Naugatuck River Greenway Project

Torrington, Harwinton and Litchfield
Connecticut

King's Mark
Environmental Review Team
Report

King's Mark
Resource Conservation and Development Area, Inc.

Naugatuck River Greenway Project

Torrington, Harwinton and Litchfield Connecticut

Environmental Review Team Report

Prepared by the
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of the King's Mark
Resource Conservation and Development Area, Inc.

for the
Litchfield Hills Council of Elected Officials

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Acknowledgments

This report is an outgrowth of a request from the Litchfield Hills Council of Elected Officials to the Litchfield County Soil and Water Conservation District (now the Northwest Conservation District) and the King's Mark Resource Conservation and Development Area (RC&D) Executive Council for Environmental Review Team assistance. The request was approved and the project reviewed by the King's Mark Environmental Review Team (ERT).

The King's Mark Environmental Review Team Coordinator, Elaine Sych, would like to thank and gratefully acknowledge the following Team members whose professionalism and expertise were invaluable to the completion of this report.

The field review took place on Thursday, July 25, 2002.

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I would also like to thank Rick Lynn, director, Litchfield Hills Council of Elected Officials, Marty Connor, Torrington city planner, Jerry Rollett, Torrington Department of Public Works, Christina Emery, Torrington Economic Deelopment, and Kim Barbieri, Torrington inland wetlands and planning and zoning commissions and other interested landowners and citizens for their cooperation and assistance during this environmental review.

Prior to the review day, each Team member received a summary of the proposed project along with location and soils maps. During the field review Team members were given additional information. Some Team members unable to attend the field review made visits on their own and others made additional field visits to the area. Following the review, reports from each Team member were submitted to the ERT coordinator for compilation and editing into this final report.

This report represents the Team's findings. It is not meant to compete with private consultants by providing site plans or detailed solutions to development problems. The Team does not recommend what final action should be taken on a proposed project - all final decisions rest with the towns and landowners. This report identifies the existing resource base and evaluates its significance to the proposed use, and also suggests considerations that should be of concern to the towns. The results of this Team action are oriented toward the development of better environmental quality and the long term economics of land use.

The King's Mark RC&D Executive Council hopes you will find this report of value and assistance in the review of the proposed Naugatuck River Greenway.

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Introduction

Introduction

Introduction

The Litchfield Hills Council of Elected Officials (on behalf of Torrington, Harwinton and Litchfield) has requested assistance from the King's Mark Environmental Review Team in conducting a natural resource inventory and opportunity assessment for the Naugatuck River Greenway Project.

The Litchfield Hills Council of Elected Officials (LHCEO) is conducting a study of the Naugatuck River from Stillwater Pond in Torrington to the Route 118 crossing in Litchfield, a five mile section of river. The purpose of the project is to identify problem areas contributing to water quality degradation, develop an action plan for improving water quality, and prepare a conceptual plan for improving access, enjoyment and passive recreational use of the river.

Objectives of the ERT Study

The ERT study is an important component of this multi-town project. The ERT has been asked to assess opportunities for improving fisheries, wildlife habitat, landscaping and passive recreation. A natural resource inventory of the river corridor's soils, topography, hydrology, fisheries, wildlife habitat, vegetation and river ecology is critical for future greenway planning.

An overview of stormwater control, and opportunities for enhancing passive recreation and riverbank landscaping is also important for future planning activities. Best management practices to enhance the fisheries and wildlife habitat are also needed.

The ERT Process

Through the efforts of the LHCEO, this environmental review and report was prepared for the towns of Torrington, Harwinton and Litchfield.

This report provides an information base and a series of recommendations and guidelines which cover the topics requested by the LHCEO. Team members were able to review maps, plans and supporting documentation provided by the applicant.

The review process consisted of four phases:

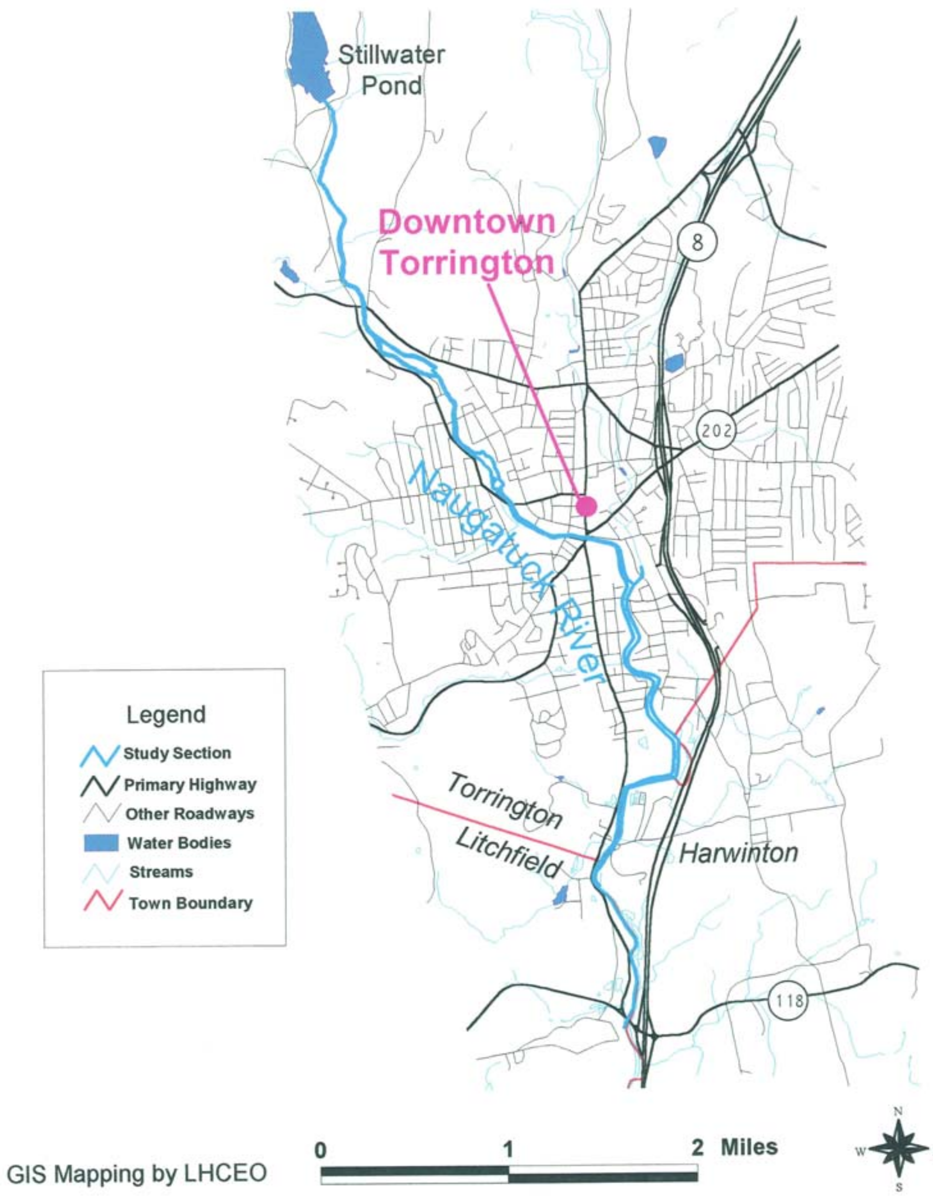
1. Inventory of the site's natural resources;
2. Assessment of these resources;
3. Identification of resource areas and review of plans; and
4. Presentation of education, management and land use guidelines.

The data collection phase involved both literature and field research. The field review was conducted on Thursday, July 25, 2002. The emphasis of the field review was on the exchange of ideas, concerns and recommendations. Some Team members made separate and/or additional site visits. Being on site allowed Team members to verify information and to identify other resources.

Once Team members had assimilated an adequate data base, they were able to analyze and interpret their findings. Individual Team members then prepared and submitted their reports to the ERT coordinator for compilation into this final ERT report.

