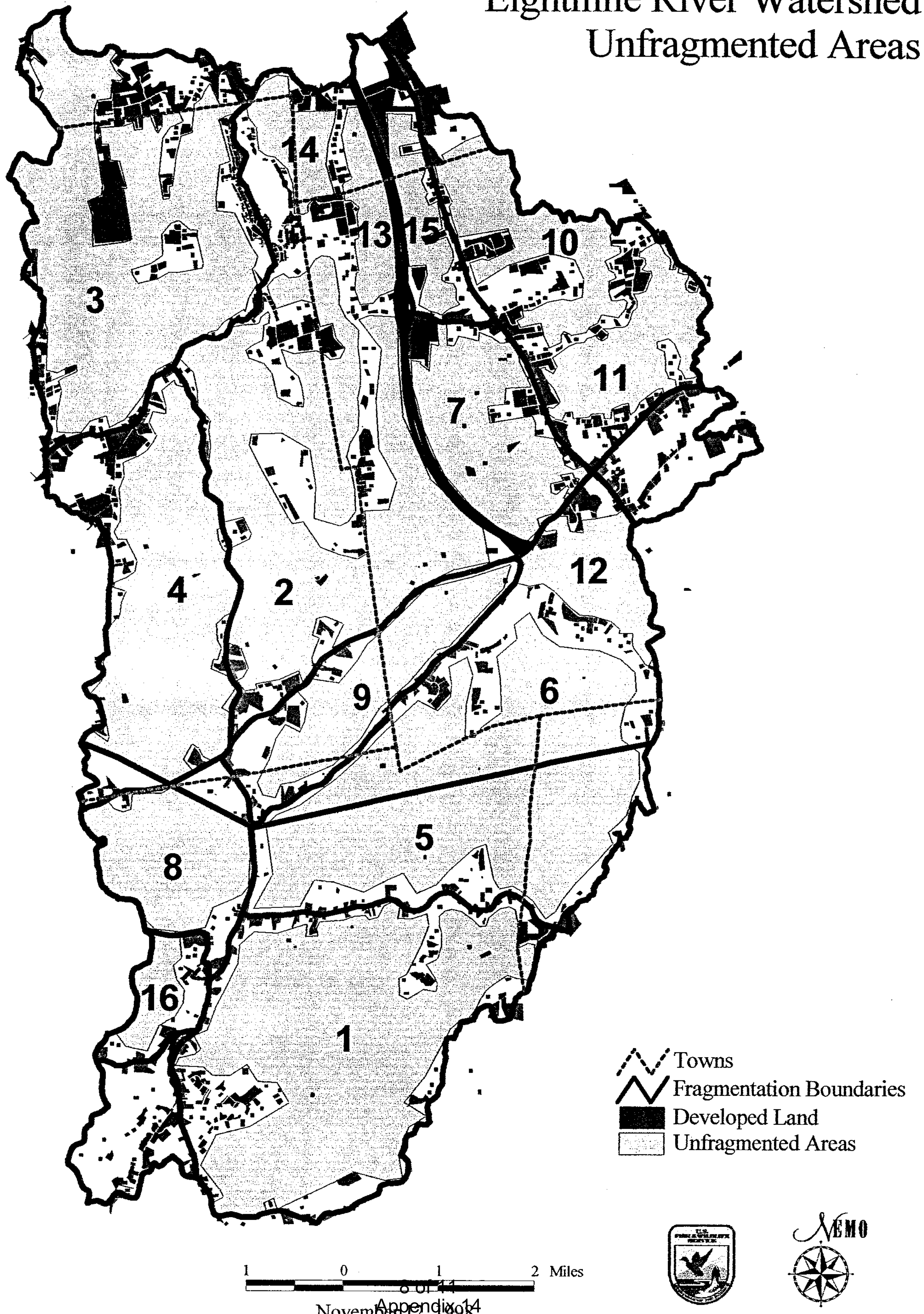
Natural Soil Group Description	Total Acres	% of Watershed	Acres Protected	% Protected
Upland soils - over friable to firm glacial till	21760	54.5	3814	17.5
Upland soils - over compact glacial till (hardpan)	6328	15.8	550	8.7
Upland soils - rocky and shallow to bedrock	4137	10.4	1905	46.0
Terrace soils - over sands and gravels	3637	9.1	621	17.1
Marsh and swamp soils	1674	4.2	386	23.1
Floodplain soils	605	1.5	107	17.7
Drainageways	332	0.8	59	17.8



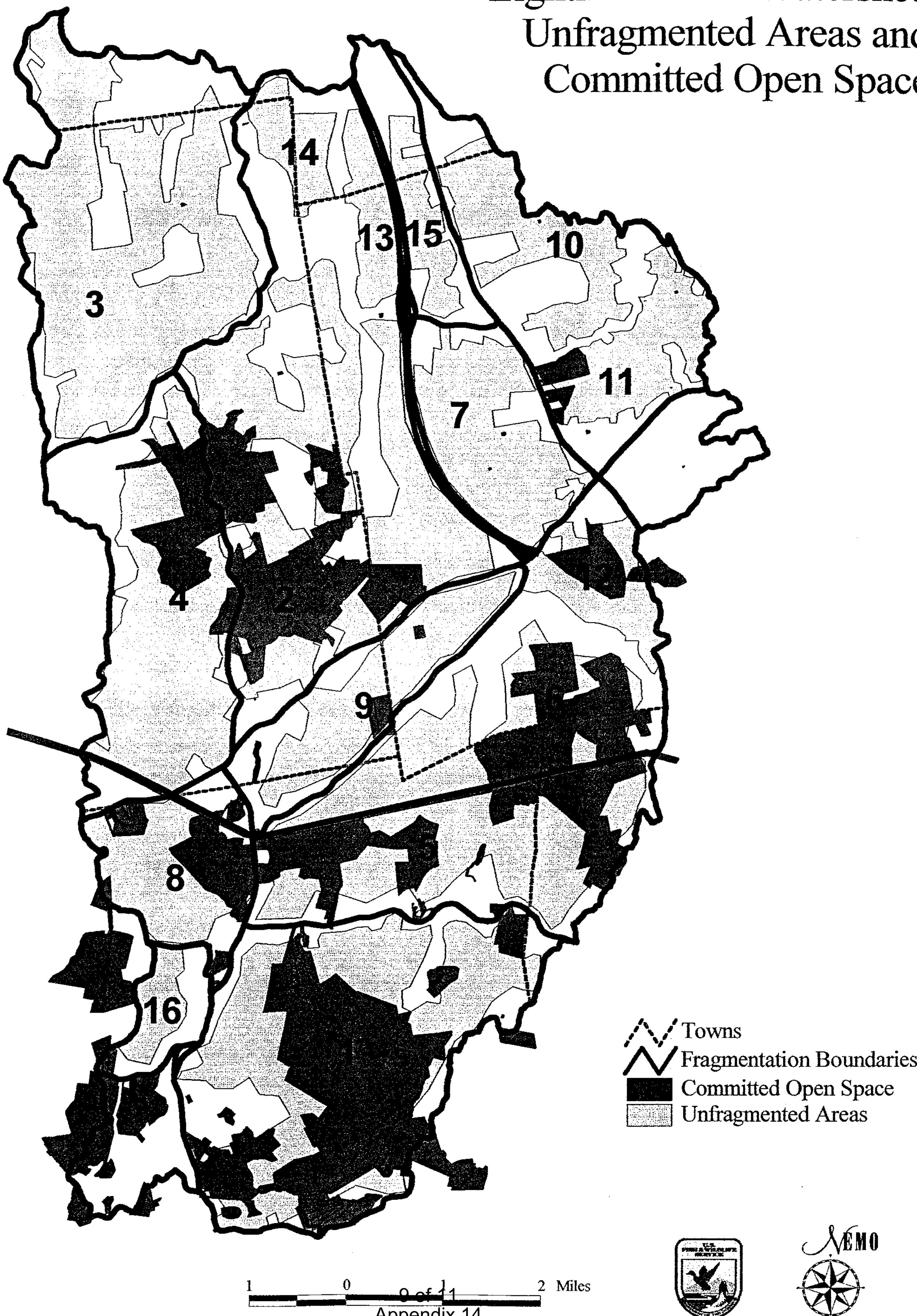
Forest (Cover) Type	Total Acres	Percent of Watershed	Protected Acres	Percent Protected
Oak Hickory	17941	44.9	3259	18.2
Mixed Deciduous	9102	22.8	1605	17.6
Impervious surface	3056	7.6	393	12.9
Oak/Pine	1951	4.9	606	31.1
Red Maple Wetlands	1678	4.2	377	22.5
Agriculture/Grass/Pasture	1605	4.0	152	9.5
Hemlock	1314	3.3	579	44.1
Tulip Poplar	743	1.9	121	16.3
Marsh/Swamp	646	1.6	94	14.6
Water	521	1.3	64	12.3
No Data	455	1.1	111	24.4
Barren/Sand	446	1.1	40	9.0
Oak/Mountain Laurel	373	0.9	119	31.9
Pine	125	0.3	43	34.4

FRAG ID	Acres	% Committed OS	% Forested	% Productive Soils	% Water Resources
1	4081.4	50	90	37	20
2	3884.9	33	92	53	16
3	3550.6	0	96	52	21
4	2488.2	20	94	52	13
5	2400.9	39	98	55	18
6	1914.6	43	94	46	17
7	1328.4	0	79	50	22
8	1128.5	32	95	52	16
9	1092.7	2	90	60	14
10	1044.3	0	92	61	17
11	923.8	8	89	51	23
12	721.4	29	89	38	16
13	454.5	0	94	53	22
14	442.0	0	98	54	21
15	426.0	0	83	51	14
16	286.3	0	96	71	7