Figure 1

Naugatuck River Greenway Project



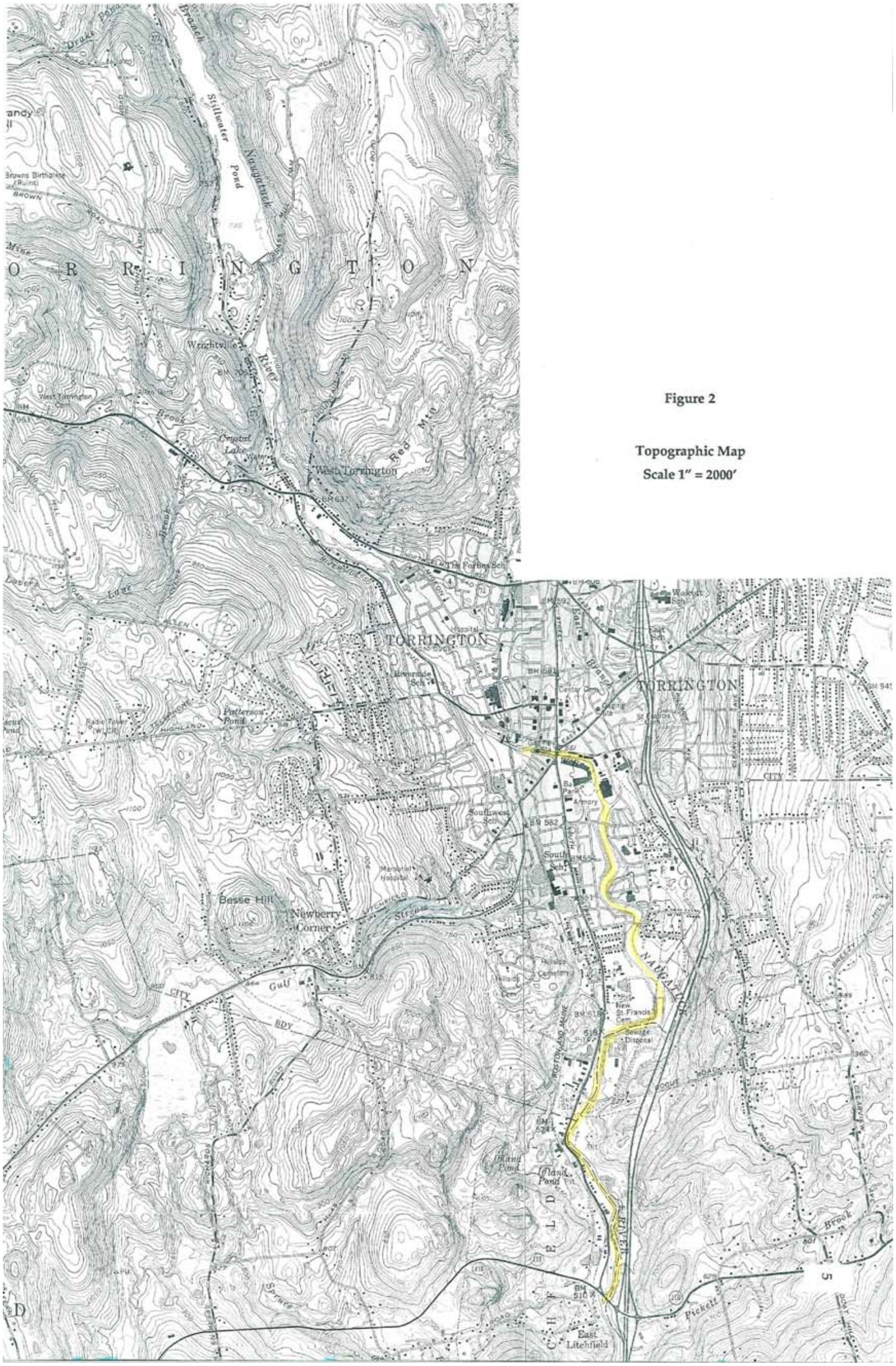


Figure 2

Topographic Map
Scale 1″ = 2000′

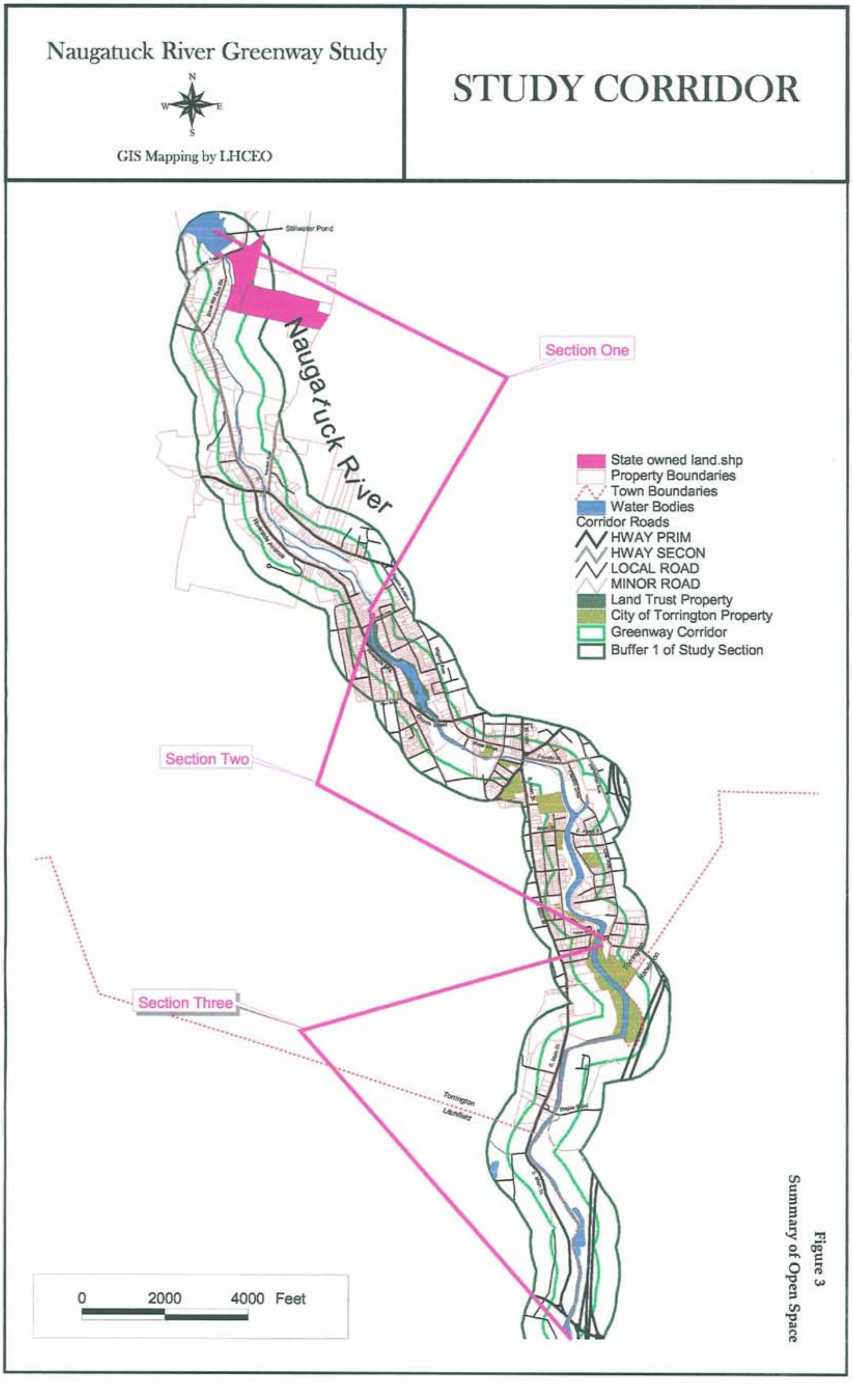


Figure 3
Summary of Open Space

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section One

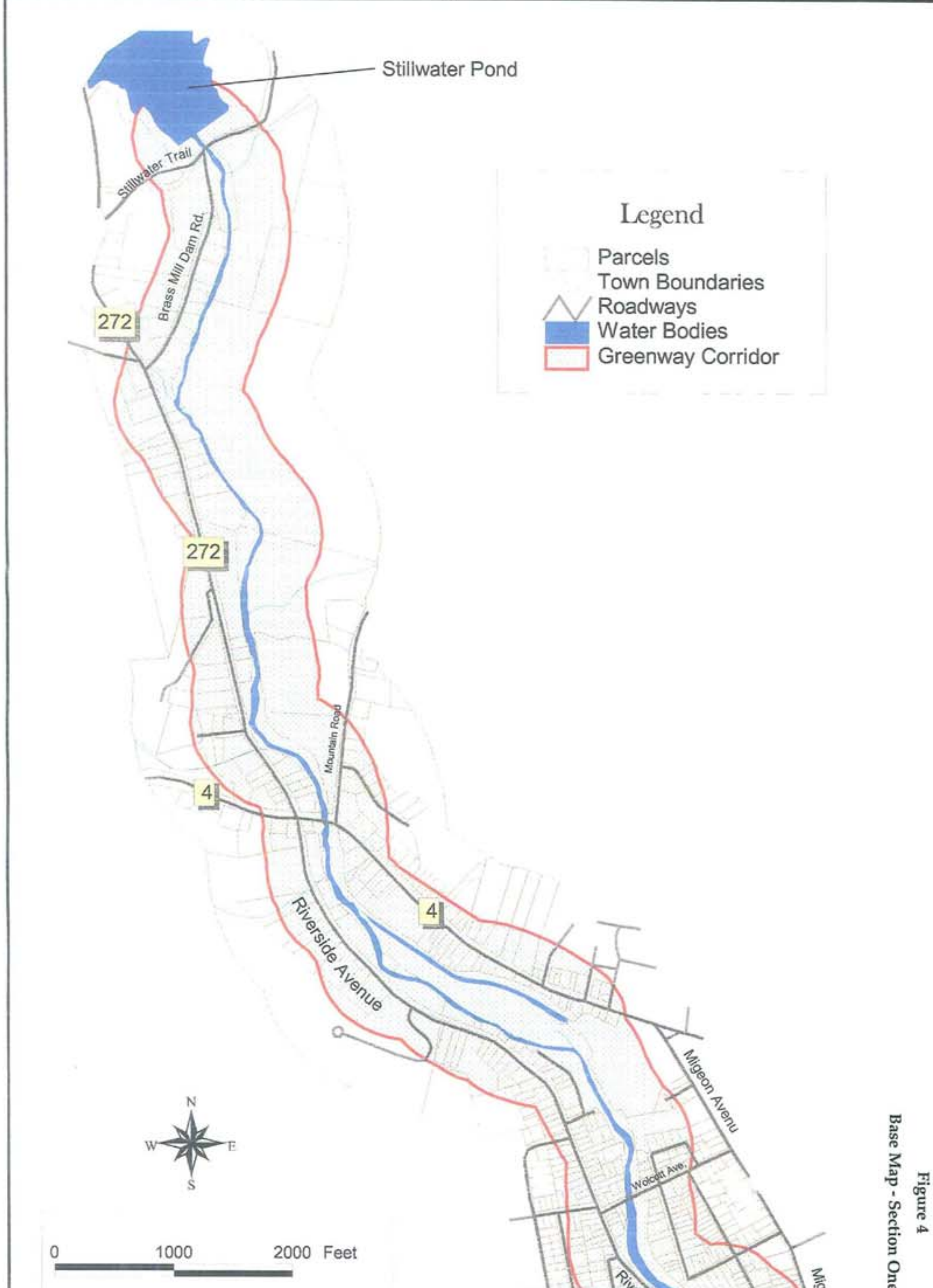


Figure 4
Base Map - Section One

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section Two

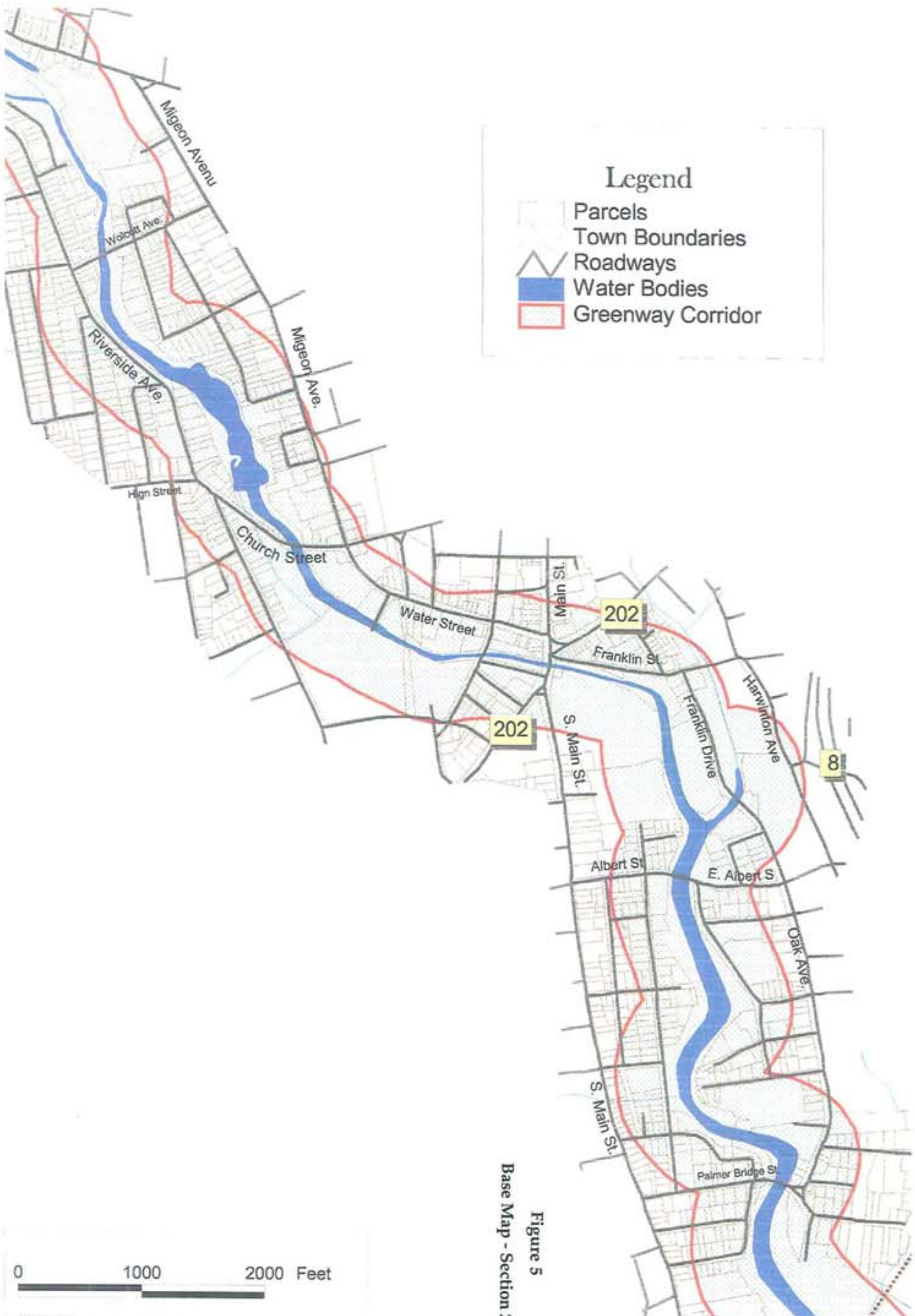


Figure 5
Base Map - Section 2

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section Three

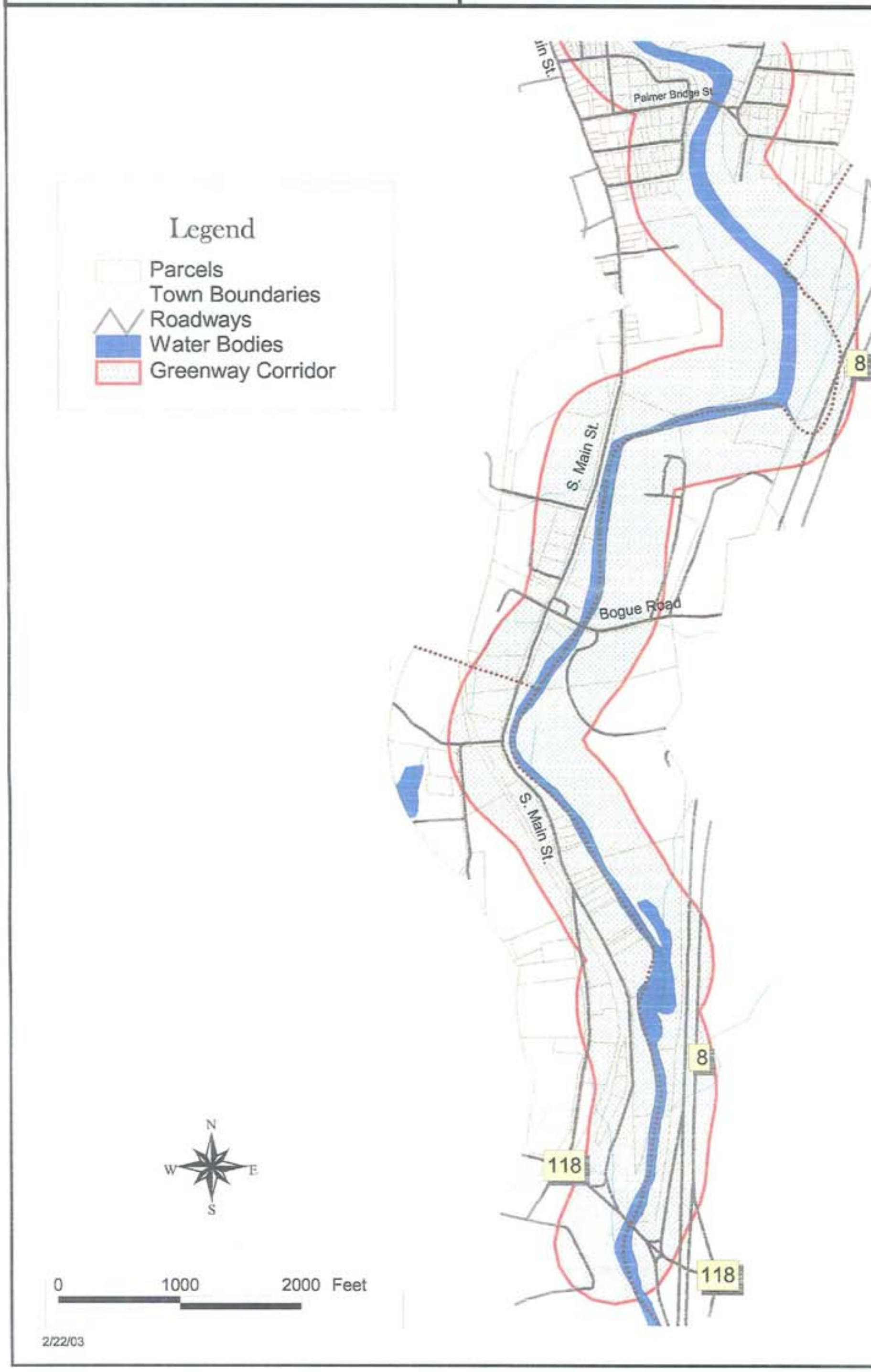


Figure 6
Base Map -Section Three

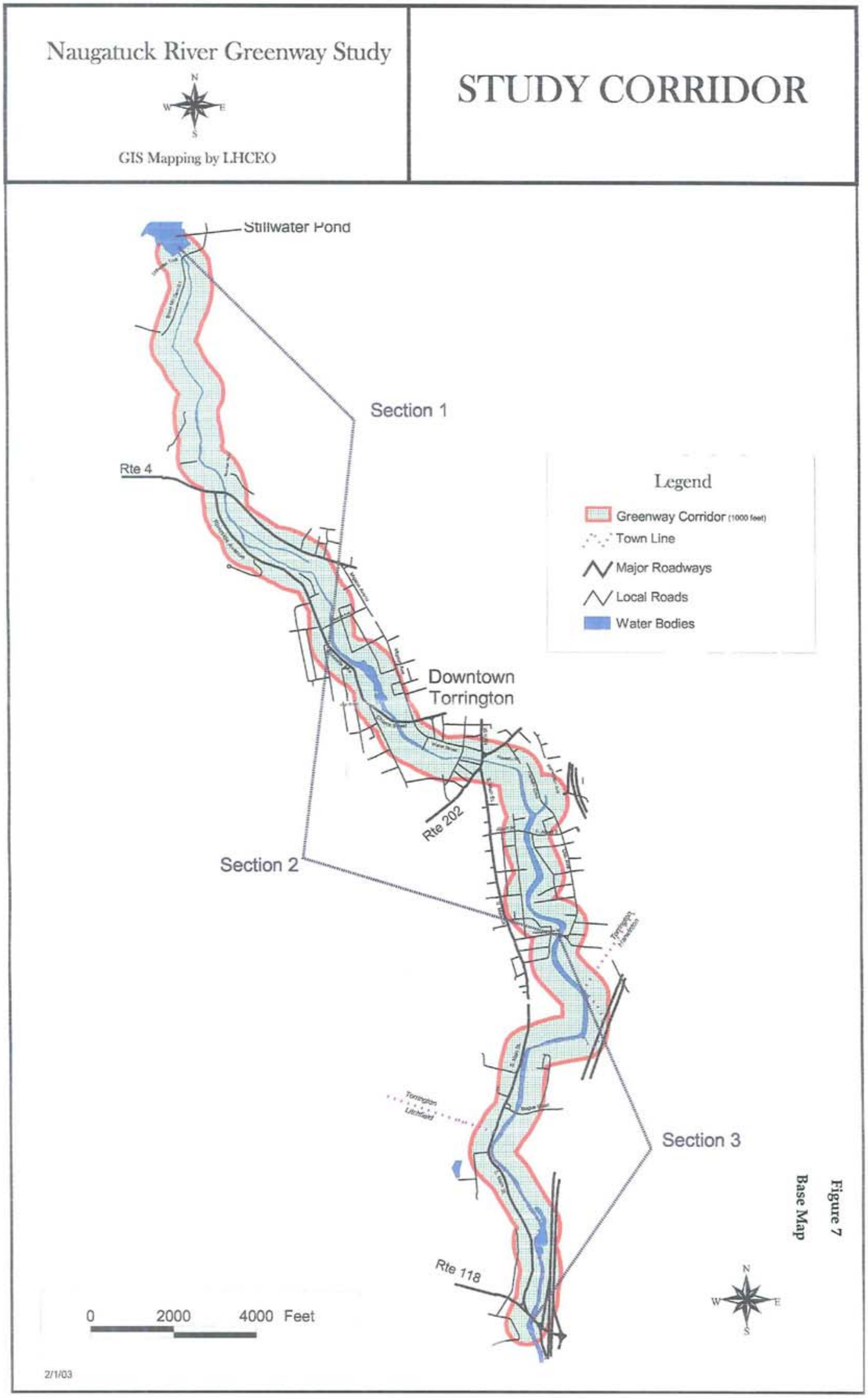


Figure 7
Base Map

A Watershed Perspective

A Watershed Perspective

Introduction

This section of the report provides an overview of water resources and related matters within the Naugatuck River Greenway Project area (Greenway Project) and is based upon Connecticut Department of Environmental Protection (CT DEP) data and knowledge of the region. These comments are given from the perspective of improving and maintaining water quality and supporting designated uses of the State's waters per the State of Connecticut Water Quality Standards[1]. This information also reflects CT DEP's growing commitment to address water resource concerns from a watershed perspective, taking into account the cumulative impact that various land use policies and activities within a given watershed may have upon water resources. Suggestions are also offered as to how this information may be applicable to the Greenway Project.

Some of these comments may overlap with those of other Environmental Review Team (ERT) members who are dealing with more specialized aspects of the review (i.e. - fisheries, etc.). In such cases, these comments are meant to support or supplement these specialized reviews, not supplant them.

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[1] CT DEP Bureau of Water Management - Planning and Standards Division. Effective 1996 & 1997. Water Quality Standards. CT DEP. Hartford, CT.

Drainage Basins

As a way of describing Connecticut's water resources in terms of the landscape, CT DEP has divided the state along natural drainage divides into eight "major basins" or watersheds. These, in turn, are divided into increasingly smaller watersheds which are described as "regional", "subregional" and "local" drainage basins. At each level, these watersheds are named after the brook, river or waterbody into which all of the water within that topographically-defined area ultimately flows. In other words, every water feature, no matter how small, has its own distinct watershed. Smaller watersheds make up larger watersheds which, in turn, make up even larger watersheds.

The Greenway Project area commences at the lower end of Stillwater Pond and follows the West Branch of the Naugatuck River, to the point where the West Branch and the East Branch merge to form the mainstem of the Naugatuck River. From here, the Greenway Project area continues along the Naugatuck River mainstem as far south as the Route 118 bridge crossing in Litchfield and Harwinton. However, for purposes of looking at the "bigger picture", it is important to know that the Naugatuck River is the largest and eastern-most tributary of the Housatonic River. Draining water from more than 311 square miles of land in 27 towns, the Naugatuck River flows approximately 40 miles southward from the center of Torrington to Derby where it empties into the Housatonic River. The Housatonic River, in turn, drains into Long Island Sound between the towns of Milford and Stratford.

If we translate this information into watersheds terms, starting at the smaller watershed level and going to the larger watershed level, we find that the Naugatuck River Greenway Project area lies within two subregional drainage basins. The upper section - above the center of Torrington - lies within the West Branch of the Naugatuck River Subregional Basin (No. 6904). The lower section

- below the center of Torrington - lies within the Naugatuck River Mainstem Subregional Basin (No. 6900). Both of these subregional basins lie within the Naugatuck Regional Basin (No. 69) which, in turn, lies within the Housatonic Major Basin (No. 6).[2]

- Greenway Project Considerations: By examining water resource issues from a drainage basin or watershed perspective, one is better able to understand and assess the cumulative impacts that assorted land use activities or policies may have upon water quality and quantity. The proponents of the Naugatuck River Greenway Project may wish to identify the water resource benefits provided by creation of a greenway area along the upper Naugatuck River. (This is especially relevant with regard to the CT DEP Naugatuck River Restoration activities discussed later in this section.) For example, water quality in the upper portion of the Naugatuck watershed in turn affects water quality in the southern portion of the Naugatuck River, the lower Housatonic River and Long Island Sound. Proponents may also wish to consider expanding the proposed greenway to include the East Branch of the Naugatuck River since activities occurring along this tributary also affect water quality and quantity in the mainstem.

Water Quality

Per Connecticut's Clean Water Act, the State has adopted Water Quality Standards which establish policy for water quality management throughout the state. The State classes surface and ground water quality based upon these standards and describes water quality goals in terms of designated uses and criteria for each water quality class. Using these classifications, the State's water resources have been broadly evaluated and assigned a classification based upon

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[2] Connecticut Geological and Natural History Survey. (Compiled by Marianne McElroy). 1981. Natural Drainage Basins in Connecticut (Map). CT DEP Natural Resources Center in cooperation with the USGS.

presumed or known water quality as well as desired use goals. These classifications are used to make decisions as to how these water resources will be managed and what sorts of water-related withdrawals or discharges will be allowed or not allowed. According to water quality classification maps, the surface waters within the proposed Naugatuck River Greenway Project area are classified as Class A or B; ground waters are classified as GA or GB.

Class A surface waters have overall excellent water quality and the following designated uses: potential drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other legitimate uses, including navigation. Class B waters have good to excellent water quality and the following designated uses: recreational use, fish and wildlife habitat, agricultural and industrial supply and other legitimate uses including navigation. Class B waters are also suitable for the discharge of treated process wastewaters. Class GA ground waters have overall excellent water quality and the following designated uses: existing private and potential public or private supplies of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies. Class GB ground waters are assumed to be degraded due to a variety of pollution sources and have the following designated uses: industrial process water and cooling waters; baseflow for hydraulically-connected surface water bodies; presumed not suitable for human consumption without treatment.

According to the State of Connecticut "Water Quality Classifications" map[3], the surface water quality of the West Branch of the Naugatuck River - from Stillwater Pond to approximately 0.6 miles south of where the river flows under Route 4 - is classified as A. At this point, the surface water quality becomes B, a classification which continues down the rest of the West Branch and the

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Hartford, CT.

[3] CT DEP Environmental and Geographic Information Center. Adopted March 1999 (Version 01/24/00-1). Water Quality Classifications - Housatonic River, Hudson River, and Southwest Coastal Basins (Sheet 1 of 3) (Map). CT DEP. Hartford, CT.

Naugatuck mainstem all the way to the Route 118 bridge crossing and beyond. The groundwater classifications on either side of the river follow a similar pattern. The groundwater from Stillwater Pond to approximately O.25 miles below the Route 4 bridge crossing is classified as GA, at which point the classification becomes GB. This classification continues all the way along the West Branch and mainstem until approximately 0.25 miles south of the Torrington-Litchfield town line, at which point, the groundwater classification switches back to GA.

The surface water in the West Branch of the Naugatuck River switches from an A to a B classification in the area previously described because this is the approximate point at which treated wastewater discharges begin to enter the river. This point also roughly demarcates where the river starts to flow through what is considered an "urbanized area" with its associated stormwater runoff impacts. Similarly, in this vicinity groundwater changes to a GB classification because it is located in an historically urbanized area. In such locations, it is presumed that the groundwater is not suitable for drinking without treatment due to land use and the likelihood of spills or releases of hazardous materials or waste. Since this area is served by public water supply, it presents less of an issue in terms of drinking water. However, it is important to bear in mind that groundwater flows through the ground and ultimately discharges into ponds, lakes, streams and rivers. During the drier months of the year, groundwater is especially important because it provides baseflow to rivers and streams. The quality of the groundwater, in turn, affects the quality of the surface water.

To determine whether the State's surface water resources are meeting designated use goals per the water quality classifications assigned to them, CT DEP conducts aquatic use support assessments of selected water bodies throughout the state. The entire length of both the Naugatuck mainstem and the West Branch of the Naugatuck have been included in this assessment program. (The entire length of the East Branch of the Naugatuck has been assessed as well.)

Generally, the three parameters used to assess river segments are: fish consumption, aquatic life support and primary contact for recreation. The degree to which these different uses are being supported by the river, in turn, determine "overall use support". Each designated use is evaluated according to the degree to which the water is suitable for that use and is assigned one of the following use support descriptors: fully supporting, threatened (fully supporting but threatened), partially supporting, not supporting, not attainable or not assessed.[4]

The portion of the Naugatuck mainstem that lies within the Greenway Project area has been assessed for designated use goals associated with Class B surface waters. Overall, this section of river was found to be fully supporting for fish consumption but threatened or only partially supporting for aquatic life. As a result, the section of river below the Torrington Water Pollution Control Facility has been included on the Draft 2002 "List of Waterbodies Not Meeting Water Quality Standards", also referred to as the "303(d) List"[5]. The conditions contributing to water quality impairment in this section of the Naugatuck are attributed to one or more of the following factors: industrial point sources; municipal point sources; urban runoff and storm sewers; and hydromodification (includes flow regulation and modification, and channelization).