Eightmile River Watershed
Unfragmented Areas



Eightmile River Watershed Unfragmented Areas and Committed Open Space



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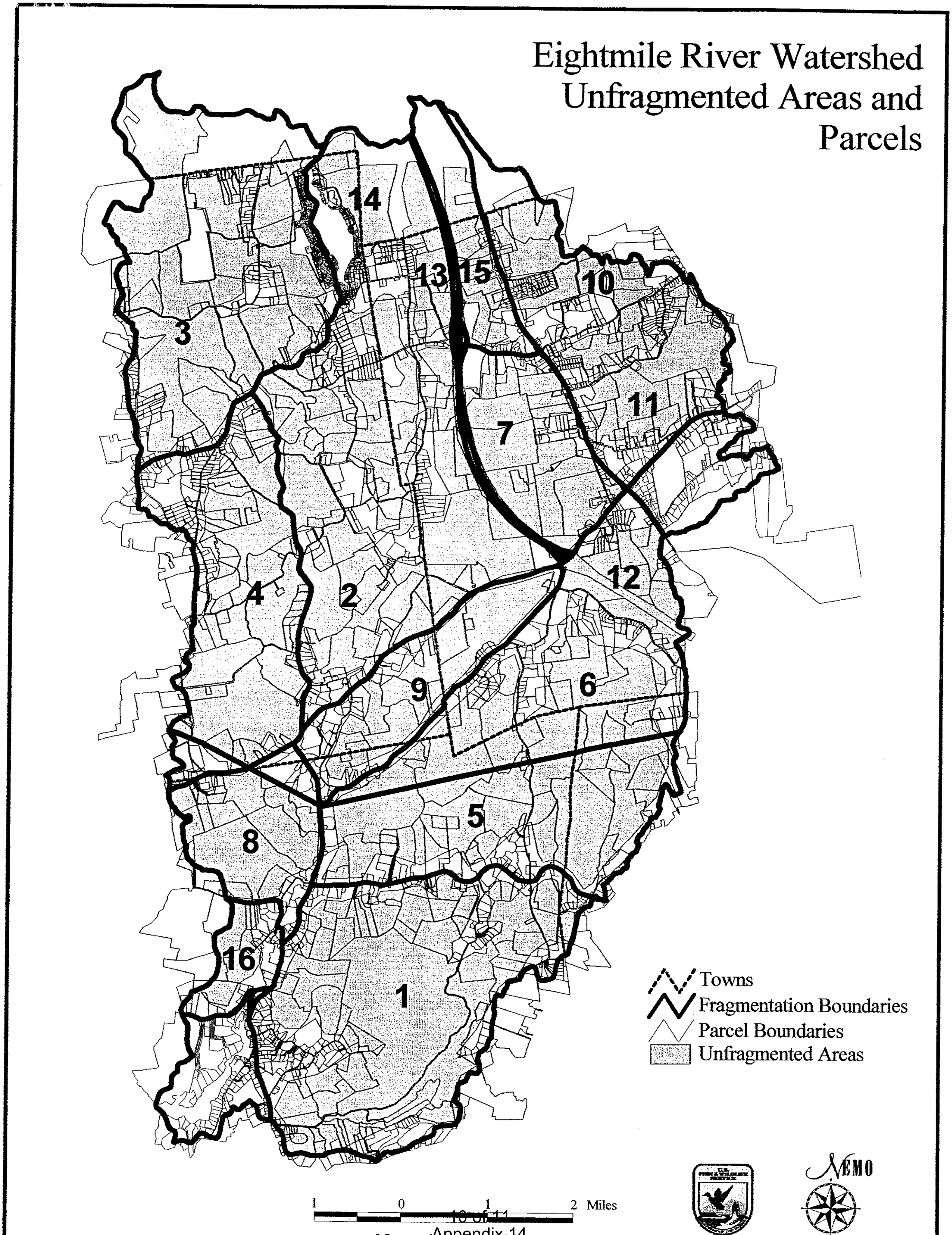
Eightmile River Watershed
Unfragmented Areas and
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Towns
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Parcel Boundaries
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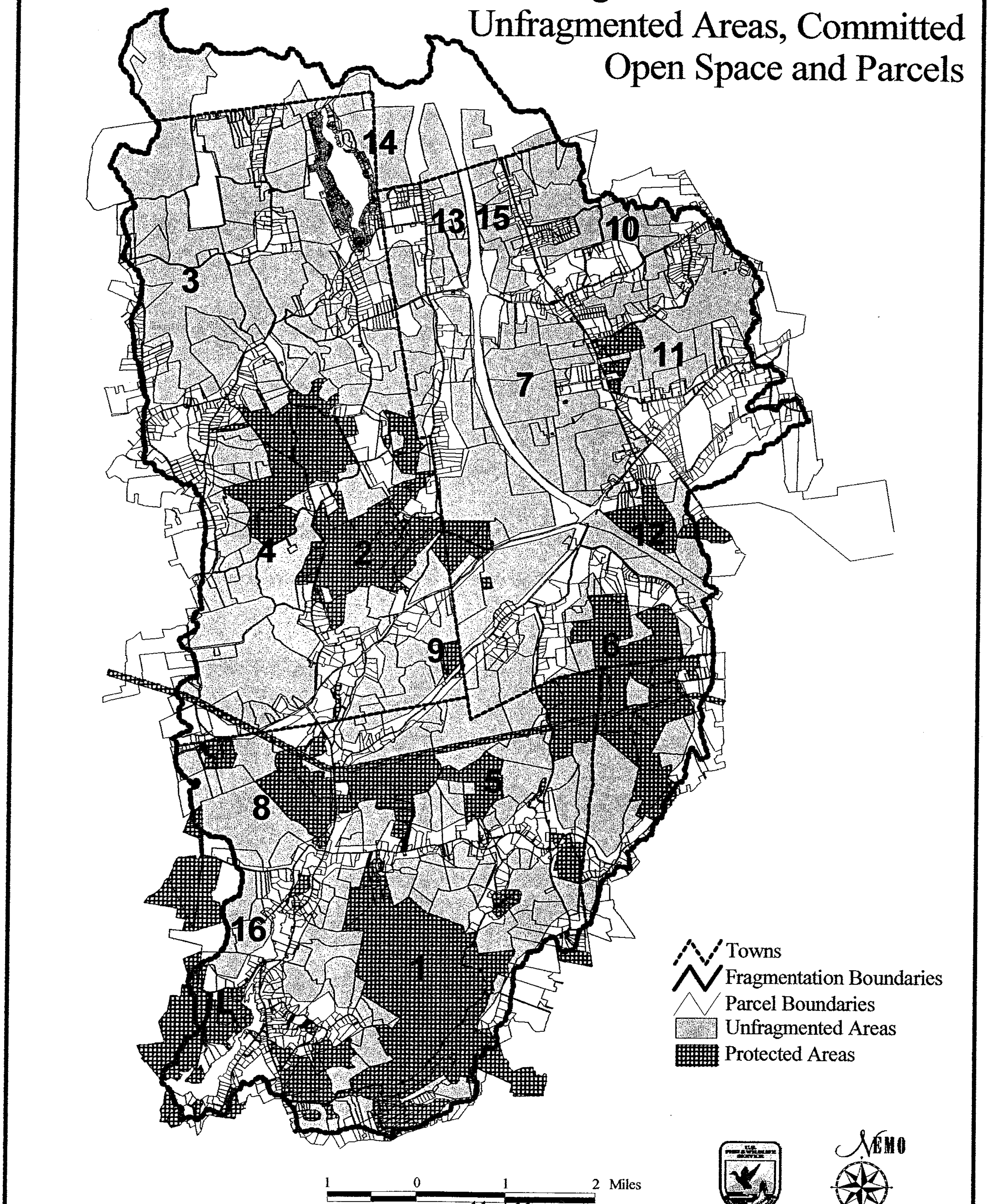
November 12, 1998

Eightmile River Watershed
Unfragmented Areas, Committed Open Space and Parcels



November 5, 1998

Appendix 15

Northeast Instream Habitat Program Report: Initial Biological and Physical Attribute Survey of the Eightmile River–Phase 1 Final Report.

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

NOTE: This document is a summary report of a large document available on the Eightmile River Study Data Disk or by download from www.eightmileriver.org

Initial Biological and Physical Attribute Survey of the Eightmile River – A Component of the Wild and Scenic River Study – Phase 1 Final Report.

Diana L. Walden and Dr. Piotr Parasiewicz

Northeast Instream Habitat Program, Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA

Prepared for: National Park Service and the Eightmile River Wild and Scenic Study Committee

In 2001, Congressman Rob Simmons and Senator Christopher Dodd successfully led an effort to have Congress authorize a Wild and Scenic River study for the Eightmile River and its major tributary, the East Branch. The Eightmile watershed is located in southeastern Connecticut and was nominated for study due to a concerted effort by local citizens who recognized the importance of this resource and had a desire to see it further protected. The resulting study is managed by the Eightmile River Study Committee and supported by the National Park Service (NPS). The initial biological and physical survey was performed as a component of the study by the Northeast Instream

Habitat Program (NEIHP) of the University of Massachusetts Amherst in 2004 and focused on fish and freshwater mussel habitat of the Eightmile River. The purpose was to gain a general overview of the ecological composition of the river, building upon literature review and preliminary fish and mussel data collection as reconnaissance for a multiyear project. The completed portion of the NEIHP Eightmile study includes description of the history of the watershed, a summary of the existing bio-physical information on the area, an assessment of the status of the fish fauna and finally, a discussion of recommended measures and areas of the watershed that may require additional attention with regard to either protection or restoration. The ongoing Phase II of this project aids the development of a computer simulation model of the instream habitat as a management tool for evaluating ecological impacts of various watershed management scenarios and the identification of protective measures.

Notable Characteristics

In the study area, the Eightmile River is a second to fourth order river and the watershed is largely undeveloped in a densely populated area of the country. It is rare for a watershed in coastal Connecticut to remain so highly forested (80-90%), with relatively few point and non-point pollutant discharge sources. The lack of industrial development and associated water withdrawal, as well as lack of major dams, means a consistent, more natural flow for the river and the associated aquatic community. Its baseline condition may serve as a target for other rivers in the state. It has high water quality and unique geology that includes numerous deposits of sand and gravel, which tend to export clean, cold groundwater to the river. These types of stream reaches support many fish species due to high water quality, low temperature, and good bedding sites for spawning. The watershed also contains high diversity in coarse, physical habitat types as the river runs from higher gradient, boulder filled tributary streams to a lower elevation, tidally influenced, brackish cove (Figure 1).

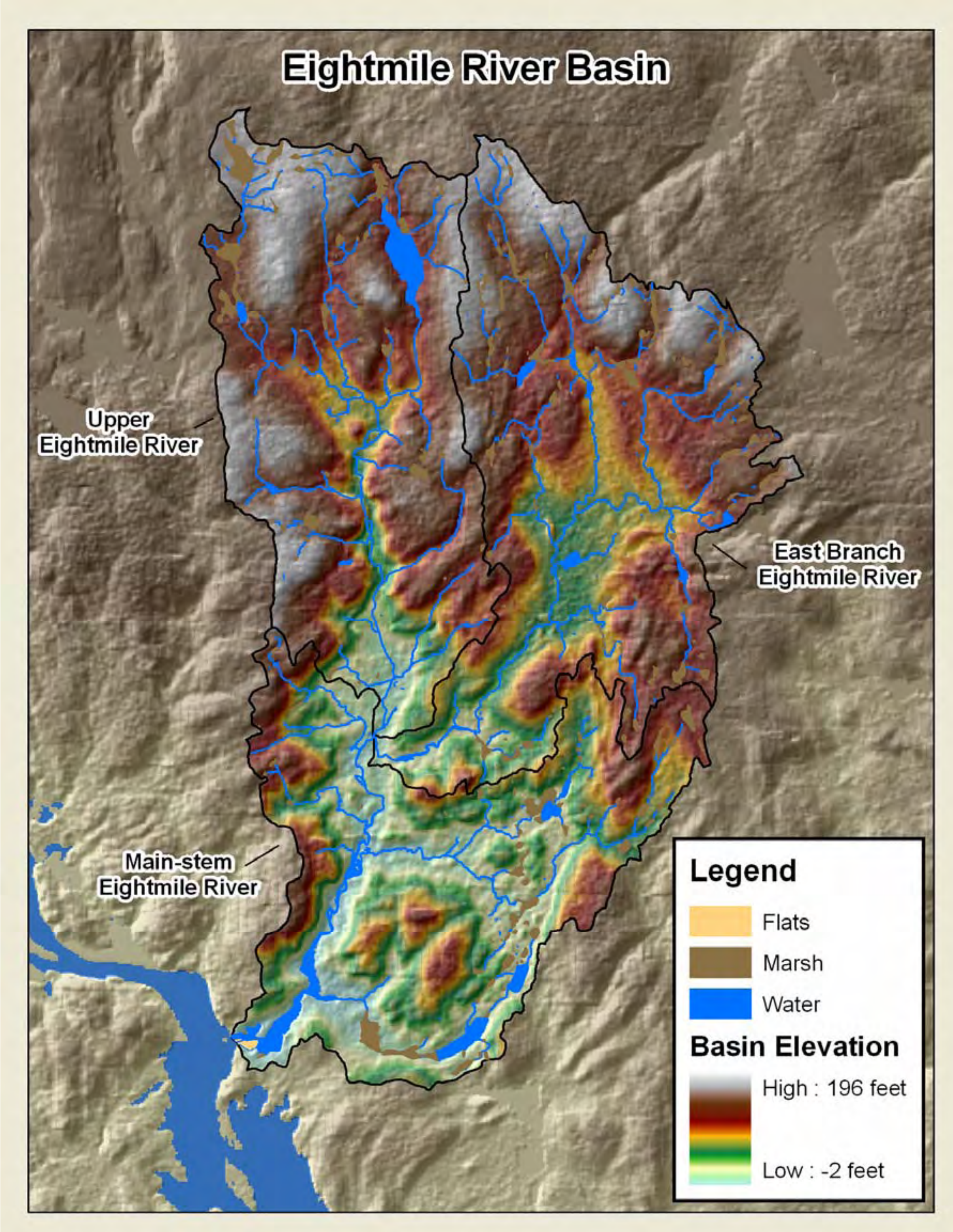


Figure 1: Relief map of the Eightmile River Basin.