On the West Branch of the Naugatuck River, the upper portion of the river that lies within the Greenway Project has been assessed for designated use goals associated with Class A surface waters while the lower section (i.e. - Brass Mill Pond downstream to confluence of East and West Branches) has been assessed for designated use goals associated with Class B surface waters. The upper section

[4] More information about the Connecticut's water quality assessment program can be found in the most recent "Water Quality Report to Congress", also known as the 305(b) report: CT Bureau of Water Management. October 2002. 2002 Water Quality Report to Congress (prepared pursuant to WA Sec. 305(b). Hartford, CT.
[5] CT DEP. May 2002. DRAFT 2002 LIST OF CONNECTICUT WATERBODIES NOT MEETING WATER QUALITY STANDARDS (Appendix A). (prepared pursuant to CWA Sec. 303(d)). Hartford, CT.

was determined to be fully supporting for fish consumption, aquatic life support, primary contact and overall use support. In the lower section, fish consumption was found to be fully supporting. However, aquatic life support was deemed only partially supporting in the stretch of river below Old Brass Mill Dam. Because of this, this river segment is also included on the Draft 2002 "List of Waterbodies Not Meeting Water Quality Standards". The likely reasons for the impairment of this lowest segment are attributed to urban runoff and storm sewers; hydromodification (including channelization); and habitat modification (including removal of riparian vegetation).

Although sections of both the mainstem and West Branch of the Naugatuck are listed as not meeting water quality standards, overall water quality is much improved as compared to earlier times. However, water quality data shows that there is still room for improvement.

- Greenway Project Considerations: A considerable portion of the potential greenway corridor passes through an urban landscape where there are many factors that affect water quality that are beyond the scope of this Greenway Project. None-the-less, it is to be hoped that the Greenway Project will identify ways in which creation of a greenway can contribute toward improving water quality of the Naugatuck River. Protecting existing open space and re-establishing vegetative buffers along the river corridor, stabilizing erosion sites caused by human activities, identifying detrimental stormwater discharges and addressing them are examples of how the Greenway Project can help improve water quality. Raising awareness about the effect that our everyday activities and land use decisions have on river water quality and providing increased public access so that people can enjoy the river are indirect but important ways in which the Greenway Project may also contribute toward improving water quality.

Flood Control

With regard to the factors impairing water quality on both the Naugatuck mainstem and West Branch, it is important to note that, as a result of the 1955 flood, considerable stretches of the these two rivers were channelized or otherwise modified by the U.S. Army Corps of Engineers (ACOE) to reduce the potential for future flooding. In addition, ACOE has requirements for maintaining these channels which include periodic removal of vegetation. Upstream of downtown Torrington, flood control dams have been constructed on both Hall Meadow Brook (a major tributary of the West Branch) and the East Branch of the Naugatuck River[6]. Flood control, particularly river channelization and maintenance, is an example of where public safety concerns generally take precedence over conserving the ecological integrity of natural systems. Channelized systems are designed to carry away large volumes of water quickly and efficiently. So that this can occur, the river channel is modified, often dramatically, to eliminate obstacles and allow water to flow swiftly. The river may be straightened and placed in a rectangular, trapezoidal or triangular-shaped channel lined with concrete or stone rip-rap. Vegetation, particularly trees and shrubs, are generally removed or kept to a minimum so that roots will not undermine the constructed channel and so that trunks and stems will not impede flow.

From an ecological perspective, these channelized river segments have generally resulted in environments unfavorable to many plant and animal species that might normally be found in these areas. By straightening and smoothing the channel, including the river bottom, habitat for fish and other aquatic life may be greatly diminished. The exposed, often steep sides of the channel may make it difficult for wildlife to access the river or deter use of the river's edge. The

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[6] Hall Meadow Brook Dam is surrounded by John Minetto State Park. The East Branch Dam is surrounded by Sunnybrook State Park which is currently closed.

removal of vegetation and natural overhangs, generally decreases food sources and shelter for aquatic life. Removal of vegetation also reduces shade along the banks and over the river which may lead to increased water temperatures. Taken altogether, these factors may create an inhospitable environment that results in ecologically barren sections of river and impedes movement of aquatic and terrestrial wildlife in and along the river.

Although flood control projects are engineered for human safety, they may also have the effect of cutting people off from the rivers which flow through their communities. By channelizing the river and removing vegetation, much of the river's aesthetic appeal may be lost. Steep banks and other safety considerations may also limit access to the river for recreation. As a result, the river may be viewed as a liability rather than an asset.

While the flood control channelization which occurred on the Naugatuck mainstem and West Branch in Torrington may not be as dramatic as compared to elsewhere, it has none-the-less impacted the ecological functions, aesthetics and recreational opportunities of these two rivers. This being said, one must bear in mind that the Torrington flood control projects were created in response to a devastating flood, using the technology and knowledge of that time period and before we gained the level of environmental awareness that we have today.

Much to its credit, the City of Torrington has already ventured into the growing realm of communities interested in trying to find ways to work with ACOE to modify existing flood control projects to enhance the natural environment. During the summer of 2000, after several years of planning on the part of the City, ACOE, CT DEP and others, more than 300 boulders were installed within a 4,000 foot channelized section of the Naugatuck River in downtown Torrington to create more habitat for fish.

- **<u>Greenway Project Considerations:</u>** As part of the Greenway Project and the proposed redevelopment of downtown Torrington, it is to be hoped that the City can continue to work with ACOE to find ways to modify the existing flood control projects to enhance the ecological health of these two rivers as well as increase enjoyment of these water resources for residents and visitors.

Dams

Beginning in the 1700's, the Naugatuck Valley became an attractive location for industrial development as the steep gradient of the river and its tributaries offered favorable sites to construct dams and provide water power for early mills. Subsequently, the Naugatuck River was also used as industrial water supply for cooling, processing and disposal of wastes. This historic use of the river for power and supply led to a plethora of dams being constructed on the mainstem as well as tributaries of the river. Except for major dams that are still in use for electric power production, public water supply or flood control, many of the smaller dams have fallen into disuse and/or have been abandoned. Hundreds of such dams are scattered on Connecticut's rivers and streams, including the Naugatuck and its tributaries.

During the past decade, interest in removing obsolete dams from rivers to increase flows, improve water quality and restore fish passage as well as other riverine functions has increased sharply across the country. Dam removal is very costly and requires much cooperation on the part of federal, state and municipal governments, nonprofit organizations, businesses and private landowners. Removal involves not only demolishing the dam but also ascertaining the amount of sediment that has accumulated behind the dam and testing it for potential toxicity. Depending on the situation, these sediments may require special removal and disposal.

The Naugatuck River is at the forefront of the dam removal movement. On the lower Naugatuck River, in the municipalities of Waterbury and Naugatuck, four unused dams were removed or breached in 1999. Plans are underway to remove or modify several more. These dam removals were done in conjunction with the upgrade of the Waterbury Wastewater Treatment Plant to help improve water quality and improve fish passage.

Within the Greenway Project area, there are four dams, all located on the West Branch of the Naugatuck. The uppermost dam is a former industrial water supply dam that impounds the West Branch and creates Stillwater Pond. This dam which is owned by CT DEP was recently repaired and is in good condition. The lowermost dam on the West Branch is located at the foot of Brass Mill Pond on land owned by the Heritage Land Preservation Trust (Land Trust). This dam is known by several different names including: Old Brass Mill Pond Dam, Coe Dam and American Brass Dam. In 1990, this dam was inspected by an engineering consultant for the CT DEP Bureau of Water Management, Inland Water Resource Division - Dam Safety Program. A request for maintenance was made at that time to the Land Trust. The Land Trust is currently in the process of researching its options and determining costs associated with either repairing or removing this dam. In between the Stillwater Pond dam and Brass Mill Pond dam are two smaller dams. Just downstream of the Route 4 crossing and above the point where a small canal branches off of the river is the Union Hardware Dam, also known as the Brunswick Dam. This dam is now presumably owned by FM Precision Golf Company. Further upstream, there is reportedly another small dam known as the Ausít Dam. CT DEP has no information relative to these dams at the present time.

Besides these four dams, there are other dams upstream of the Greenway Project area which influence how water flows through the West Branch and/or the Naugatuck mainstem. As mentioned previously, there are flood control dams on Hall Meadow Brook and the East Branch. In addition, there are dams creating water supply impoundments within both the Hart Brook and Nickel Mine Brook watersheds. (These brooks are tributaries to the West Branch.) Both of these watersheds are within of the Torrington Water Company public water supply area. On both Hart Brook and Nickel Mine Brook, the river segments below the lowermost water supply impoundment dams are listed as impaired for aquatic life support on the Draft 2002 "List of Waterbodies Not Meeting Water Quality Standards" due to flow alteration as a result of upstream impoundments[7].

- **Greenway Project Considerations:** Since Old Brass Mill dam is in the corridor of the Greenway Project, there may be important opportunities to work with the Land Trust in determining the fate of the dam. If the dam is ultimately removed, the dewatered section along the river will create an important open space. The Greenway Project proponents may also wish to determine the effect that impoundments further up in the watershed have on the West Branch and mainstem of the Naugatuck. There may be opportunities to increase flows and improve the ecologic health of the river.

Naugatuck River Restoration Project

The CT DEP, in cooperation with federal agencies, municipalities, private industries and local citizen organizations, has been engaged in a comprehensive initiative to restore the water quality and ecological integrity of the Naugatuck River. Clean-up of the Naugatuck has been underway since state and federal clean water legislation was enacted in the late 1960s and early 1970s. Initial efforts focused on cleaning up discharges from industries and the eight municipal wastewater treatment plants (WWTPs) located on the Naugatuck and

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[7] On Hart Brook, the 0.50 mile segment for the Reubin Hart Reservoir to its confluence with the West Branch was determined to be partially supporting for aquatic life support. On Nickel Mine Brook, the 0.30 mile segment from Crystal Lake to its confluence with the West Branch was determined to be partially supporting for aquatic life support.

its tributaries. In more recent years, attention has been focused on upgrading industrial wastewater treatment systems, reducing or eliminating industrial end-of-pipe discharges, and cleaning up stormwater discharges from industrial and construction sites. Between 1992 and 2000, per State pollution abatement orders, five of the larger municipal WWTPs upgraded their facilities to advanced wastewater treatment and a sixth facility's flow was redirected to the new Waterbury WWTP. The City of Torrington WWTP, located on the Naugatuck mainstem approximately 1.25 miles above the Route 118 bridge, was upgraded in 1994 and was the second of the six facilities to be upgraded.

In addition to these undertakings, CT DEP has also assigned a full-time field inspector to the Naugatuck Watershed who regularly inspects approximately 40 industrial facilities for compliance. As mentioned previously, in conjunction with the Waterbury WWTP upgrade, four dams on the Naugatuck mainstem were removed or breached and plans are underway to remove at least two more dams and construct a fish passage and recreational bypass around another. These efforts are part of a larger plan to restore anadromous fish passage to approximately 30 miles of the lower Naugatuck River up to the Thomaston Dam. As water quality in the river has improved over the years, CT DEP Fisheries has also expanded its fish stocking program of trout and broodstock salmon on certain sections of the river, and has designated the Naugatuck Mainstem - from the confluence of the East and West Branches in Torrington to the Kinneytown Dam in Seymour - as a Trophy Trout Stream. As described earlier, CT DEP Fisheries also worked with the City of Torrington, the Army Corp of Engineers and others on a "bouldering" project to improve fisheries habitat in a channelized section of the Naugatuck River in downtown Torrington.

In addition to CT DEP's activities, communities, environmental organizations and citizen groups are working to improve the quality of the Naugatuck River and reconnect people with the river. Most notable is a growing vision among these entities to create a greenway along the entire length of the Naugatuck River from Torrington to Derby. The Council of Governments Central Naugatuck Valley, Naugatuck Valley Chapter of Trout Unlimited/Naugatuck River Watershed Association and the Housatonic Valley Association have all been working with towns and cities throughout the mid and lower Naugatuck Valley on greenway planning. As a result of these efforts, Governor Rowland designated the section of the Naugatuck River from Thomaston to Derby as an official State greenway in the Spring of 2001. This designation does not automatically protect the river corridor but has implications with regard to the State Plan of Conservation and Development.

- <u>Greenway Project Considerations:</u> The City of Torrington and the Towns of Litchfield and Harwinton are in an ideal position to obtain official designation for the river section north of Thomaston and extend the Naugatuck Greenway. In addition, the City of Torrington's downtown redevelopment plans offer an important opportunity to improve the ecological integrity of the river corridor and reconnect the community with the river. Given that these communities lie in the northern portion of the basin where the headwaters of the Naugatuck originate, the significance of the Torrington/Litchfield/Harwinton Naugatuck Greenway Project should not be underestimated. The land management decisions made in these areas ultimately affect downstream water quality and the overall success of the Naugatuck River Restoration Project.

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Conservation District Review

Conservation District Review

This section will discuss the issues of sediment, erosion and stormwater control for the Naugatuck River Greenway and will detail the environmental issues that need to be addressed along the Naugatuck River Corridor to facilitate the implementation of a Greenway. The Naugatuck River Corridor is unique and valuable to the City of Torrington and an integral part of its downtown revitalization project.

Erosion, Sediment and Stormwater Control for Water Quality Preservation

One measure of success of a Greenway is the number of people using it. Therefore, to keep a Greenway attractive you need to keep the water resource it is paired with in a healthy state. There are many ways to protect water quality before, during and after the creation of a Greenway to assure sustained use. If done properly most of these measures will improve the aesthetics of a greenway. The first step is to raise awareness of the Naugatuck River. In this reviewer's study of this section of the Naugatuck River corridor, he discovered that many people who live directly on or adjacent to the river, or drive across it many times per day, do not know where the Naugatuck River is. To raise awareness, a Naugatuck River sign needs to be placed in both directions at each of the eleven river crossings mentioned below. This could be done at an approximate cost of ~$10,000.