Reference Fish Community

It is expected that most rivers should contain a majority of fish species that require riverine habitat for all or part of their lifecycle (Fluvial specialists and fluvial dependents). However, the more rivers are modified, dammed, and altered, the more likely it becomes that the community is dominated by fish which prefer ponded areas and that can utilize multiple types of habitat (Macrohabitat generalists). A Reference Fish Community (RFC) is developed in order to approximate the assemblage of fish species, which should be expected in a river similar to the one studied (based on size, ecoregion, and physical characteristics), if there were limited anthropogenic influences (i.e. maintained ecological integrity). With the help of the Connecticut Department of Environmental Protection, NEIHP developed one Reference Fish Community (RFC) for the Upper Branch and East Branch of the Eightmile River, as well as a second RFC for the Mainstem of the river below the confluence.

The RFC for the East Branch and Upper Branch of the Eightmile consists of a diverse assemblage of 18 species (Figure 2). The top seven most abundantly expected species include American eel, Atlantic salmon, blacknose dace, longnose dace, white sucker, fallfish, and tessellated darter. Approximately 83% of the community consists of fluvial specialist or fluvial dependent species.

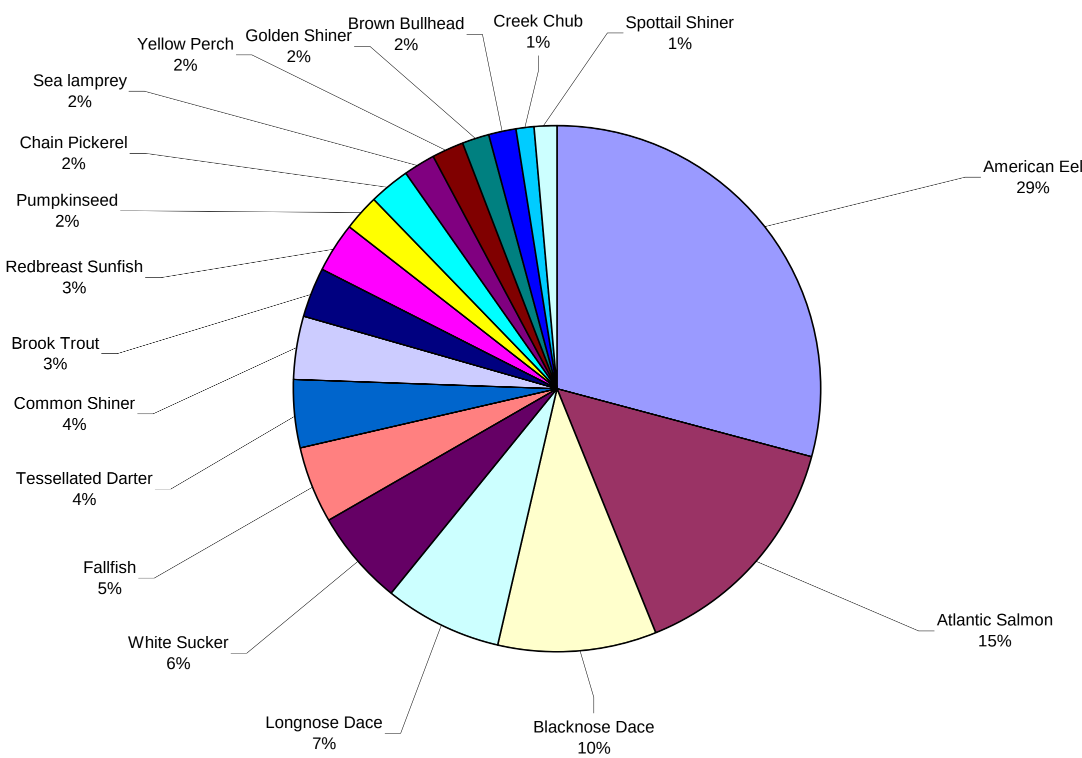


Figure 2: Reference Fish Community developed for the Upper Branch and the East Branch of the Eightmile River. The community is shown in proportion of expected abundance for each species.

The RFC for the Mainstem of the Eightmile consists of an assemblage of 17 species (Figure 3). The seven species expected to be most abundant are white sucker, common shiner, fallfish, American eel, tessellated darter, blacknose dace, and Atlantic salmon. The proportion of the community consisting of fluvial specialist and fluvial dependent species is approximately 80%.

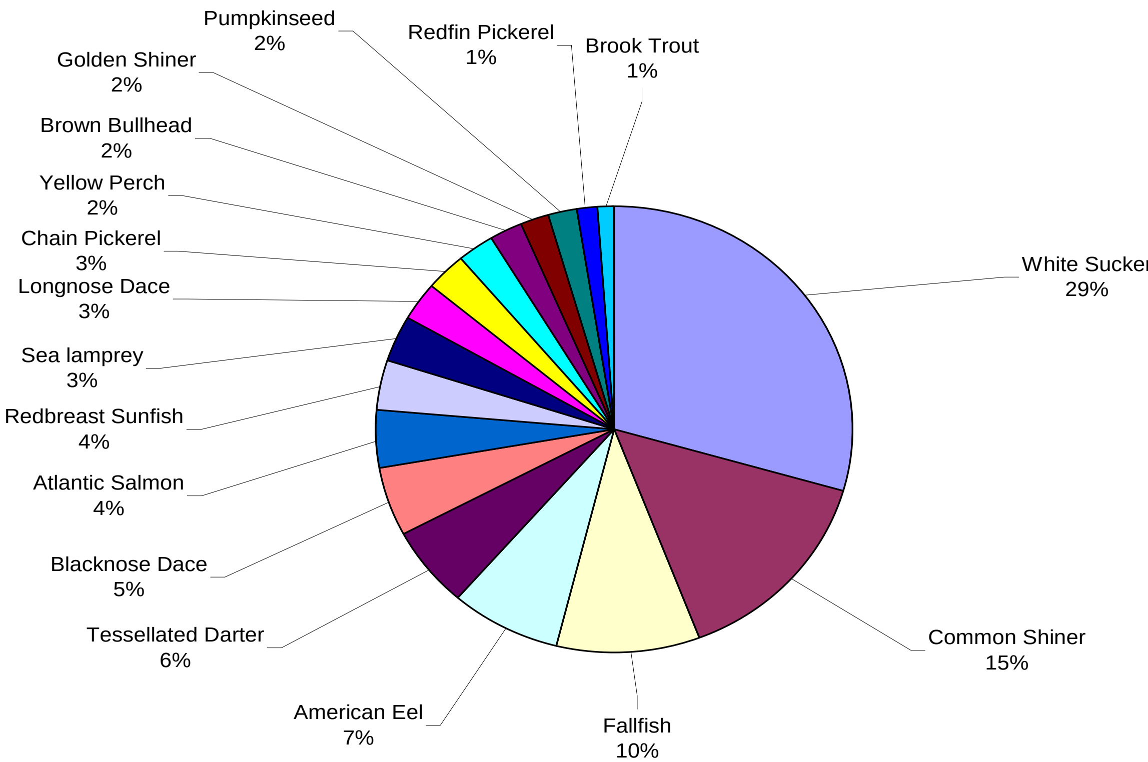


Figure 3: Reference Fish Community developed for the Mainstem of the Eightmile River. The community is shown in proportion of expected abundance for each species.

Existing Fish Community

The generalized, actual species assemblage (the eXisting Fish Community, or XFC) for both sections of the Eightmile River was determined through grid electrofishing at numerous representative locations throughout the watershed in the summer of 2004. The proportions found in the actual survey were projected using the same calculations used for determining the RFC. It was then compared to the RFC to determine the affinity between the results.

The projected assemblage for the East Branch and Upper Branch of the Eightmile consists of 16 native species and 3 introduced (Figure 3). Fallfish is now the most dominant, followed by blacknose dace, common shiner, white sucker, and American eel.

The proportion of fluvial species in the XFC is approximately 75% and the affinity between the RFC and XFC assemblages is 53%.

The projected existing fish community for the lower Eightmile Mainstem, consists of 20 native species and 4 introduced species (Figure 4). The five most dominant species are now led by the tessellated darter, followed by redbreast sunfish, American eel, common shiner, and spottail shiner. The affinity between the RFC and XFC for the Mainstem is at 50%. Sixty percent of the XFC were fluvial specialists or fluvial dependant. In comparison with RFC the native fauna is slightly shifted towards pond or generalist species.

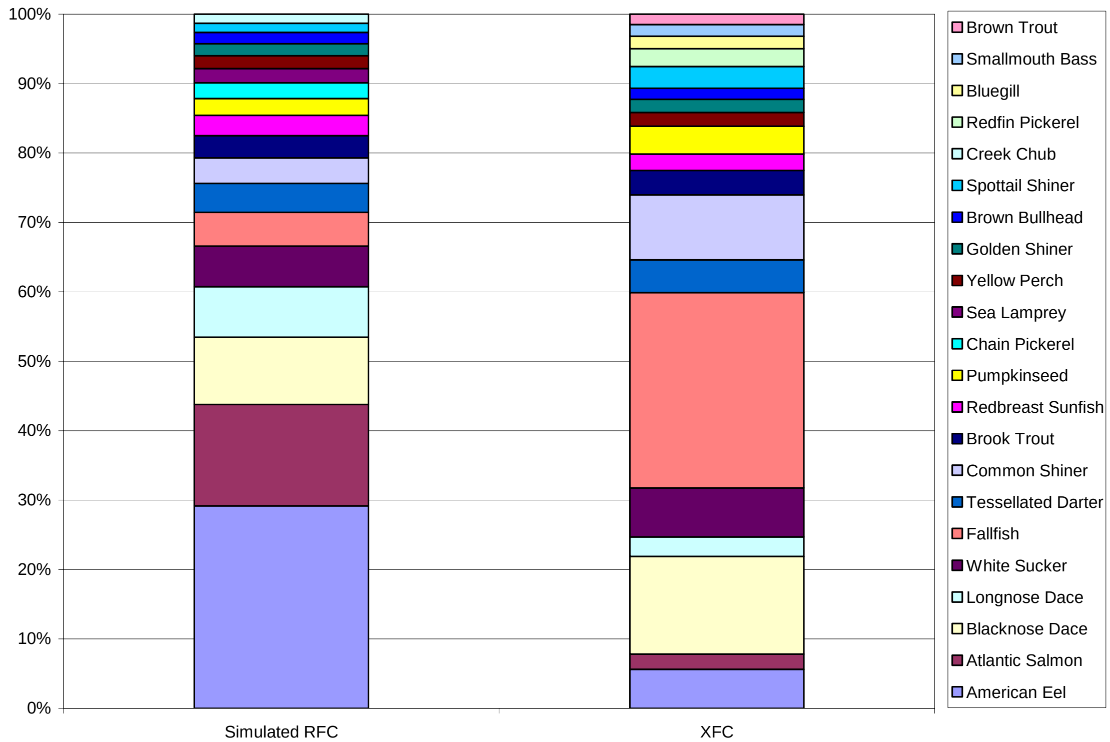


Figure 3: Comparison of Reference Fish Community (RFC) and Existing Fish Community (XFC) structure for the Upper Branch and East Branch of the Eightmile River.

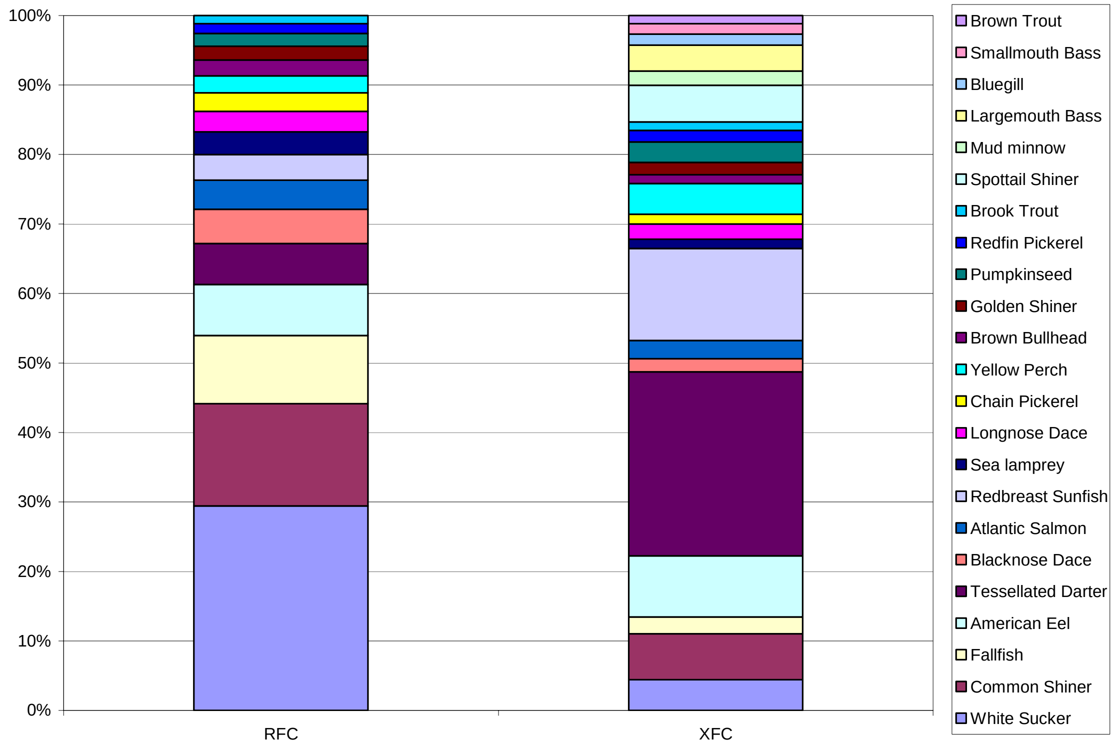


Figure 4: Comparison of Reference Fish Community (RFC) and Existing Fish Community (XFC) structure for the Mainstem of the Eightmile River.

Mussel Habitat Survey

Four sites in the Mainstem and the East Branch were chosen as locations to do reconnaissance level SCUBA surveys for freshwater mussels. The results of the survey indicate that the freshwater mussel community, while not particularly abundant, is diverse and generally healthy. More than half (7 out of 12) of the mussel species known to occur in Connecticut are present and the community includes at least two state listed species (Table 1). The invasive Asian clam was the most abundant mollusk species in Hamburg Cove, but it did not appear to affect the presence of other species at this time.

Table 1. Bivalve mollusk species that were observed in four sites on the Eightmile River. Connecticut status abbreviations are as follows: INV = invasive; SC = species of special concern; NL = not listed.

Site	Mussels/clams	Common name	Density	CT status
Site 1	*Margaritifera margartifera*	Eastern pearlshell	Low	SC
	Pyganodon cataracta	Eastern floater	Low	NL
	Elliptio complanata	Eastern elliptio	Moderate	NL
	Alasmidonta undulata	Triangle floater	Low	NL
Site 2	*Margaritifera margartifera*	Eastern pearlshell	Low	SC
	Elliptio complanata	Eastern elliptio	Low	NL
Site 3	*Pyganodon cataracta*	Eastern floater	Low	NL
	Elliptio complanata	Eastern elliptio	Low	NL
Site 4	*Corbicula fluminea*	Asian clam	Moderate	INV
	Pyganodon cataracta	Eastern floater	Low	NL
	Elliptio complanata	Eastern elliptio	Low	NL
	Lampsilis radiata	Eastern lampmussel	Low	NL
	Ligumia nasuta	Eastern pondmussel	Low	SC
	Anodonta implicata	Alewife floater	Low	NL

Temperature and Flow

Physical characteristics were also recorded concurrently at the fishing locations in an attempt to determine associations between fish species densities and physical habitat. The hydromorphology or distribution of pools and runs, physical attributes, fish density, and temperature data were analyzed in each site to document the present status of the river. Hourly water temperature readings were documented with 14 thermal recorders through the summer. Overall water temperature was raised by a high number of shallow impoundments in headwaters as well as some channel modifications (Figure 5). Past flow records were also analyzed to determine whether there were trends of limited available habitat. Compared to the early 20th century, the magnitude, duration and frequency of low flows have significantly changed, creating more stable flow conditions. We found that average water temperatures in the East Branch were warmer than the Upper Branch, likely due to lack of canopy shading.

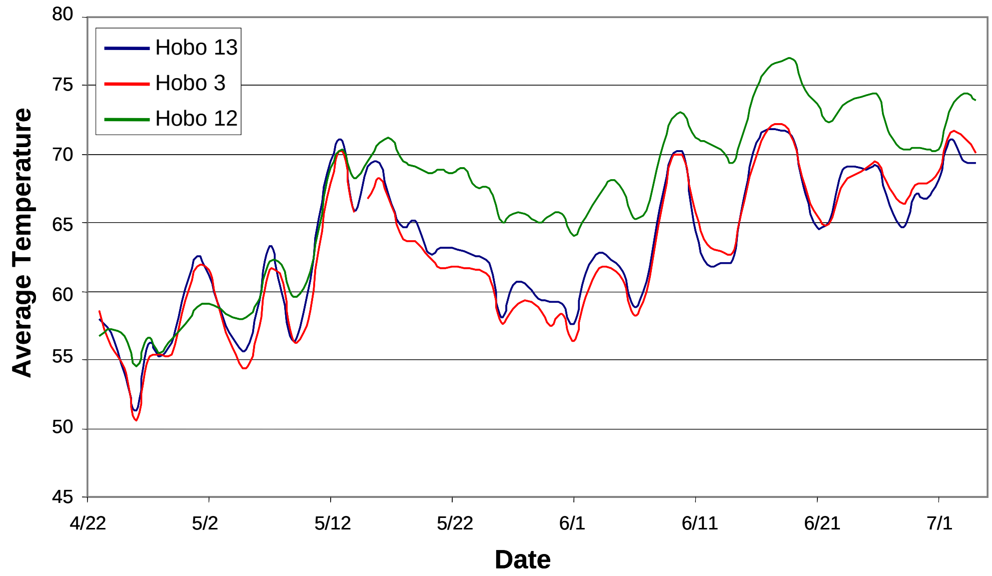


Figure 5. Temperature recordings (in degrees Fahrenheit) from tributaries of the Eightmile River and the East Branch, April 22 – July 1, 2004. Note: Hobo 12 was placed below a large impoundment (Lake Hayward) on the tributary identified as Lake Hayward Brook. The other two probes were located on tributaries without dams. With the first hot day the temperature under Lake Hayward departures from pattern observed in unimpounded streams and remains higher for the rest of the summer.

Conclusions

The Eightmile river system has a diverse community of species overall and relative fish density is similar to the regional average. The existing fish community corresponds to the projected reference community only roughly though, and some lead species such as longnose dace, brook trout, Atlantic salmon and American eel are present in abundances lower than expected. Relatively low affinities between XFC and RFC are mostly caused by underrepresentation of diadromous species (Atlantic salmon and American eel), which is a due to the regional impact on populations created by numerous dams on the rivers along the East Coast. Introduced species make up less than 10% of the existing fish community and there is a good recruitment for the majority of common fish species. We did note that species diversity decreases in sites where the river channel has been modified and the sites in or immediately downstream of large alluvial deposits generally had high fish densities and low species diversity.

The elevated water temperatures seem to be the main problem of Eightmile River ecosystem. It is reflected in the fact that the XFC is shifted towards higher temperature tolerant species than predicted in the RFC. A lower than expected proportion of longnose dace and brook trout potentially suggests a lack of flow concentration caused by structures (e.g. boulders or large woody debris). This may be a reflection of the relatively young, successional surrounding forest habitat. Apparently the Eightmile River is still on the path of recovery from historical impact. However, at the regional average it is considered to be a high quality river demonstrating an urgent need for a regional restoration effort. Therefore, we strongly support the designation of the Eightmile River as a Wild and Scenic River.

Recommendations

We recommend developing a simulation model of habitat, flow and temperature conditions as a tool to precisely define protection/restoration targets and management options for the watershed. At the same time the potential impact of new and planned development on temperature and flow regime, especially in the areas of gravel deposits must be carefully considered. We also propose introducing measures to lower water temperature such as removal of small dams in the headwaters or by the increase of canopy cover and application of land use practices and restoration measures that induce additional woody habitat structure. This should be accompanied by continuous evaluation of the status of fish fauna, habitat, flow and water temperature. To address the critical knowledge deficits, we also recommend a detailed investigation of the abundance and diversity of mussel fauna and a study of the potential effects of boat traffic on the aquatic fauna in Hamburg Cove.

Acknowledgements

The National Park Service and the Eightmile River Wild and Scenic Study Committee financially supported this study. The Inland Fisheries Division of the Connecticut Department of Environmental Protection and Salem Land Trust provided us with reference survey data and invaluable advice. We would like to thank the entire Eightmile River Wild and Scenic Study Committee for continuing assistance in providing information essential to our success during the field season. Thanks to all of the private landowners who graciously granted us access to the river through their properties.

Appendix 16

Buildout Analysis Report & Memo from Study Committee

Eightmile River Watershed Management Plan
Draft Aug. 25, 2005

TO: Whom it may concern
FROM: Eightmile River Wild and Scenic Study Committee
RE: Planimetrics Report dated October 22, 2005
DATE: 6/14/06

The Eightmile River Wild and Scenic Study Committee studied the Eightmile River and its watershed for possible designation as a federal Wild and Scenic River. As part of that study, the Study Committee commissioned Planimetrics of Avon, Connecticut, to prepare an analysis of potential future development in the watershed. That report, the "Eightmile River Wild and Scenic River Buildout Analysis" provides a brief historical review of development in the watershed, an analysis of growth trends in the three towns which comprise the watershed, and offers recommendations for municipal management activities to protect the outstanding resource values of the watershed.

While the report contains information that contributes to the discussion of the future of the watershed, the Study Committee does not (necessarily) endorse the report's conclusions relating to the possible impact of completion of the Route 11 expressway on population growth in the watershed. The time frame of the report's preparation and the level of resources dedicated to that effort did not allow for a comprehensive analysis at a level that justifies the report's conclusions.

The committee's specific concern is based on the relatively limited assumptions used to predict population growth. The writer did not find a positive correlation between highway construction and population growth based on a very broad examination of this issue. In the opinion of the Study Committee, the data used was too broad and did not account for important variables which would influence population growth, such as the amount of vacant land available, the level and density of existing development, and the generation of non-residential growth in place of population growth. No distinction was made among rural, suburban and urban settings.

In addition, the section entitled "Tools for Protecting the Watershed" includes a large "menu" of possible tools that might be considered in any review of watershed protection. While some tools might be appropriate for the Eightmile River Watershed, others are not practical or feasible in this area. This report in no way represents the actual recommendations of the Study Committee.