The purpose of this section is to identify sediment, erosion and stormwater control problems on the river corridor and define future actions needed to keep the water resource healthy. The five-mile stretch of the Naugatuck River corridor between Stillwater Reservoir and the State Route 118 Bridge in Torrington is mostly developed. There are very few areas where original soil types exist. As you can see on the soil maps for the area, most of the soil bordering the river are given the symbol "Bk" which means these areas are comprised of fill materials. However, erosion, sediment and stormwater control are still an integral part of preserving the water resources of the Naugatuck River. Given the variety of materials the riverbank is made of, there are many ways to protect the corridor and allow for the creation of a greenway. Below is a description of all the riverbank types that exist now in the Naugatuck River Corridor. For details on protecting the water resource, please see the section titled Preservation and Improvement of Water Quality.

1. Vertical concrete retaining walls (pocked with many storm sewer outfalls)
2. Large aggregate rip-rap dikes (2 to 1 slopes)
3. Vegetated earthen dikes
4. Varying widths of forest communities
5. Bedrock channels
6. Shallow slack water marshes from dam backup
7. Heavily eroded banks from uncontrolled vehicle and pedestrian traffic.
8. 11 Road Crossing, each of which has a storm sewer system that emits to the river
    a) Stillwater Trial (West Branch)
    b) Migeon Ave. Route 4 (West Branch)
    c) Wolcott Ave. (West Branch)
    d) Church Street (West Branch)
    e) Stop + Shop Driveway (West Branch)
    f) Prospect Street (West Branch)
    g) Route 202 (West Branch)
    h) Albert Street (Main Stem)
    i) Bridge Street (Main Stem)
    j) Bogue Road (Main Stem)
    k) State Route 118 (Main Stem)

Preservation and Improvement of Water Quality

The largest causes of water pollution and fish habitat degradation for this stretch of the Naugatuck River are the addition of eroded materials entrained in stormwater runoff and thermal effects. The following is a list of pollutants in order of largest to smallest impacts.

1. Sediments
2. Nutrients
3. Bacteria
4. Oxygen Demand
5. Oil and Grease
6. Trace Materials
7. Toxic Chemicals
8. Chlorides
9. Thermal impacts
10. Trash

The above listed pollutants enter the river through the following pathways (see bold headings below). Once these pathways have been identified in the field there are an array of methods to protect water resources including structural, vegetation establishment and educational/outreach. Please see the Urban Stormwater Runoff Management Practices section for a detailed list of ways to protect water quality.

Stormwater Sewers

There are hundreds of stormwater outlets along the study stretch of the Naugatuck River. To get control of the pollutants being added to the river all these outfall points need to be inventoried and mapped. In addition, information is needed on the catchment area of each stormwater outfall. These outfalls can be something as small as a footing or roof drain to something as large as the Cook Brook Watershed (which now is mostly a stormwater control system piped directly to Besse Park Pond). Underground storm sewer systems also need to be mapped. If there are no engineering records on file, then each large outfall catchment area needs to be surveyed, smoke or dye tested (smoke and dye testing is a process that facilitates the identification of stormwater sewers and how they are interconnected). One method of keeping pollutants out of the river is to install drain markers to make the public aware that anything that goes into the storm sewer will end up in the Naugatuck River. During times of very dry weather outfall water can be tested for compounds that would indicate the presence of an illicit discharges (i.e. sanitary or industrial sewers hooked directly to the stormwater sewer system).

There are programs that provide free storm drain markers (see http://dep.state.ct.us/olisp/stormdrain/stormdrainmarker.pdf). However custom made storm drain markers are more effective and relatively cheap.

Direct Runoff from Paved Areas

There are many stormwater treatment methods that can be used to renovate stormwater before it reaches the Naugatuck River. There are many technologies to choose from, and cheaper more efficient technologies are being developed regularly. To assess which system to install you need to look at the pollutant type, amount of water, area available to install stormwater products and cost. Of course the cheapest alternative, if possible, is to eliminate the pollutant source. Please see the section titled Urban/Stormwater Runoff Management Practices for more details.

Construction Sites

Most construction sites along the Naugatuck River are big enough that a certified Erosion and Sediment Control Plan (E&S plan) is required. Please use The 2002 Connecticut Guidelines for Erosion and Sediment Control (CT DEP 2002, Bulletin #34). If an E&S plan is implemented correctly the water leaving a construction site is free and clear of suspended materials or it leaves the site through ground water. Please note that these 2002 Guidelines should also be used if construction of a greenway is considered.

Eroding River Banks

There are a few locations where the riverbank is being heavily eroded. In some of the worst spots (the western stretch of riverbank between River Drive and

Park Avenue) pedestrian and vehicle access issues are the major contributors that facilitate erosive forces that degrade water quality. Hundreds of cubic yards of material are entering the river from this source. To stabilize these areas access must be controlled. Soil stabilization can be accomplished by armoring walkways and keeping runoff from washing over unvegetated soils. Motorized vehicles need to be eliminated from the riparian area because vegetation can not establish in areas with the repetitive compaction and abrasive forces of aggressively treaded wheels. Pathways perpendicular to the bank contours need to be terraced and armored to eliminate down cutting. Access pathways can be created at regular intervals in riparian areas with established vegetation between each pathway to protect the water quality. These perpendicular pathways are needed to allow the public to access the resource. Pathways running horizontal to the riverbank contours could be designed in typical greenway fashion. In areas where the greenway is passing over soils it would be possible to use a porous aggregate such as crushed rock or gravel (see Concrete Grid and Modular Pavement). In areas of rip-rap dikes and concrete river corridor containment, paved pathways could be used.

Sand and Gravel Operations

The best way to protect water quality degradation from sand and gravel operations is to capture runoff and settle suspended solids before the runoff reaches the river. To further protect the water resources a vegetated buffer (of at least 50 feet in width) is required between any operations and the river. An additional benefit of stilling stormwater and maintaining a vegetated buffer is that water is given the opportunity to infiltrate and be purified by traveling with ground water. Please see section titled Resource Storage and Extraction Management Practices for details.

Nutrients From Agricultural Areas and Fertilized Grounds

Please note the discussion of vegetated buffers above. A vegetated buffer is most effective at attenuating nutrient rich runoff. Species and planting recommendations are contained in the Appendices and Tables section of this report.

Thermal Impacts

The creation of a greenway would be an integral part in the creation of a thermal refuge at the intersection of the Naugatuck River and the Gulf Stream.

Urban/Stormwater Runoff Management Practices

- Catch Basins - A stormwater runoff inlet equipped with a small sediment sump or grit chamber
- Collection & Treatment of Stormwater - Physical and chemical operations that provide treatment of urban stormwater runoff but are less involved and costly than treatment plant technology and can be either used independently or interfaced with other best management practices.
- Concrete Grid or Modular Pavement - Strong structural materials having regularly interspersed voids which are filled with pervious materials such as sod, gravel or sand.
- Dry Detention Basins - Collects and stores stormwater runoff in a temporary pool of water for less than 24 hours.
- Extended Detention Basin - A basin design to collect and store stormwater runoff in a temporary pool for more than 24 hours.
- Grass Lined Swales - Small vegetated depressions constructed in permeable soils, designed to convey stormwater from an area smaller than one acre.
- Infiltration Trench - A blind subsurface trench backfilled with gravel or similar void creating materials for the temporary collection and storage of stormwater runoff prior to exfiltration.
- Sand Filters - Sand filter are gravity driven constructed filtration systems designed to reduce non-point pollutant loading from urban watershed to surface water resources.
- Porous Pavement - Porous pavement is graded aggregate cemented together by asphalt into a coherent mass that has sufficient interconnected voids to provide a high rate of permeability to water.
- Public Education and Outreach - Non-point source instructional programs, workshops and information campaign conducted by the local conservation district.

- Riparian Forested Buffers - See Appendices and Tables for recommended species
- Roof Runoff Systems - Installed to handle roof runoff by directing it to down spouts that lead to infiltration trenches or rain gardens
- Street Sweeping - Regular mechanical sweeping of adjacent streets and disposing of the spoils properly (as described at the web site http://dep.state.ct.us/wtr/guide/rdsand.htm
- Urban Forestry - Protecting and planting trees before during and after urban site development.
- Water Quality Inlets (Oil / Grit Separators) - Water quality inlets are subsurface multi-chamber inlets installed in parking lots to trap coarser sediments and hydrocarbons in runoff before it is released to the river
- Greenbelting - A program to protect and restore a stream corridor, carried out through a cooperation of the City of Torrington, The Army Corps of Engineers and local residents and conservation organizations
- Slope Protection - The stabilization of steep or erosive slopes with live stem cuttings, plants, geotextiles or as a last resort rip-rap and retaining walls

Resource Storage and Extraction Management Practices

- Administrative Control Mechanism - Erosion and Sediment Control Ordinances.
- Check Dams - Small, temporary stone dams constructed in swales and waterways to dissipate flow energy
- Construction Entrance and Road Stabilization - Stabilization of access routes, on-site vehicle transportation routes and parking areas
- Dust Control - Application of water or biodegradable tacking agents
- Filter Strips - A strip of perennial grass, shrubs or trees established across the slope to manage for pollutant removal through overland flow
- Grassed Waterways - A natural or constructed channel that is below ground level and established to convey overland flow
- Slope Drains - Used to convey water from the top of steep slopes to the toe in a pipe to reduce the erosive forces on the delicate face of the slope
- Storm Drain Intel Protection - Material placed over or around a stormwater inlet used to protect the drain from being filled with excessive sediments
- Filter Fabric Fence - A temporary fence constructed of a porous geotextile that allows water to penetrate but keeps suspended solids behind
- Water Bar - used to divert water off a sloping road or trail to prevent the collection of moving water

Stormwater Phase II

The U.S. Environmental Protection Agency's (EPA's) Stormwater Phase II Final Rule (Phase II) requires urbanized areas, with population densities of 1,000 people per square mile, to develop and implement a stormwater management program. As of the drafting of this ERT, Torrington is a City that will be required to implement the EPA's Phase II stormwater regulations. Contact the Northwest Conservation District for Phase II implementation scheduling. Please note that the Phase II regulation has not yet gone into effect and the City of Torrington has already gone a long way toward meeting the requirements of Phase II. There will be six "minimum control measures" required by the Phase II regulation. The City Land Use and Engineering Department have made excellent progress in meeting the pending requirements of Phase II. The Northwest Conservation District (NCD) is currently assisting the City of Torrington to meet three of the six "minimum control measures" in advance of the mandated implementation.

1. Public Education and Outreach
2. Public Participation and Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Sediment, Erosion and Stormwater Control
5. Post-Construction Runoff Control
6. Pollution Prevention and Good Housekeeping.

Public Education and Outreach

The NCD has submitted a grant to sign all Naugatuck River (East Branch, West Branch and Main Stem) crossings to raise public awareness of river's existence. The NCD also participates in the Torrington Environmental Network (TEN) whose mission partially involves improving the health of the Naugatuck River.

Public Participation and Involvement

The NCD is sponsoring series of Stream Walk Trainings that teach volunteers how to assess the health of a Naugatuck River stream segment. The results are submitted to the District and target problem areas that can be prioritized for remediation.

Construction Site Sediment, Erosion and Stormwater Control

The NCD has been providing a number of trainings and workshops to teach proper erosion, sediment and stormwater control practices. One series of trainings involved teaching town land use staff and volunteers how to use the new 2002 Connecticut Guidelines for Soil Erosion and Sediment Control (CT

DEP, 2002 - DEP Bulletin #34). Other trainings include modules on soil capabilities and limitation, as well as wise land use decision making.

Illicit Discharge Detection and Elimination

Torrington's Public Works Department is performing dye testing in an effort to map stormwater sewers. This will facilitate the identification and location of potential illicit discharges.

Pollution Prevention and Good Housekeeping.

Torrington's land use department has already initiated an aggressive campaign to inventory businesses for an education campaign on good housekeeping practices to protect the surrounding water resources.

All the activities mentioned above will go a long way toward protecting the Naugatuck River's water resources. A healthy water resource adjacent to the Greenway will only benefit the revitalization of metropolitan Torrington.

Aquatic Resources

Aquatic Resources

Site Description

The Naugatuck River Greenway Project is to focus on the West Branch Naugatuck River from Stillwater Pond downstream (south) to the East Branch Naugatuck River confluence, Torrington then continuing along the Naugatuck River mainstem from that confluence southerly to the Route 118 road crossing, Harwinton. Approximately 5 miles of river are within the bounds of the Naugatuck River Greenway Project.

Significant segments of the Naugatuck River and the West Branch Naugatuck River through Torrington have long been impacted by man-made alteration. Swift water flow within the steep gradient channels of both the Naugatuck River and it's West Branch provided ideal conditions for the development of water powered facilities. Early in the history of the Torrington area, dams were constructed across both rivers to provide power for the operation of a variety of mills. Industrialization of the river corridors and use of the rivers as receiving streams for municipal sewage and a wide variety of industrial discharges followed the development of water power. Following a devastating flood of August 1955, lengthy segments of the Naugatuck River and both the East Branch and West Branch were channelized and rip-rap lined by the U.S. Army Corps of Engineers as authorized under Public Law 685. This federal law was passed to provide for immediate flood control protection in the Torrington area.