THIS REPORT IS SUBJECT TO STUDY COMMITTEE COMMENTS - SEE PREVIOUS PAGE

October 22, 2005

EIGHTMILE RIVER WILD & SCENIC RIVER BUILDOUT ANALYSIS

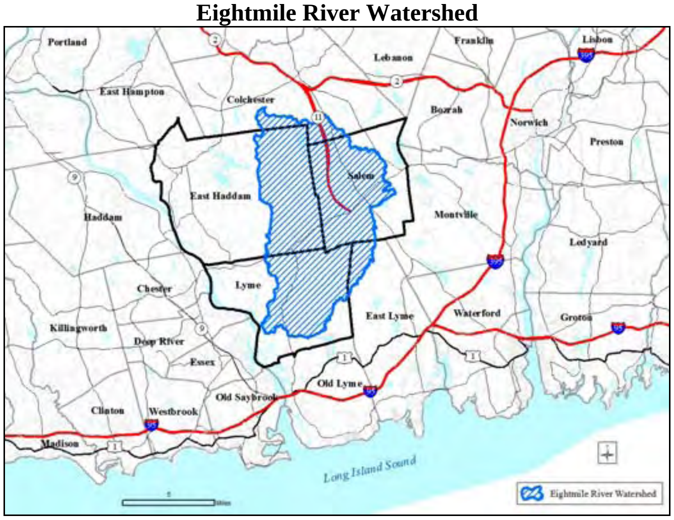
INTRODUCTION

The Eightmile River is a tributary of the Connecticut River, located in the rural towns of East Haddam, Lyme, and Salem, CT. Despite Connecticut possessing the highest population density in the nation, the Eightmile River Watershed is fortunate to be located in a relatively undeveloped area of the State, allowing much of the River and surrounding landscape to remain in its natural state.

To protect the wild and scenic character of the River, the Eightmile River Wild & Scenic Study Committee, in association with the Connecticut River Estuary Regional Planning Agency, the Connecticut Nonpoint Education for Municipal Officials Project (NEMO), the Nature Conservancy, and the National Park Service, is studying the River and its watershed for designation as a federal Wild and Scenic River. The purpose of this report is the supplement the work of these agencies by providing the following:

- a brief historical overview of development trends in southeastern Connecticut and the State as a whole;
- an analysis of growth trends in the three towns that comprise the Watershed;
- future growth projection scenarios for the Watershed, including the effect of a completed Route 11; and
- detailed recommendations on municipal regulatory and non-regulatory tools for achieving the management goals for protecting the outstanding resource values of the Watershed.

Eightmile River Watershed



STATE & REGIONAL DEVELOPMENT TRENDS

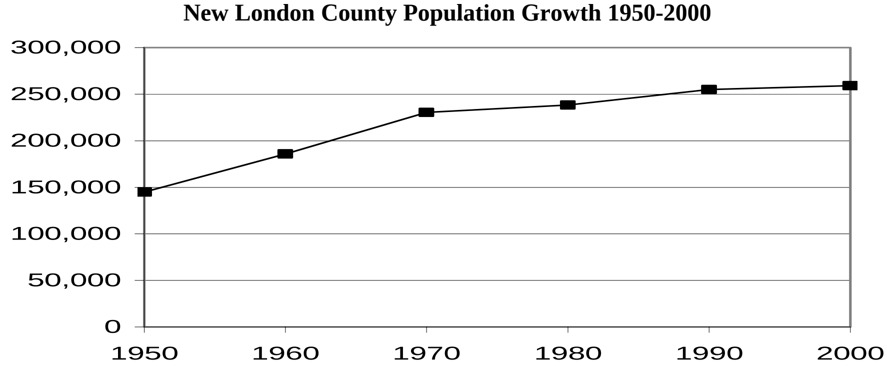
Prior to World War II, development in Connecticut was concentrated in densely populated villages and cities, where residents could live a short distance from daily activities. Employment was typically found in factories and mills that initially relied upon water for power and railroads to bring in raw materials and transport finished products to market. The 1955 Flood proved too much for many of these firms that had already been in a state of decline due to competition in the southern United States and abroad, sending some villages and cities into decline as well.

The years shortly after the end of World War II marked a dramatic shift in development patterns within southeast Connecticut and the State as a whole as suburban expansion began in the towns immediately surrounding central cities. The advent of the Interstate Highway System in the mid to late 1950s further fueled suburban expansion by allowing workers to commute further distances.

Coastal towns experienced significant growth to serve the growing demands of summer residents and tourists. Many cottages would later be converted to year-round use by residents commuting to jobs in coastal communities such as Bridgeport, New Haven, Groton, and New London.

Several military installations including the Groton Submarine Base and the Coast Guard Academy continue to play significant roles in the region. Industries such as Electric Boat and Pratt & Whitney, that had provided war materials during World War II, thrived during the Cold War, making defense manufacturing a primary component of Connecticut's economy. The collapse of the Soviet Union coincided with the collapse of the real estate market in the late 1980s and early 1990s, dealing Connecticut a double blow with a subsequent decline in defense spending, affecting defense contractors throughout the State.

New London County Population Growth 1950-2000



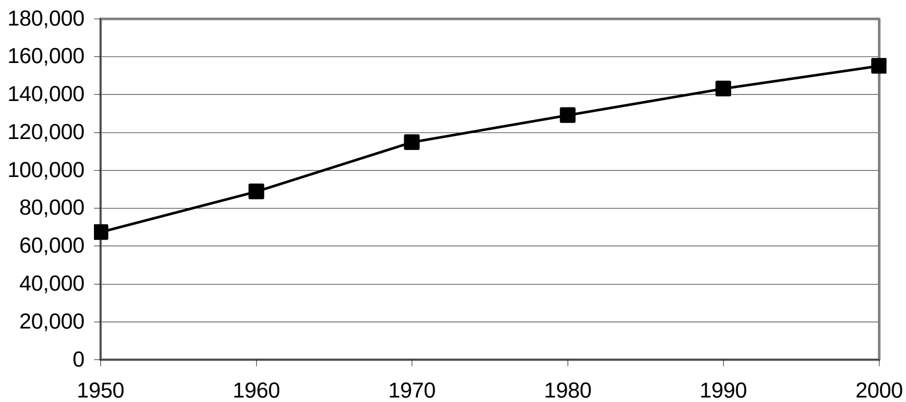
U.S. Census Bureau

During the 1950s and 1960s, New London County experienced an average annual population growth rate of 2.3%, comparable to statewide growth rates during that period. The 1970s and 1980s marked a decline to a 0.5% average annual growth rate that also closely mirrored statewide growth rates. Growth during the 1990s was virtually flat with an average annual growth rate of 0.2%, marking the first time in 50 years that statewide growth outpaced the County.

Growth in the insurance industry would spark significant suburban expansion in the Capitol Region that would peak during the late 1980s before a collapse in the real estate and banking industries would impact insurance investments, leading to restructuring and nearly a decade of stagnant growth.

Middlesex County, while predominantly outside the Capitol Region, plays a significant role in the Hartford Labor Market and is influenced by the fortunes of the insurance industry. During the 1950s and 1960s, Middlesex County experienced an average annual population growth rate ranging from 2.6% to 2.8%, exceeding statewide growth rates during that period. The 1970s through the 1990s marked a decline in average annual growth rates from 1.2 % in the 1970s down to 0.8% during the 1990s, closing the gap between statewide growth rates.

Middlesex County Population Growth 1950-2000



While tourism has always been a component of the Connecticut economy with attractions such as Hammonasset Beach, Mystic Seaport, and Mystic Aquarium attracting visitors from throughout the Northeast, it was not until the opening of the Foxwoods Casino in the early 1990s that tourism played a major role in the State economy. Foxwoods Casino, and later the Mohegan Sun Casino, would fill voids in both jobs and State revenues, employing an estimated 21,000 workers in southeastern Connecticut and paying over $300 million in slot machine revenue to the State by 2000. The lower wage casino and other service sector jobs in the region would lead to a high demand for affordable housing, placing pressure on older housing stock in region towns, where workers engage in a practice known as 'hot bunking' or taking turns sharing a single bed among workers on different shifts.

Biotechnology is another growing sector of the State economy, led by firms such as Bayer, Pfizer, and U.S. Surgical. Pfizer is playing an increasingly significant role in the economy of southeastern Connecticut, constructing nearly two-million square feet of research and development space in Groton and New London that will add thousands of jobs in the Region. Unlike casino employees, Pfizer employees will likely seek out moderate to luxury housing options within the Region.

WATERSHED DEVELOPMENT TRENDS

The Eightmile River Watershed is comprised of nearly 40,000 acres or approximately 62 square miles, spread across five towns. The bulk of the Watershed, or over 36,000 acres, is concentrated in the three towns of East Haddam, Lyme and Salem, which are located on the fringes between the steep terrain of the Eastern Uplands, that had been the focus of early industrialization in Connecticut, and the gently sloping Eastern Coastal Slope, that is the center of Connecticut's maritime economy. The Watershed's isolation relative to major employment centers in the region, such as Groton, New London, and Norwich, has allowed the Watershed to escape the brunt of post-war suburban expansion.

In recent years, open space preservation has also played a significant role in curbing potential residential development by taking available land off the market before it becomes available for development. Since 1998, 2,777 acres or nearly seven percent of the land within the Watershed has been conserved as open space or farmland, displacing as many as 777 new houses.

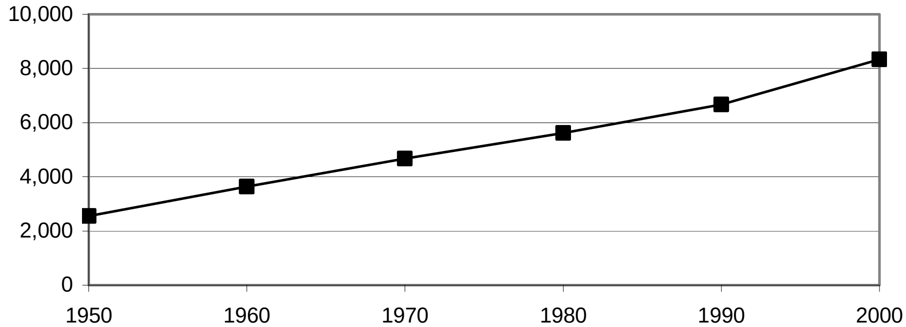
The Connecticut Turnpike (I-95), I-395 (originally Route 52), Route 2, and Route 9 have all served as avenues for both suburban expansion and new economic growth within the region. However, none of these expressways provides convenient access to significant portions of the Watershed for regional commuters or industry. The incomplete Route 11 expressway penetrates the Watershed but its sole connection to Route 2 in Colchester may be too remote from the Hartford Labor Market to have a significant effect on development. The impact of connecting Route 11 to I-95 in Waterford will be a subject of discussion later in this report.

East Haddam

East Haddam is the most populous of the three towns that comprise the Watershed, due initially to the industrialization and immigration of the 19th Century, and later due to the abundance of recreation opportunities and its access to jobs both inside and outside the region via Route 9.

During the later half of the 20th Century, East Haddam consistently outpaced State and regional growth, with average annual population growth rates ranging from 1.7% to 3.6% (see chart on opposite page. A continually decreasing average household size in East Haddam over the last 50 years often drove the rate of housing construction higher than the rate of population growth.

East Haddam Population Growth 1950-2000



U.S. Census Bureau

The Center for Land Use Education and Research (CLEAR) has conducted a series of land cover analyses between 1985 and 2002, based on satellite imagery, to document changes in land cover over time. While land cover data does not always provide a clear indication of use (barren land, tall grasses and turf can be attributed to either agricultural uses or various stages of development), it does reveal that between 1985 and 2002, 1,051 acres or four percent of East Haddam's forested land was cleared for various purposes. During that same period, an additional 327 "developed" acres were created (an 11% increase) and an additional 803 acres of "barren", "turf and grass" and "other grasses and agriculture" land cover were created (a 26% increase).

While not all of the 1,051-acre loss of forestland can be attributed to housing development, the 920 building permits issued for new housing units during that time likely account for much of the clearing activity. For each housing unit constructed, East Haddam lost 1.14 acres of forestland and added 1.23 acres of developed, barren, and grassed land capable of increasing stormwater runoff, erosion, and the application of fertilizers and pesticides.

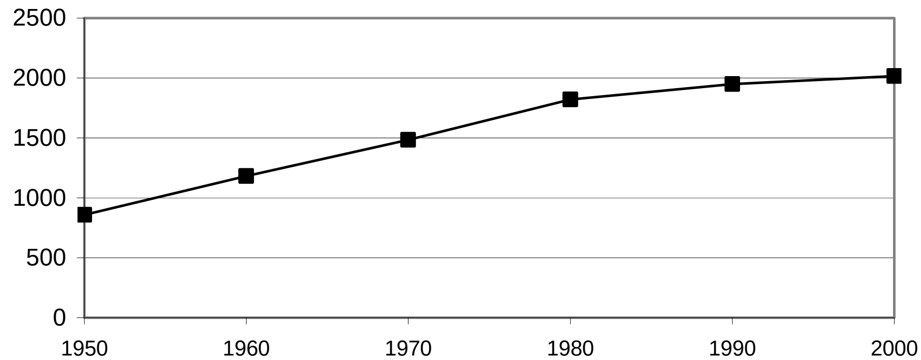
Open space preservation efforts since 1998 have conserved 892 acres of land in East Haddam. Given current zoning regulations and known environmental constraints, this land could have supported between 200 and 300 additional housing units if developed.

Lyme

Lyme is the least populous of the three Watershed towns. The Town's population actually peaked in 1800 on the strength of its maritime industries and would steadily decline to only 546 residents by 1930 before beginning a 70-year trend of slow growth. Lyme is the most isolated of the Watershed towns in terms of expressway access and is more than three towns removed from the regional employment centers of Groton, New London, and Norwich.

Lyme experienced average annual population growth rates ranging from 3.3% in the 1950s down to 0.3% during the 1990s, more than doubling in size during the last 50 years due to its small population. Like East Haddam, Lyme's rate of housing growth outpaced population growth between 1970 and 1990, due in part to decreasing average household size.

Lyme Population Growth 1950-2000



U.S. Census Bureau

The CLEAR land cover analysis reveals that between 1985 and 2002, 586 acres or four percent of Lyme's forested land was cleared for various purposes. During that same period, an additional 116 developed acres were created (an 11% increase) and an additional 512 acres of land cover were created in the "barren", "turf and grass" and "other grasses and agriculture" (a 44% increase).

During that 17-year period, Lyme issued 192 building permits for new housing units. Disturbingly, the ratio of cleared forestland relative to new housing is nearly triple that of East Haddam at 3.05 acres per new housing unit. Similarly, the ratio of newly created "developed", "barren", and "grassed" acreage is more than double that of East Haddam at 2.67 acres per new household, significantly increasing the potential for additional stormwater runoff, erosion, and attendant pollutants.

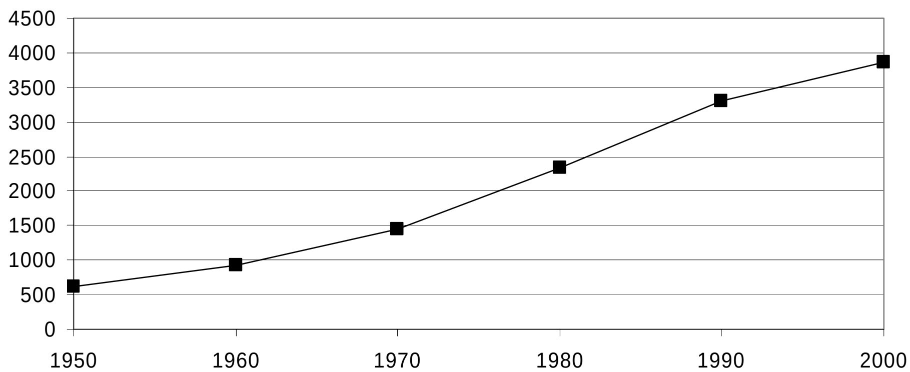
Since 1998, Lyme was the most aggressive of the three main watershed towns with respect to open space protection, conserving a phenomenal 1,724 acres or nearly eight percent of the entire Town in only seven years. If developed, this acreage could have supported over 400 new homes under current environmental and regulatory conditions.

Salem

Salem is the fastest growing of the three Watershed towns due to its location closest to employment opportunities in Norwich, Groton and New London as well as its direct access to Colchester and Hartford via Routes 11 and 2.

Salem experienced average annual population growth rates ranging from a peak of 4.9% during the 1970s down to a low of 1.5% during the 1990s. Salem is considered one of the fastest growing communities in the region and by 2000 its population had grown to more than six times its 1950 population. Typical of the other towns in the Watershed, the rate of housing growth in Salem outpaced population growth between 1970 and 2000, due in part to decreasing average household size.

Salem Population Growth 1950-2000



U.S. Census Bureau

The CLEAR land cover analysis for Salem reveals that between 1985 and 2002, 788 acres or six percent of Salem's forested land was cleared for various purposes. During that same 17-year period, an additional 286 "developed" acres were created (a 23% increase) and an additional 569 acres of "barren", "turf and grass" and "other grasses and agriculture" were created (a 27% increase).

Like Lyme, Salem's ratio of cleared land per new housing unit (334 building permits for new housing) during the 17 years covered by the CLEAR Study is significantly higher than East Haddam's at 2.35 acres of forestland lost per new housing unit. Similarly, there were 2.56 acres of "developed", "barren", and "grassed" acreage created per new housing unit.

Salem was the least aggressive of the three main Watershed towns in terms of conserving open space over the last seven years. Salem's 161 acres of open space conserved since 1998 represents less than one percent of Salem's total land area but nonetheless potentially displaced more than 70 additional housing units.

GROWTH PROJECTION SCENARIOS

According to the buildout analysis provided by the Study Committee, there is significant potential for additional housing units ranging from 157% to 260% growth.

Buildout Analysis Results

	Housing Units			
	Current	**Potential**	**Total**	**Percent Growth Potential**
East Haddam	3,967	7,611	11,578	192%
Lyme	1,051	2,733	3,784	260%
Salem	1,453	2,279	3,732	157%
Total	6,471	12,623	19,094	195%

Eightmile River Wild & Scenic Study Committee

These projections indicate that Salem is only 39% developed in terms of housing potential, given its current zoning and the amount and condition of developable land, while East Haddam and Lyme are 34% and 28% developed respectively.

Housing Growth Projections

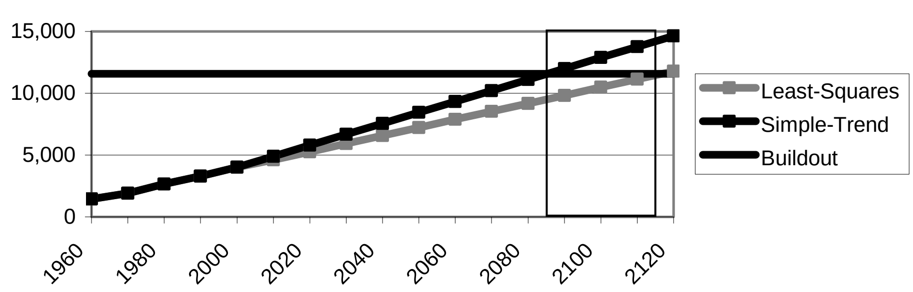
East Haddam

Several projection methods were used to offer a range of possible growth scenarios for each of the towns in the study. The first projection method used is the simple-trend method, which takes the growth trends of the last decade and extrapolates or projects those trends into the future until growth reaches the total housing buildout of 11,578 dwellings projected above.

Another method for projecting growth called the least-squares method looks at growth trends between 1960 and 2000 and minimizes fluctuations in growth over time to project an average or smoothed trend into the future.

To determine when total buildout might be reached, the trends produced using these two methods were plotted over time. The results depicted below reflect a range of 75 years to 110 years before the total buildout of 11,578 dwelling units is reached in East Haddam.

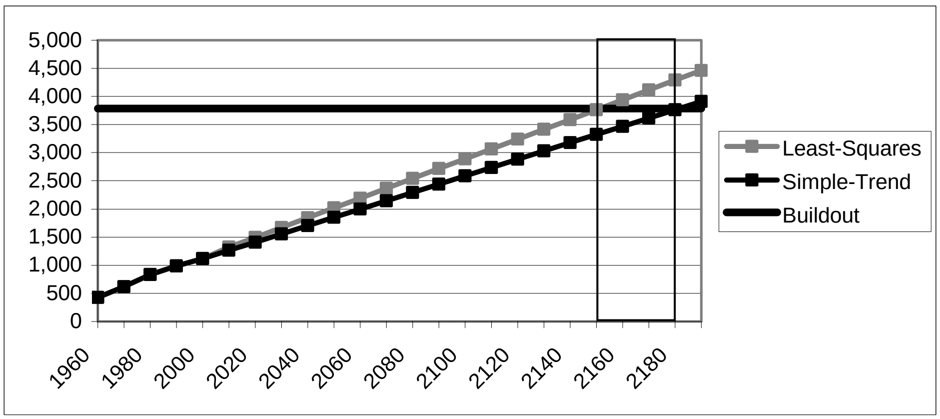
East Haddam Housing Growth Projections



Lyme

As stated earlier, Lyme has the smallest population and slowest population growth of the three towns in this analysis. While some of the slow growth can be explained by the aggressive acquisition of open space during the last decade, we believe that the Census Bureau undercounted housing units in Lyme during the 2000 Census (only three additional units accounted for over ten years) and have substituted data obtained from the Department of Housing and Urban Development (130 building permits for new dwellings over the same ten years).

Lyme Housing Growth Projections

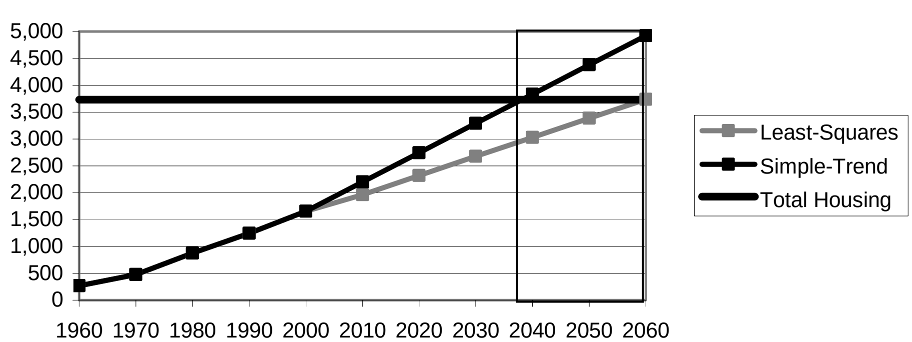


The results of the two projection methods produced a range of possible buildout dates from approximately 145 years for the least-squares projection method to 175 years for the simple-trend projection method.

Salem

As the fastest growing of the three towns, Salem's results are dramatically different. Based on the two trend analyses, Salem could reach its buildout potential of 3,732 dwellings in approximately 30 to 55 years. If these projections hold true, Salem would have to move quickly to implement some of the strategies outlined later in this report if they are to have any significant impact on protecting the Watershed and the overall character of the Town.