Water quality conditions have since improved within the Naugatuck River and the West Branch Naugatuck River through Torrington due to the elimination or upgrade of waste water effluent. The Department of Environmental Protection classifies the Naugatuck River as a Class Bc surface water. Surface water of this classification is known or presumed to meet the following designated uses: recreational use, coldwater fish and wildlife habitat, agricultural, industrial and other legitimate uses including navigation.

The West Branch Naugatuck River segment from Stillwater Pond downstream to the Brunswick Dam is classified as Class A surface water. Designated uses for surface water of this classification are potential drinking water supply, fish and wildlife habitat, recreational use, agricultural, industrial and other legitimate uses including navigation. The river is then classified as Class Bc surface water from Brunswick Dam downstream to the Naugatuck River confluence.

Despite improvements to water quality, instream and riparian habitat of the Naugatuck River and it's West Branch through Torrington remain impaired as the result of commercial, industrial and urban development along with flood control modifications. The rivers are notably lacking in instream cover (e.g. large boulder, accumulations of woody debris), are segmented by dams and/or utility crossings, and have an extremely limited, non-contiguous vegetated riparian floodplain.

The exception is the segment of the West Branch Naugatuck River from Stillwater Pond downstream to the Route 4 crossing. The river channel is in a natural state with diverse instream habitat features (i.e. a heterogeneous mix of streambed materials, fallen and/or overhanging vegetation, undercut banks, riffles and pools) and a nearly contiguous corridor of riparian vegetation comprised of mature trees (conifers and hardwoods) and an understory of woody shrubs.

Aquatic Resources

Prior to the alterations associated with industrial and urban development, the Naugatuck River through Torrington likely provided habitat for a cold water riverine fish assemblage. Construction of dams, channelization, and destruction of riparian habitat have dramatically altered the Naugatuck River's physical characteristics and are theorized to have subsequently reduced the river's ability to support a diverse fish community and in particular have a reduced support for cold water species. Inland Fisheries Division fish population surveys of the Naugatuck River have confirmed that, despite water quality improvements, physical habitat impairment remains a significant factor limiting fish species support.

The Division had conducted a number of fish surveys in the Naugatuck River in Torrington during the mid- and late 1990's. The surveys were conducted in the river segments at the Bogue Road crossing and the Palmer Bridge Street crossing. A segment of the West Branch Naugatuck River adjacent to Bradlees Plaza was also surveyed. These surveys revealed nearly identical fish communities of the following species: blacknose dace (*Rhinichthys atratulus*), longnose dace (*Rhinichthys cataractae*), cutlips minnow (*Exoglossum maxillingua*), creek chub (*Semotilus atromaculatus*), fallfish (*Semotilus corporalis*), common shiner (*Luxilus cornutus*), tessellated darter (*Etheostoma olmstedi*), rock bass (*Ambloplites rupestris*), and white sucker (*Catostomus commersoni*). These riverine species are commonly associated with either cool- or cold water riverine systems and can tolerate watercourses with degraded physical habitat.

Also collected in the surveys were largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), fathead minnow (*Pimephales promelas*), golden shiner (*Notemigonus crysoleucas*), yellow perch (*Perca flavescens*), and brown bullhead (*Ameiurus nebulosus*).

These species inhabit warmwater lakes and ponds and large, slow moving rivers; they are considered a transient species in rivers such as the Naugatuck River.

With guidance from the Inland Fisheries Division, the City of Torrington and U.S. Army Corps of Engineers completed an instream habitat enhancement project in the year 2000. Approximately 450 large boulders (3 to 4 feet in diameter) were randomly placed in the river channel from the East Albert Street crossing downstream to John Toro Sports Complex off Davis Street. The boulders were intended to provide large cover in the channel which had been eliminated when the river was modified for flood control. Division surveys of this river reach completed in the year 2001 showed the fish community responding favorably to the habitat enhancement. Two additional species, brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), were found.

The Inland Fisheries Division has never conducted fish surveys in the West Branch Naugatuck River reach from Stillwater Pond to Route 4. This channel of this river segment is apparently in an unaltered state despite some residential development within the riparian corridor. Based upon Division surveys of streams with similar physical characteristics, the fish community within this segment of the West Branch Naugatuck River is anticipated to be comprised of the following species: brook trout (*Salvelinus fontinalis*), blacknose dace, longnose dace, fallfish, tessellated darter and white sucker.

The Inland Fisheries Division has since begun to stock hatchery reared trout in the Naugatuck River through Torrington. Approximately one-quarter of the 54,000 trout allocated for the Naugatuck River upstream of the Thomaston Flood Control Dam are distributed within the river through Torrington. Beginning in 2002, the Division has designated the Naugatuck River segment through Torrington as a Trophy Trout Stream. This designation limits the daily creel limit of trout to two fish.

In addition to trout, the Division liberates adult Atlantic salmon (*Salmo salar*) broodstock in the Naugatuck River for angling. Although the greatest number of salmon are released downstream of Route 118, a portion are stocked in the river segment from Bogue Road to the Harwinton townline.

Angling is allowed through intermittent segments of the West Branch Naugatuck River from Stillwater Pond to Route 4. Approximately 350 adult hatchery reared brook, brown and rainbow trout are stocked to satisfy angler demand.

Habitat Enhancement Recommendations

As previously mentioned, physical habitat impairment is likely to be the primary factor limiting complete support of a coldwater fish assemblage throughout much of the Naugatuck River and the West Branch Naugatuck River within the bounds of the Naugatuck River Greenway Study. The following are recommendations for the enhancement of riverine habitat within each of the three sections of the study corridor.

Section One.

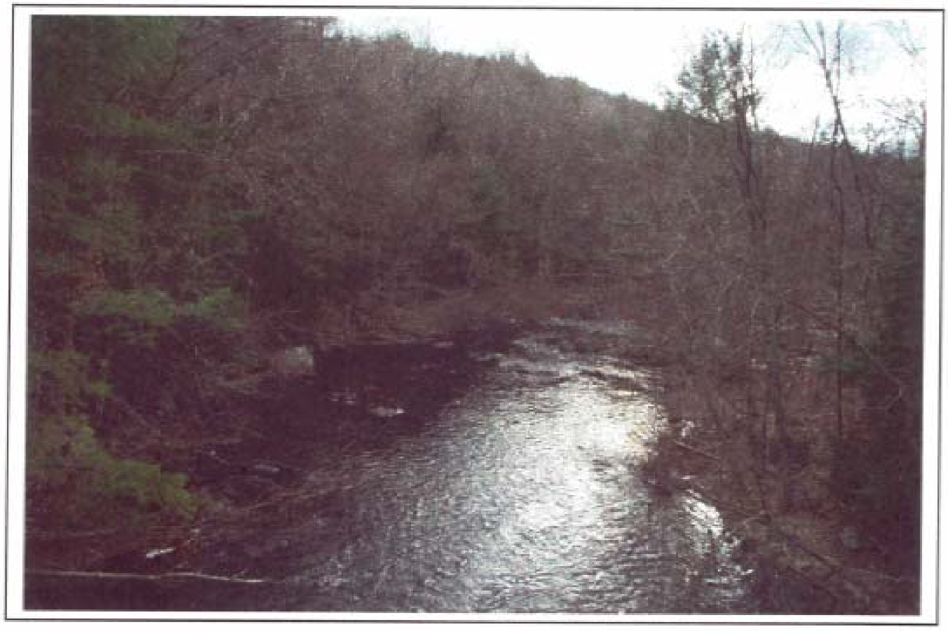
This section includes the West Branch Naugatuck River from Stillwater Pond downstream to Wolcott Avenue. The river reach from Stillwater Pond to the Brunswick Dam impoundment is in a natural condition with light to moderate development within the riparian corridor. The following habitat enhancement measures are recommended for Section One:

- Land along the river corridor should either be purchased or be preserved by easement to maintain or to provide an opportunity to enhance the integrity of the riparian habitat. As research indicates, a vegetated riparian area within

100 feet of perennial watercourses provides critical functions for the overall "health" of the watercourse. Please refer to the following documentation presenting Division policy and position regarding vegetated riparian buffers for additional information.

- A low head dam spans the West Branch Naugatuck River approximately 750 downstream of the Route 4 crossing. The dam, which I refer to as the Brunswick Dam, was installed to provide water power to an industrial complex (once housing the Brunswick Corporation) located off Migeon Avenue. The intake to a canal from the impoundment has been sealed and therefore the dam itself is no longer serving the function as it was once intended. Complete removal or breaching of the dam is recommended. This will allow for fish passage and the restoration of riverine habitat within the "footprint" of the impoundment.

The following photographs depict conditions along and within the West Branch Naugatuck River through *Section One.*



West Branch Naugatuck River downstream of Stillwater Pond Road.

Brunswick Dam across West Branch Naugatuck River.

DEPARTMENT OF ENVIRONMENTAL PROTECTION
INLAND FISHERIES DIVISION

POLICY STATEMENT
RIPARIAN CORRIDOR PROTECTION

I. INTRODUCTION, GOALS, AND OBJECTIVE

Alteration and exploitation of riparian corridors in Connecticut is a common event that significantly degrades stream water quality and quantity. Inasmuch as riparian ecosystems play a critical role in maintaining aquatic resource productivity and diversity, the Inland Fisheries Division (Division) recognizes that rigorous efforts are required to preserve, protect, and restore these valuable resources. Consequently, a riparian corridor protection policy has been developed to achieve the following goals and objective:

Goals

Maintain Biologically Diverse Stream and Riparian Ecosystems, and

Maintain and Improve Stream Water Quality and Water Quantity.

Objective

Establish Uniform Riparian Corridor Buffer Zone Guidelines.

II. DEFINITIONS

For the purpose of implementing a statewide riparian corridor protection policy, the following definitions are established:

Riparian Corridor: A land area contiguous with and parallel to an intermittent or perennial stream.

Buffer Zone: An undisturbed, naturally vegetated area adjacent to or contained within a riparian corridor that serves to attenuate the effects of development.

Perennial Stream: A stream that maintains a constant perceptible flow of water within its channel throughout the year.

Intermittent Stream: A stream that flows only in direct response to precipitation or which is seasonally dry.

III. RIPARIAN FUNCTION

Naturally vegetated riparian ecosystems perform a variety of unique functions essential to a healthy instream aquatic environment. The delineation and importance of riparian functions are herein described. Vegetated riparian ecosystems:

* Naturally filter sediments, nutrients, fertilizers, and other nonpoint source pollutants from overland runoff.

* Maintain stream water temperatures suitable for spawning, egg and fry incubation, and rearing of resident finfish.

* Stabilize stream banks and stream channels thereby reducing instream erosion and aquatic habitat degradation.

* Supply large woody debris to streams providing critical instream habitat features for aquatic organisms.

* Provide a substantial food source for aquatic insects which represent a significant proportion of food for resident finfish.

* Serve as a reservoir, storing surplus runoff for gradual release into streams during summer and early fall base flow periods.

IV. RIPARIAN CORRIDOR BUFFER ZONE GUIDELINES

Recognizing the critical roles of riparian corridors, the Division provides buffer zone guidelines that are designed to bring uniformity and consistency to environmental review. The guidelines are simple, effective, and easy to administer. The following standard setting procedure should be used to calculate buffer zone widths.

Perennial Stream: A buffer zone 100 feet in width should be maintained along each side.

Intermittent Stream: A buffer zone 50 feet in width should be maintained along each side.

Buffer zone boundaries should be measured from either, (1) edge of riparian inland wetland as determined by Connecticut inland wetland soil delineation methods or (2) in the absence of a riparian wetland, the edge of the stream bank based on bank-full flow conditions.

The riparian corridor buffer zone should be retained in a naturally vegetated and undisturbed condition. All activities that pose a significant pollution threat to the stream ecosystem should be prohibited.

Where the Division policy is not in consonance with local regulations and policies regarding riparian corridor buffer zone widths and allowable development uses within these areas, local authorities should be encouraged to adopt the more restrictive regulations and policies.

12/13/91
Date

James C. Moulton
Acting Director

POSITION STATEMENT
UTILIZATION OF 100 FOOT BUFFER ZONES TO PROTECT RIPARIAN AREAS IN CONNECTICUT

BY

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I. INTRODUCTION

One tenet of the Inland Fisheries Division Policy on Riparian Corridor Protection is the utilization of a 100 foot buffer zone as a minimum setback along perennial streams. The adoption of such a policy is sure to be controversial. Laymen, developers and natural resource professionals alike will ask questions such as: Why was a standard setting method adopted? What's magical about 100 feet? Will 100 feet be sufficiently protective, or will it be overly protective? In response, this paper outlines the ramifications of adopting a riparian corridor policy including the use of a 100 foot buffer zone.

II. STANDARD SETTING VERSUS SITE SPECIFIC BUFFER ZONES

There are two approaches for determining buffer zone width; standard setting and site specific. Standard setting methods define an area extending from the streambank edge or highwater mark to some landward fixed point boundary. Site specific methods utilize formulas that incorporate and consider special site specific land characteristics, hence, the calculation of a variable width buffer zone. In both case, buffers are employed to define an area in which development is prohibited or limited.

A major advantage of standard setting methods is that they are easy to delineate and administer, thereby improving the consistency and quality of environmental assessments. Furthermore, valuable staff time would not be required to determine site specific buffer zones along each and every watercourse of concern.