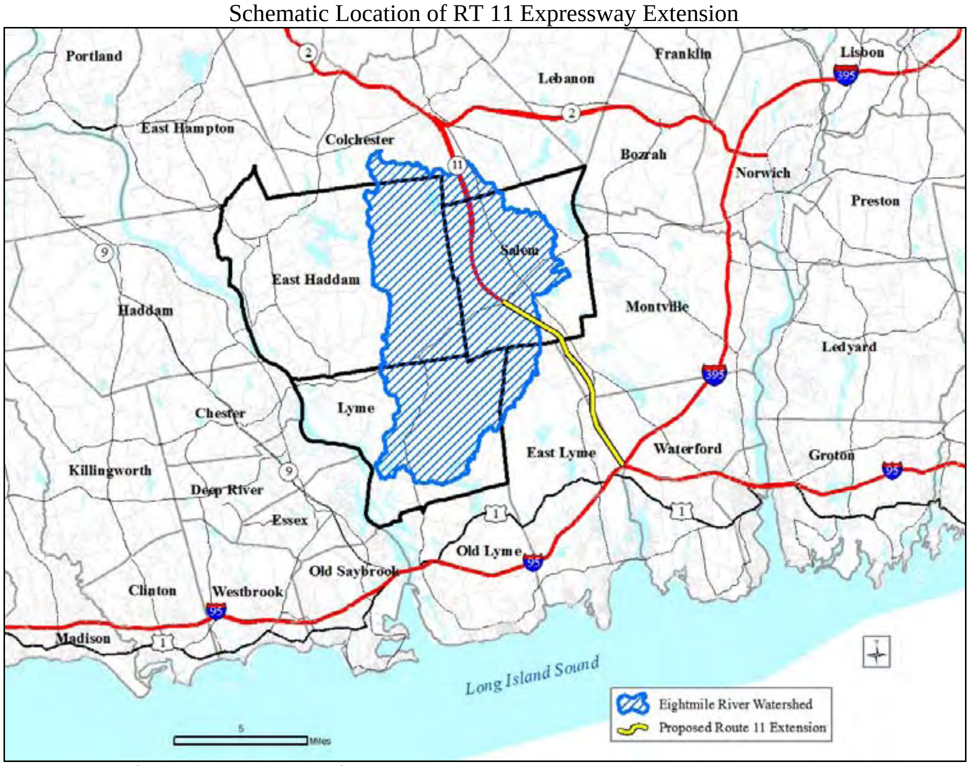
Salem Housing Growth Projections



ROUTE 11 IMPACT ASSESSMENT

The final leg of the Route 11 expressway between Route 82 in Salem and I-95/I-395 in Waterford has been fast-tracked by the Federal Highway Administration and right-of-way acquisition has begun. The following map illustrates the general routing of the expressway.

Schematic Location of RT 11 Expressway Extension



Route 11 alignment from Connecticut Department of Transportation 2005 Master Transportation Plan

Correlation Coefficient

A correlation coefficient can vary between zero and one with a value of zero meaning that there is no correlation between variables and a value of one representing a perfect correlation. A negative number implies a negative correlation in which two variables behave oppositely.

Correlation Analysis

To determine whether the completion of Route 11 would have an impact on development within the Watershed, an analysis was performed utilizing population data for all 169 towns in Connecticut between 1950 and 2000 to determine if there was any correlation between population growth (both in terms of the rate of growth and actual population counts) and direct access to an expressway of four or more lanes.

Correlation coefficients (see sidebar) were calculated for several statewide data sets, comparing the presence or lack of an expressway to total population growth between 1950 and 2000, and the average annual population growth rate between 1950 and 2000. In this analysis, a correlation coefficient was used to measure how closely these two attributes (the presence of an expressway and population growth) relate to one another in communities across the State.

Assuming that the presence of an expressway in a community would have a strong positive influence on the rate of growth in that community, when the presence or lack of an expressway in communities across the State was compared to their average annual population growth rate between 1950 and 2000, one would expect a close correlation between the two factors. Comparing these factors across every community in Connecticut actually results in a correlation coefficient of -0.256, meaning that there is a weak negative correlation between these factors. Squaring this value produces a coefficient of determination of 0.06 meaning that only 6% of the variation in population growth rates in Connecticut communities can be explained by the presence or lack of an expressway. This leaves 94% of the variation in population growth left unexplained and possibly due to factors such as the price and availability of land, the quality of schools, employment opportunities, etc.

Coefficient of Determination

Squaring the correlation coefficient produces a coefficient of determination, which in this analysis represents the percent of the variation in population growth that can be explained by the presence or lack of an expressway.

Since the rate of growth is also a function of the size of a community (ex. 1,000 new residents in a town of 10,000 would represent 10% growth while 1,000 new residents in a city of 100,000 would represent only 1% growth), the actual number of residents added to a community over time provides a more standardized measure of growth. When total population growth between 1950 and 2000 is compared to the presence or lack of an expressway in communities across the State, a positive correlation coefficient of 0.177 and a coefficient of determination of 0.0313 results, indicating that only 3% of the variation in total population growth in Connecticut communities can be explained by the presence or lack of an expressway.

To better understand the impact of the presence of an expressway on communities of different sizes, all 169 communities were sorted into discrete population groupings and average annual population growth rates were calculated for each group over time. The results presented below illustrate that while there are differences between communities with and without expressways, there is no consistent pattern to those differences over time.

Average Annual Population Growth Rates for Connecticut Communities 1950-2000

1950 Population	1950s	1960s	1970s	1980s	1990s	1950-2000
Under 1000						
No Expressway	3.6%	3.0%	2.3%	1.7%	1.4%	2.4%
Expressway	5.2%	4.2%	4.0%	1.9%	0.8%	3.2%
1000-1999						
No Expressway	6.1%	4.4%	1.3%	1.2%	0.8%	2.7%
Expressway	4.7%	5.9%	2.1%	1.4%	1.1%	3.0%
2000-2999						
No Expressway	5.1%	4.0%	1.6%	1.3%	1.0%	2.6%
Expressway	4.8%	5.5%	1.4%	1.0%	0.6%	2.6%
3000-3999						
No Expressway	5.3%	3.4%	1.5%	1.2%	1.0%	2.5%
Expressway	5.0%	4.4%	2.2%	1.1%	1.5%	0.4%
4000-4999						
No Expressway	5.3%	5.0%	1.3%	0.9%	1.3%	2.7%
Expressway	4.6%	3.4%	0.9%	1.4%	0.6%	2.2%
5000+						
No Expressway	3.8%	2.7%	1.0%	0.6%	0.5%	1.7%
Expressway	1.9%	1.3%	-0.2%	0.4%	0.2%	0.7%

TOOLS FOR PROTECTING THE WATERSHED

There are numerous regulatory and non-regulatory tools available to communities within the Watershed that can be used not only to protect the outstanding resource values of the Watershed, but also:

- increase the quantity and quality open space,
- improve the pattern of residential development,
- reduce development pressure on other environmentally sensitive areas,
- adjust the residential development potential, and
- protect the overall character of the towns.

Some of these tools may already be in place in some form within the Watershed but may benefit from minor adjustments or a more comprehensive approach in concert with additional tools.

Increase the Quantity and Quality Open Space

Increase Open Space Set-asides

The Connecticut General Statutes (CGS) allow communities to require a portion of the undeveloped land within a new subdivision to be set aside for open space and indeed, there are few communities in Connecticut (if any) that do not take advantage of this provision. Where most communities differ is in the quantity and quality of open space that is actually preserved through this process. Many communities are increasing their open space requirements to as much as 15% to 20% of the overall development. At this early stage of residential development within the Watershed, such significant set-aside requirements can have a dramatic impact on the amount of open space preserved.

Plan for Open Space

The most effective tool for ensuring the quality of open space is an open space plan that identifies the most desirable open space for achieving the community's open space goals, such as providing parks or greenways, protecting wildlife habitat or important natural resources, buffering incompatible land uses, etc. Absent a plan that identifies specific parcels, a simple set of guidelines for use, access, ownership, and quality can guide Planning Commissions as they consider the value of proposed open space.

Require Equivalent Quality Open Space

To ensure that the quality of open space is representative of the development as a whole, Commissions can require that the percentage of wetlands, watercourses, floodplain, and steep slopes contained within the open space is no greater than the parcel as a whole. Since these areas are for the most part self-preserving, the protection of open space designation is not always necessary. For those instances where floodplain or similarly constrained land achieves an open space goal, such as providing a link in a greenway system, the commission should be able to waive this requirement to ensure public access or resource protection through appropriate ownership.

Accept Fees in-lieu-of Open Space

In those instances where the amount, quality, or location of proposed open space does not achieve a desired open space or other community goal, communities can accept a fee or combination of land and a fee in-lieu of open space equal to ten percent of the fair market value of the undeveloped land. The limit of ten percent applies regardless of whether a community normally requires a 15 to 20 percent open space set-aside. The discretion to offer a fee lies with the developer while the discretion to accept a fee lies with the Planning Commission.

Open space fees must be placed in a separate open space fund to be used to purchase more appropriate open space that meets community open space goals or needs. Through bonding and/or annual town contributions, a more effective open space fund can be created to leverage state and federal open space grants when desirable open space parcels become available.

Accept Alternative Open Space

One approach that might be particularly appropriate for protecting the Watershed would be to allow developers to substitute alternative open space within the Watershed in-lieu-of open space in developments located outside of the Watershed. In doing so, development within the Watershed is reduced in return for fully developing parcels located outside of the Watershed. Communities could also purchase critical open space within the Watershed and allow developers to "buy" their equivalent portions from the Town and offset the purchase price. This ensures that the Towns make the most effective use of their limited open space funds

Encourage Open Space Donation

One final open space tool that costs communities almost nothing to implement is to promote the benefits of open space donation. Many residents are emotionally attached to their land and communities and would rather see their land preserved in its natural state than developed into housing after they are gone. There are also a number of tax benefits to donating open space that can make such a donation easier on the owner or their estate.

Preserve Undeveloped Land

Implement Public Act 490

Towns can take several steps to forestall or prevent the development of undeveloped farmland, forest and privately held open space. Public Act 490 (PA 490) allows communities to offer reduced tax rates on designated farmland, forest and private open space in return for the land remaining undeveloped for ten years. Land that is developed while designated under the program is subject to a penalty until ten years have elapsed, making this only a temporary measure.

Purchase Development Rights

A more permanent program that can also be more cost effective than purchasing open space is to purchase development rights. In Connecticut, fee-simple ownership of land includes a package of rights including water, mineral, air and development rights that can be purchased separately from the land. Development rights are the right to develop according to the zoning regulations governing a parcel of land. They can be purchased at a fraction of the total cost of the property, preventing all or a portion of the land from being developed in the future. The owner is free to continue living on or farming the land utilizing whatever development already exists on the property. Like open space, there are matching grant programs available for purchasing development rights and preserving farmland.

Several studies have shown that purchasing open space or development rights can be cost effective for communities over the long term. While preserving open space or purchasing development rights can be initially costly and reduce tax revenues, approximately two-thirds of most municipal budgets are devoted to educational costs and the cost of educating children of new development would eventually exceed the purchase price.

As noted earlier in this report, the Towns of East Haddam, Lyme, and Salem have conserved 2,777 acres of open space in the last seven years alone, displacing as many as 777 new housing units. If developed, these houses would add 3,163 residents to the Watershed and the potential for over 500 new schoolchildren.

Improve the Pattern of Residential Development

Around the country, people are beginning to realize that the traditional zoning patterns of inflexible, large-lot zoning regulations have resulted in what people perceive as residential sprawl. This is an unflattering name for what has been recognized as the systematic consumption of rural land into similar characterless subdivisions.

Encourage Conservation Subdivisions

A simple step that many communities can take is to permit conservation or cluster subdivisions that allow reductions in minimum lot requirements such as area, frontage, and lot coverage. The benefits of this flexibility can include: more open space, less disturbance of the environment, less infrastructure to construct and maintain, and less stormwater runoff.

One deterrent to this approach is that the developer is often required to perform soil testing and design a conventional subdivision at additional expense that he/she has no intention of building, simply to determine the number of dwelling units that can be built in a clustered development.

Adopt Density-Based Zoning

Faced with the prospect of significant housing growth that threatens a town's rural character or its ability to provide necessary services, many communities' "knee-jerk" reaction is to try to increase rural minimum lot sizes in an attempt to reduce rate of growth and the total buildout of the community.

While effectively reducing buildout potential, such a measure will also:

- consume raw land at a much faster rate,
- increase the amount of road surface and lawn,
- increase stormwater runoff and non-point pollutants such as oil, salt, fertilizer, and pesticides, and
- encourage larger homes to justify the cost of the larger lots, making the community less affordable.

In the end, it may also have little if not the opposite effect on the rate of growth in the community.

Density-based zoning allows residential density and buildout potential to be tailored to meet community goals and objectives, such as protecting the Eightmile River Watershed, without the negative side effects noted above. Rather than use a minimum lot size to determine the development potential of land, density-based zoning replaces conventional minimum lot size requirements with a simple density factor

A comparable density factor for a one-acre minimum lot size zone might be anywhere from 0.6 to 0.8 dwelling units per acre after factoring out:

- any mandatory open space set-aside,
- the area consumed by roads, and
- an efficiency loss factor that accounts for irregularities in the land that affect the layout of parcels.

Assuming a density factor of 0.7 units per acre, a 100 acre parcel would allow 70 dwellings.

The chief benefit of density-based zoning over conventional zoning, or even conventional zoning with clustering provisions, is the simple flexibility that it provides. Under conventional zoning, minimum lot size and frontage requirements dictate the pattern of development and the location of infrastructure, leaving open space and protection of important resources as almost an afterthought. Under density-based zoning, sensitive areas and desirable open space can be identified and set aside at the beginning of the design process, with housing arranged to avoid these areas and take maximum advantage of access to open space, scenic views, water features, etc. The design of roads, and not the location of open space, becomes the final step in the process.

Other benefits of density-based zoning over conventional minimum lot area regulations include:

- total growth can be anticipated and planned for;
- lot sizes can be reduced without increasing the number of housing units;
- the total buildout potential can be moderated through adjustments in density;
- densities can be adjusted without creating non-conforming lots (there is no minimum lot size to judge small, older lots by);
- the amount of infrastructure to be constructed and maintained can be reduced, thus reducing stormwater to be collected and treated;
- sensitive areas within a subdivision can be avoided and the impacts on larger sensitive areas such as aquifers and watersheds can be reduced;
- the amount of raw land consumed can be reduced as much as soil conditions will allow; and
- residents and wildlife are able to enjoy all of the benefits of the larger open spaces surrounding the homes.

To adjust the density and buildout potential of a one-acre zone within a Watershed community, the 0.7 dwelling units per acre density can simply be reduced. A reduction from 0.7 to 0.5 units per acre would result in nearly a 30% reduction in density without requiring an increase in lot size. In our 100-acre example above, 70 lots would be reduced to 50 lots. A developer could conceivably develop 50 homes on 70 acres of land but would likely develop one-acre or smaller lots to reduce infrastructure costs, leaving the balance as open space.

Reduce Pressure on Sensitive Areas

Adopt a Buildable Area Regulation

When property is developed under conventional zoning regulations, developers will typically attempt to fit as many building lots onto a parcel as possible, often incorporating wetlands, steep slopes, and floodplains into lots in order to maximize the return on their investment in land and infrastructure. To ensure the ability to construct a home, many communities have instituted "buildable area" regulations that require that each lot contain a minimum buildable area that is free of steep slopes, floodplain, etc. The result is that lot sizes are increased to meet the buildable area requirements and overall development potential is reduced. This approach encourages these sensitive areas to remain under private ownership and provides them with little protection after development.

Adopt a Developable Area Regulation

A similar approach to a buildable area regulation is a "developable area" regulation, which may sound like a subtle distinction but the benefits are significantly greater. A developable area regulation is used in conjunction with density-based zoning and discounts wetlands, floodplains, and steep slopes before the density factor is applied to the land to be developed. In doing so, the development potential is determined up front and there is no incentive for the developer to incorporate these sensitive areas into building lots in order to maximize the number of dwelling units.

Building on the earlier example, if the equivalent density factor for a one-acre zone is 0.7 units per acre and 20% of our 100-acre property is constrained by wetlands and steep slopes, the development would result in a maximum of 56 dwellings.

$$(100 - 20) \times 0.7 = 56$$

Benefits of the developable area approach include:

- total growth can be anticipated and planned for;
- buildout potential is tailored to the ability of the land to support development;
- the expense of soil testing and designing conventional subdivisions for the sake of determining density becomes unnecessary;
- lot sizes and the amount of infrastructure to be constructed and maintained can be further reduced;
- development pressure on sensitive areas is reduced;
- more open space can be preserved; and
- conventional development patterns become the exception and not the norm.

Protect Water Quality

Adopt Stringent Coverage Requirements

Many towns adopt standards to regulate the density, bulk, and appearance of development but do not consider the impact of lot coverage on surface and groundwater resources. Impervious surfaces such as pavement and buildings prevent stormwater from penetrating into the ground, creating stormwater runoff that can lead to a host of problems including: increased erosion, flooding, non-point source pollution, and the need for unsightly storm drainage facilities that can detract from the character of the community.

Maximum impervious coverage requirements can be tailored to the character and purpose of each zone to place fixed limits on the amount of building coverage, pavement, and other impervious surfaces, thus reducing the amount of stormwater runoff. Flexibility in impervious coverage can be provided in exchange for meeting prescribed best management practices for stormwater management such as creating rain gardens, infiltrating clean stormwater into the ground, and creating bio-filtration systems to reduce non-point source pollution such as pesticides and fertilizers entering wetlands.

Adopt More Stringent Stormwater Management Requirements

In addition to coverage requirements that reduce the amount of runoff, measures can be taken to improve the quality and quantity of stormwater leaving a development. Stormwater collected from paved surfaces used by motor vehicles can contain many surface water contaminants such as oils, salt, sand and silt. Stormwater that is collected and discharged from a property without regard for downstream conditions can lead to flooding and property damage.

To improve the quality of stormwater leaving a site, regulations can require the renovation of stormwater through natural means such as bio-filtration through wetland vegetation and/or mechanical means such as oil separators and mechanical sand/silt separators.

Zero increase in runoff regulations can limit the rate of post-development stormwater runoff from a site to pre-development rates through infiltration of roof stormwater, and the storage, renovation, infiltration, and metered release of pavement runoff. In doing so, the effects of increased stormwater runoff volume and velocity can be mitigated.

Create Overlay Protection Zones

An Eightmile River Overlay Zone or similarly named zone could be a special purpose "floating zone" that applies on top of underlying residential, commercial, and industrial zones, placing more restrictive standards on activities within the River's riparian zone. Such a zone could establish more stringent buffer standards adjacent to the River, limit clearing and other activities that would encourage erosion and alter the wild & scenic character of the River.

Floodplain Overlay Zones could similarly overlay underlying zoning and limit activities within floodplains that would increase flooding (and erosion), place additional property in harms way, allow sewage to contaminate floodwaters and/or infiltrate drinking water systems, or create floating debris that could lead to downstream stream channel obstructions or collision damage.

A much broader Eightmile River Watershed Overlay Zone could encompass the entire Watershed within a given town and apply not only more restrictive coverage requirements, but could also reduce residential densities and strictly regulate uses with the potential to create surface water pollution such as gas stations or outdoor storage of hazardous materials.

Surface and Groundwater Protection Ordinances

Septic System Management and Underground Storage Tank Ordinances, while typically considered groundwater protection tools, can also be beneficial for surface water protection in cases of extreme failure. For many residents, septic systems and underground oil tanks are often overlooked until a problem occurs or the sale or refinancing of the property warrants their inspection or removal.

A Septic System Management Ordinance can require the periodic inspection and cleanout of septic systems to ensure their functionality and longevity. Septic system contractors can submit required proof of inspection and cleanout as required, and those property owners that do not comply can be issued warnings followed by fines. The septic system contractors can be willing participants in such a program by sending out reminders to their customers.

An Underground Storage Tank Ordinance is intended to prevent groundwater contamination by residential fuel oil leaks but can also protect surface water in locations where groundwater seeps occur on steep terrain. Such an ordinance can take many forms ranging from a simple registration and testing program to a ban on all residential underground fuel tanks. Typically, an ordinance will allow for the amortization of existing tanks, depending on their age and potential threat to groundwater. A documented steel tank might be allowed to remain for a fixed period from its installation (short of its designed life expectancy) while an undocumented tank would have to be removed immediately due to its unknown age. Double walled fiberglass tanks with monitoring equipment might be allowed to remain longer with regular testing.

These strategies are by no means the only measures capable of protecting important resources within the Watershed. Other partners in the Eightmile River Wild & Scenic Study, such as NEMO and the Nature Conservancy, are renowned for their knowledge on protecting water quality, wildlife habitat and other important resources. However, we believe that these strategies represent the most effective means of mitigating development impacts on communities in a manner that is both practical and defensible.

To chose one comprehensive strategy that would have the greatest positive impact on development within the Watershed with the least amount of committed resources, adopting density-based zoning in combination with a developable land regulation and conservation subdivision provisions would be the preferable choice. This simple approach costs communities almost nothing to implement and can have far reaching impacts on community character, development potential, natural resources, open space, water quality, wildlife habitat and overall quality of life.

To illustrate the impact of just one aspect of this approach, if each of the three towns had conventional one-acre zoning and adopted density-based zoning while reducing the density from 0.7 units per acre to 0.5 units per acre (as in the hypothetical 100-acre subdivision), the buildout potential within the three towns would be reduced by over 3,600 new dwelling units, potentially saving up to 5.6 square miles of additional open space at buildout.

Adjusted Buildout Results

	Housing Units				
	Current	**Potential**	**Total**	**Unadjusted Total***	**Reduction in Units**
East Haddam	3,967	5,436	9,403	11,578	2,175
Lyme	1,051	1,952	3,003	3,784	781
Salem	1,453	1,628	3,081	3,732	651
Total	6,471	9,016	15,487	19,094	3,607

*Unadjusted totals from the chart on Page 8.

With or without an adjustment to current densities, adding a developable land regulation alone could significantly reduce densities by removing wetlands, steep slopes, and floodplains from the density equation. As illustrated by the estimated 777 housing units displaced by the acquisition of 2,777 acres of open space within the Watershed between 1998 and 2005, additional open space acquisition beyond that required during the subdivision process can further reduce the potential for additional housing units and their attendant impacts on the Watershed.

Because it would displace housing, additional open space acquisition will also hasten the projected buildout dates presented in this report for each of the three communities but this is a positive outcome as it would protect natural resources and community character in the process.

SUMMARY

While we are unable to anticipate changes in many factors affecting growth, we can project past trends into the future to offer several possible growth scenarios. The results provide a different sense of urgency for each community with respect to protecting the quality of resources within both the Watershed and the remainder of each community.

The one factor that barring legal obstacles is within our ability to foresee, the completion of Route 11, cannot be proven to be a significant indicator of future growth. In the absence of a clearly discernable trend that can be applied to account for Route 11's impact on future growth within the Watershed, we are left to speculate on what its impact may ultimately be.

It would be wise to caution on the side of Route 11 having a positive impact on future growth and take many of the steps outlined in this report that are necessary to protect the Watershed. Growth is inevitable and Route 11 only has the potential to accelerate (or hinder) that growth. Having these measures in place will ensure that no matter how fast development occurs, it will be done in a manner that minimizes impacts on the Watershed, increases open space, protects surface and groundwater resources for future generations, protects overall community character, and enhances quality of life for all residents.

Notes & Comments

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