The exact width of a buffer zone required for riparian corridor protection is widely disputed (Bottom et al. 1985 and Brinson et al. 1981). Buffer width recommendations found in the literature vary from as little as 25 feet to as great as 300 feet (Palfrey et al. 1982). The 100 foot buffer is widely accepted in Connecticut having been adopted by numerous inland wetland and conservation commissions as an appropriate minimum setback regulation for streambelts. In addition, Division staff have been recommending the utilization of the 100 foot buffer zone to protect streambelts since the early 1980's. Scientific research has not been generated to dispute the adequacy of utilizing 100 foot buffer zones to protect Connecticut's riparian corridors. In fact, to ensure that riparian functions are not significantly altered, recent scientific information points towards maintaining buffer zones that would be at a minimum, 100 feet in width (see section III).

Site specific methods define buffer widths according to the character and sensitivity of adjacent streamside lands. These buffer widths, also referred to as "floating buffers," consider physical site characteristics such as slope, soil type, and vegetative cover. The advantage of site specific methods is that buffer widths are designed using site characteristics and not an arbitrary predetermined width. Unfortunately, there is no "one" universally accepted formula or model and none have been developed for use in Connecticut. Most formulas are based on the degree to which sediment can be removed or filtered by natural vegetation, thus, the primary useage is sediment control. Other weaknesses of site specific techniques are (1) all areas must be evaluated on a case-by case basis and, (2) the subjectivity of different techniques (i.e. if the evaluation technique is inadequate, the buffer width will also be inadequate).

Additionally, these formulas only concentrate on one specific riparian function at a time and do not take into account multiple riparian functions, especially those of inland fisheries values as discussed in Section III. Consequently, site specific formulas approach riparian function on a single dimension rather than taking a more realistic, holistic approach.

In the absence of a scientific model to determine buffer widths suitable to protect Connecticut's riparian corridors, the utilization of a standard setting method is environmentally and politically prudent.

III. RIPARIAN FUNCTION

To assess the efficacy of a 100 foot buffer zone, the literature was searched to identify studies which have applied a quantitative approach to buffer width determination. Literature was searched for studies which both support and dispute the 100 foot zone. The following is a summary "by riparian function" of quantitative studies which assess buffer widths.

Sediment Control

Width, slope and vegetation have been cited as important factors in determining effectiveness of buffer zones as sediment filters (Karr and Schlosser 1977). Wong and McCuen (1981), who developed and applied a mathematical model to a 47 acre watershed, found that a 150 foot zone along a 3% slope reduced sediment transport to streams by 90%. Mannering and Johnson (1974) passed sediment laden water through a 49.2 foot strip of bluegrass and found that 54% of sediment was removed from the water. Trimble and Sartz (1957) developed recommendations as to width of buffer areas between logging roads and streams to reduce sediment load. They determined a minimum strip of 50 feet was required on level land with the width increasing 4 feet for each 1% slope increase. Buffer widths as determined by Trimble and Sartz (1957) have been characterized as evaluated guesses rather than empirically defined widths (Karr and Schlosser 1977). Rodgers et al. (1976) state that slopes greater than 10% are too steep to allow any significant detention of runoff and sediment regardless of buffer width. After a critical review of the literature, Karr and Schlosser (1977) determined that the size and type of vegetative buffer strip needed to remove a given fraction of the overland sediment load cannot be universally quantified. Existing literature does suggest that 100 foot riparian buffers will assist with sediment entrapment, although efficacy will vary according to site conditions.

Temperature Control

Brown and Brazier (1973) evaluated the efficacy of buffer widths required to ameliorate stream water temperature change. They concluded that angular canopy density (ACD), a measure of the ability of vegetation to provide shading, is the only buffer area parameter correlated with temperature control. Results show that maximum angular canopy density or maximum shading ability is reached within a width of 80 feet. Study sites were 9 small mountain streams in Oregon that contained a conifer riparian vegetative complex. Whether or not maximum angular canopy density is reached within 80 feet in a typical Connecticut deciduous forest riparian zone is doubtful. Tree height in Connecticut riparian zones is smaller than in Oregon (Scarpino, personal communication), therefore buffers greater than 80 feet in width would be required for temperature maintenance in Connecticut.

Nutrient Removal

Nutrient enrichment is caused by phosphorous and nitrogen transport from, among other things, fertilized lands and underground septic systems. Most research on nutrient enrichment has focused on overland surface flow. Karr and Schlosser (1977) report that 88% of all nitrogen and 96% of all phosphorous reaching watercourses in "agricultural watersheds" were found to be attached to sediment particles; thus, successful nutrient removal can be accomplished through successful sediment removal. There are conflicting reports on the ability of buffer widths to remove nutrients with most research being tested on grass plots. Butler et al. (1974) as cited by Karr and Schlosser (1977) found that a 150 foot buffer width of reed canary grass with a 6% slope caused reductions in phosphate and nitrate concentrations of between 0–20%. Wilson and Lehman (1966) as cited by Karr and Schlosser (1977) in a

IV. OTHER POLICY CONSIDERATIONS

Measurement Determination

The proposed policy states that buffer zone boundaries should be measured from either the edge of the riparian inland wetland as determined by Connecticut inland wetland soil delineation methods or in the absence of a riparian wetland, the edge of the streambank based on bank–full flow conditions. This boundary demarcation is absolutely necessary to ensure that all riparian wetlands are protected. For example, if all measurements were to start from the perennial stream edge and extend landward for a distance of 100 feet, many riparian zones that contain expansive wetlands greater than 100 feet in width would be left unprotected.

Also, since boundary demarcation includes wetland delineation, the ultimate width of the buffer will vary according to site specific features. Consequently, buffer width determination as stated by Division policy is a "hybridization" of both standard setting and site specific methods. This hybridization of methods is advantageous since it acknowledges the sensitivity of streamside wetlands.

Home Rule

Where the Division policy is not in consonance with local regulations and policies regarding riparian corridor buffer zone widths, local authorities would be encouraged to adopt the more restrictive regulations and policies. This feature incorporates flexibility to acknowledge the importance of local "home rule" regulations or policies already in accepted practice. Conversely, towns and cities without accepted policies and regulations could choose to enact the Division policy.

Allowable Uses in Buffer Zones

The Division policy states that "the riparian corridor buffer zone should be retained in a naturally vegetated and undisturbed condition and that all activities that pose a significant pollution threat to the stream ecosystem should be prohibited." In essence, the buffer zone becomes an area where no development should be allowed. For this policy to be effective, there should be no exceptions, a blanket restriction of all uses would be recommended. Further clarification and more precise definitions of allowable uses will, however, be required in the future if the policy evolves into a departmental regulation.

Recently, the Connecticut Supreme Court has ruled that local agencies can prohibit specific development within buffer zones. The *Lizotte v. Conservation Commission of the Town of Somers, 216 Conn.320 (1990)* decision ruled that the construction or maintenance of any septic system, tank, leach field, dry well, chemical waste disposal system, manure storage area or other pollution source within 150 feet of the nearest edge of a watercourse or inland wetland's seasonal high water level can be prohibited (Wetlands Watch 1990). If this decision is a precursor of the future, Connecticut courts will continue to the support the use of buffers, especially those which restrict or prohibit detrimental activities.

V. CONCLUSIONS

The following actions are required to preserve, protect, and restore Connecticut's riparian corridors:

1. The Inland Fisheries Division needs to adopt and implement the proposed policy so that staff can use it as a guideline to assist cities, towns, developers and private landowners with making sound land use decisions. This policy will act to solidify a collective position concerning riparian corridor protection.

2. While the proposed policy in its "current form," represents a recommendation from the CTDEP Inland Fisheries Division, the ultimate goal of the Division should be to progressively implement this policy as either a CTDEP regulation or State of Connecticut statute.

study of effluent applied to 300 m grass plots found that nitrogen and phosphorous concentrations were reduced 4 and 6%, respectively. Studies on subsurface runoff as cited in Clark (1977) found high concentrations of nitrates at 100 feet from septic systems with unacceptable levels at 150 feet. Clark (1977) recommended that a 300 foot setback be used whenever possible, with a 150 setback considered adequate to avoid nitrate pollution. Environmental Perspective Newsletter (1991) states that experts who commonly work with the 100 foot buffer zone set by the Massachusetts Wetlands Protection Act are increasingly finding that it is insufficient since many pollutants routinely travel distances far greater than 100 feet with nitrate–nitrogen derived from septic systems moving distances of greater than 1000 feet. Research indicates that the adoption of 100 foot buffer widths for Connecticut riparian zones will assist with the nutrient assimilation; albeit, complete removal of all nutrients may not be achieved.

Large Woody Debris

The input of large woody debris (LWD) to streams from riparian zones, defined as fallen trees greater than 3 m in length and 10 cm in diameter has been recently heralded as extremely critical to stream habitat diversity as well as stream channel maintenance. Research on large woody debris input has mainly been accomplished in the Pacific Northwest in relation to timber harvests. Murphy and Koski (1989) in a study of seven Alaskan watersheds determined that almost all (99%) identified sources of LWD were within 100 feet of the streambank. Bottom et al. 1983 as cited by Budd et al. (1987) confirm that in Oregon most woody structure in streams is derived from within 100 feet of the bank. Based on research done within old–growth forests, the Alaska region of the National Marine Fisheries Service, recognizing the importance of LWD to salmonid habitat, issued a policy statement in 1988 advocating the protection of riparian habitat through the retention of buffer strips not less than 100 feet in width (Murphy and Koski 1989). All research findings support the use of a 100 foot buffer zone in Connecticut for large woody debris input.

Food Supply

Erman et al. (1977) conducted an evaluation of logging impacts and subsequent sediment input to 62 streams in California. Benthic invertebrate populations (the primary food source of stream fishes) in streams with no riparian buffer strips were compared to populations in streams with buffer widths of up to 100 feet. Results showed that buffer strips less than 100 feet in width were ineffective as protective measures for invertebrate populations since sediment input reduced overall diversity of benthic invertebrates. Buffer strips greater than 100 feet in width afforded protection equivalent to conditions observed in unlogged streams. The ultimate significance of these findings is that fish growth and survival may be directly impacted along streams with inadequate sized riparian buffer zones. All research supports the feasibility of implementing a 100 foot buffer zone in Connecticut to maintain aquatic food supplies.

Streamflow Maintenance

The importance of riparian ecosystems in terms of streamflow maintenance has been widely recognized (Bottom et al. 1985). In Connecticut, riparian zones comprised of wetlands are of major importance in the hydrologic regime. Riparian wetlands store surplus flood waters thus dampening stream discharge fluctuations. Peak flood flows are then gradually released reducing the severity of downstream flooding. Some riparian wetlands also act as important groundwater discharge or recharge areas. Groundwater discharge to streams during drier seasonal conditions is termed low flow augmentation. The survival of fish communities, especially coldwater salmonid populations is highly dependent upon low flow augmentation (Bottom et al. 1985). Research, although documenting the importance of riparian zones as areas critical to streamflow maintenance, has not investigated specific riparian buffer widths required to provide the most effective storage and release of stream flows.

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Section Two.

This section includes the West Branch Naugatuck River from Wolcott Avenue to the East Branch Naugatuck River confluence and the Naugatuck River mainstem from that confluence downstream to the John Toro Sports Complex off Davis Street. The physical habitat of both rivers within Section Two have been extensively altered by urban encroachment, impounding and modification flood control. The following habitat enhancement measures are recommended for Section Two:

- Complete removal or breaching of the Brass Mill Dam which spans the West Branch Naugatuck River immediately upstream of the Church Street bridge. Breaching or complete removal of the dam would restore approximately 1,500 feet of riverine and riparian habitat and would allow for unimpeded fish passage. The dam, no longer serving to provide industrial water supply, is reportedly now owned by the Heritage Land Trust. Members of that group have recently expressed an interest in removing or breaching the dam and restoring riparian habitat in the dewatered impoundment.

- Restoration of riparian habitat. Nearly the complete length of the West Branch Naugatuck River channel within Section Two is contained within retaining walls resulting from industrial, commercial and residential development in the central Torrington area. The retaining walls have eliminated or dramatically reduced the once vegetated riparian area associated with the river. As mentioned previously, vegetated riparian areas provide a variety of functions which are critical to watercourse "health". An ideal opportunity for the restoration of riparian habitat is currently presenting itself in the proposal for redevelopment of the downtown Torrington area. The Litchfield Hills Council of Elected

Officials should aggressively promote riparian habitat restoration through their involvement with redevelopment efforts in downtown Torrington.

- Removal or modification of concrete structures within the West Branch Naugatuck River channel. There are a number of concrete structures within the river channel within Section Two. These structures appear to be associated with utility (water, sewer, gas) lines. The structures create barriers to fish passage at all but the highest river flows. The structures should be removed if they are no longer serving there intended function. If the structures cannot be removed, the river channel proximate the structures should be modified to provide for fish passage and habitat enhancement. The most practical method is to create a series of "step pools" from the structure continuing a distance downstream. The step pools are created from a heterogeneous size mix of rock. The practice is known as "ramping" and is commonly used to provide fish passage over low-head dams. Design typicals for the construction of step pools follow.

- Continue with instream and riparian habitat enhancements within and along the West Branch Naugatuck River and Naugatuck River segments which had been modified for flood control. The City of Torrington and U.S. Army Corps of Engineers with guidance from the Inland Fisheries Division completed an instream habitat enhancement project in the year 2000. The project consisted of the random placement in the river channel from the East Albert Street crossing downstream to John Toro Sports Complex off Davis Street. Although the boulders enhanced habitat and increased fish species diversity, the installation of additional instream cover is desired. Structures known as "cabled log jams" are recommended. The structures are constructed of logs (with some limbs attached) cabled together and secured to the river bank. The cabled log jams are ideally placed in deep pool habitat. A description of cabled log jams follows.

- Develop a vegetation management plan for the West Branch Naugatuck River and Naugatuck River segments which had been modified for flood control. As per a maintenance agreement, the U.S. Army Corps of Engineers requires the City of Torrington to clear all vegetation from the banks of the river channels which were modified for flood control. As previously stated, riparian vegetation provides a variety of functions which are critical to watercourse "health". The Litchfield Hills Council of Elected Officials and City of Torrington should work cooperatively with the U.S. Army Corps of Engineers to develop a vegetation management strategy which allows the preservation of certain species of trees and shrubs which, upon maturation, will not compromise the integrity of the flood channel banks. The trees and shrubs selected for preservation should be native to the immediate watershed and be non-invasive.

- Create formal pedestrian access points to the river.

- Signage should be erected along the West Branch Naugatuck River and Naugatuck River at select, readily accessible vantage points atop the river banks to describe the function of key features of a stream such as pools, riffles, riparian area, and the consequence of stormwater discharges. Suggested verbiage for such signage includes:

  Stream habitat overview. A key characteristic of any productive in-stream habitat is diversity. It is imperative that the proper blend of water depths, water velocities, and substrate types be present together to form the necessary food production, spawning-incubation, and cover areas that combine to form a complete stream habitat.

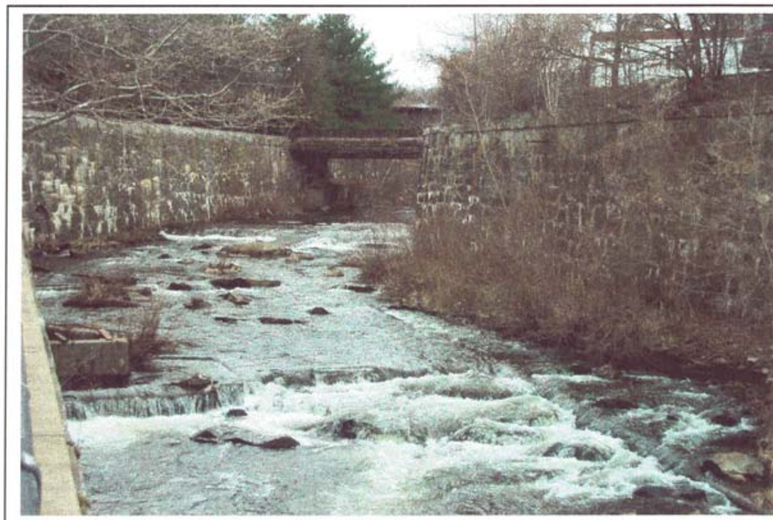
Pools. Loosely defined, a pool is a region of deeper, slower moving water with fine bed materials. With overhanging banks and vegetation, pools provide cover, shelter, and resting areas primarily for larger finfish. During low flows pools can become isolated pockets of water which allow survival of finfish and other aquatic organisms.

Riffles. Areas of shallower, faster moving water with coarser bed materials. Riffles are most often associated with "white water", a turbulence which adds oxygen to water. Riffles tend to support higher densities of aquatic insects and are thus more important areas of finfish food production. Riffles also sserve as a spawning site for most stream finfish. Due to competition and predation, juvenile and small sized finfish tend to inhabit riffles.

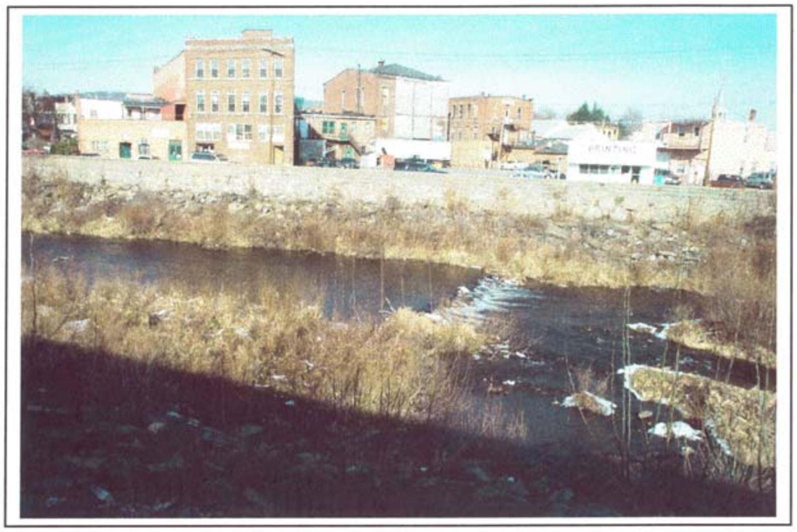
Riparian area. The riparian area is that section of land which adjoins the river channel. A well vegetated riparian area is critical to the health of the river ecosystem. Roots of trees, shrubs, and grasses bind the river bank soils and provide a resistance to the erosive forces of flowing water. Stems and leaves of river bank vegetation provide shade which prevents high water temperatures. Leaves, stems, and other plant parts that fall into the river provide food for aquatic insects. Large woody debris that fall into the river enhance physical habitat. Abundant riparian vegetation softens rainfall and enables the riparian area to serve as a reservoir storing surplus runoff for a gradual release to the river during low flow periods of summer and early fall. The riparian area is a natural filter which removes nutrients, sediments, and other non-point source pollutants from overland runoff.

The following photographs depict conditions along and within the West Branch Naugatuck River and Naugatuck River through *Section Two*.

Brass Mill Dam across West Branch Naugatuck River.

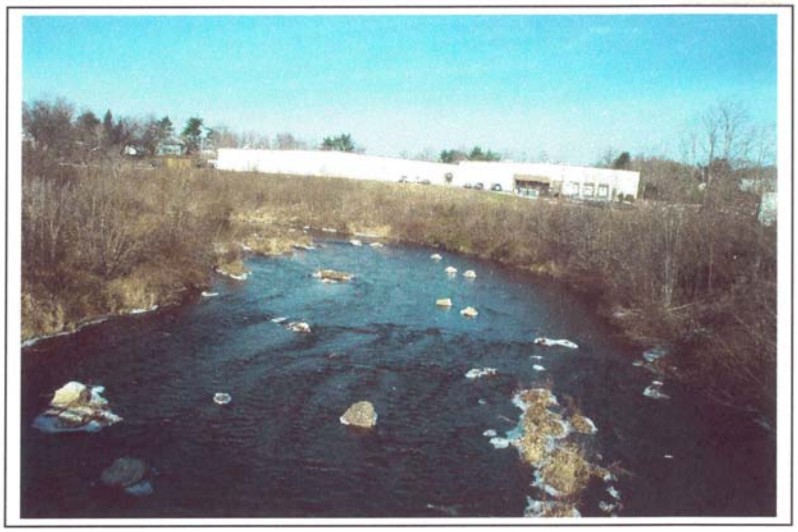


West Branch Naugatuck River upstream of Route 202 adjacent to senior housing complex.

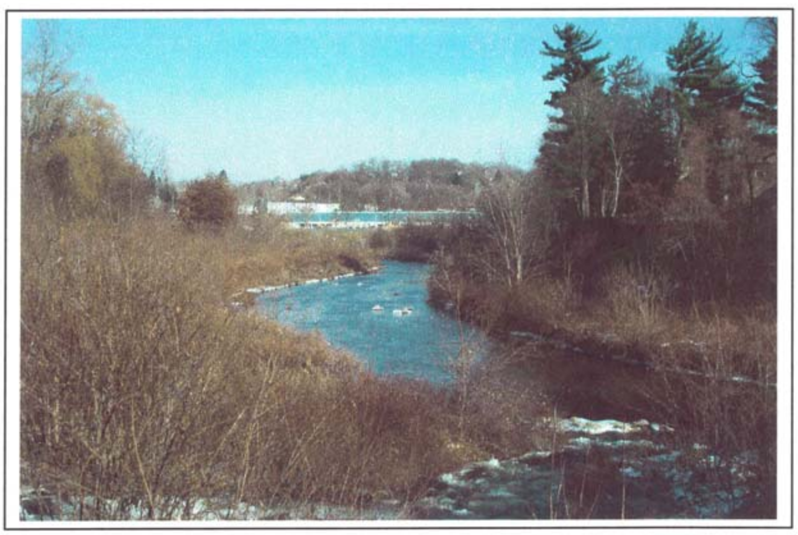


Conduit crossing of the West Branch Naugatuck River downstream of Route 202, Torrington

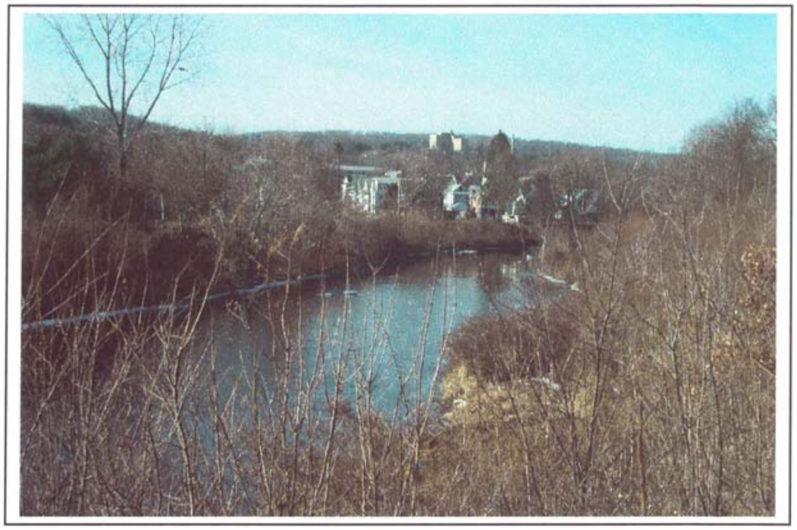
Conduit crossing of the Naugatuck River at the John Toro Sports Complex, Torrington.



Boulders placed in the Naugatuck River within the US Army Corps of Engineers flood control channel Torrington as a fish habitat enhancement project. Project. completed September 2002.



Boulders placed in the Naugatuck River within the US Army Corps of Engineers flood control channel Torrington as a fish habitat enhancement project. Project. completed September 2002.



Naugatuck River within the US Army Corps of Engineers flood control area, Torrington.

Naugatuck River within the US Army Corps of Engineers flood control area, Torrington.

STEP POOLS

Design typicals for construction

MGWC 3.9: STEP POOLS

> *Technique for grade control and improvement of aquatic habitat*

DESCRIPTION

The work should consist of constructing step-pool sequences in steep headwater stream channels for grade control and the creation of aquatic habitat through flow diversification. Step-pool channels are characterized by a succession of channel-spanning steps formed by large grouped boulders called clasts that separate pools containing finer bed sediments. As supercritical flow tumbles over the step, energy is dissipated in roller eddies and becomes subcritical in the associated downstream plunge pool.

EFFECTIVE USES & LIMITATIONS

Step-pool morphologies are typically associated with well confined, high-gradient channels with slopes greater than 3%, having small width-depth ratios and bed material dominated by cobbles and boulders. Step pools generally function as grade control structures and aquatic habitat features by reducing channel gradients and promoting flow diversity. At slopes greater than roughly 6.5%, similar morphologic units termed cascades spanning only a portion of the channel width are formed in these channel conditions. Step pools and cascades are generally found in the following Rosgen stream types: A1-A3 and B1-B3.

MATERIAL SPECIFICATIONS

Natural steps in step-pool morphologies can be formed by large clasts, bedrock outcrops, and large woody debris aligned across the channel. Engineered steps can be made from boulders, logs, and large woody debris chosen according to the desired height of the step. Additionally, boulders should be sized to resist the design storm event using MGWC 2.1: Riprap as a guide.

INSTALLATION GUIDELINES

All erosion and sediment control devices, including dewatering basins, should be implemented as the first order of business according to a plan approved by the WMA or local authority. The proposed construction sequence for step pools is as follows (refer to Detail 3.9):

1. The stream should be redirected by an approved temporary stream diversion (See *Section 1: Temporary Instream Construction Measures, Maryland's Guidelines to Waterway Construction*), the construction area should be dewatered, and any disturbed banks should be stabilized.

2. Step-pool units should be designed and constructed to have a characteristic step height, H, and step length, L, as shown in Detail 3.9, and all steps should be firmly anchored into the stream bank.

3. Step rocks shall be placed on footer rocks so that they rest on two halves of each footer rock below, and so that the step rock is offset in the upstream direction. Footer rocks should extend below the scour hole elevation.

4. As a general guideline, the ratio of the mean steepness, defined as the averaged value of step height over step length, to the channel slope, S, should lie in the range of 1 to 2 $(1 \bullet \{(H/L)_{AVE}/S\} \bullet 2)$. Typical spacings for step pools and cascades are provided in Detail 3.9(b) relating to alluvial channel morphologies.

5. Whenever practical, a reference reach with similar flow rates, bed and bank material characteristics, type and density of riparian vegetation, and channel gradient should be surveyed at low flows to determine appropriate values of H and L. At high discharges, step-pool characteristics may be obscured.

MGWC 3.9: STEP POOLS

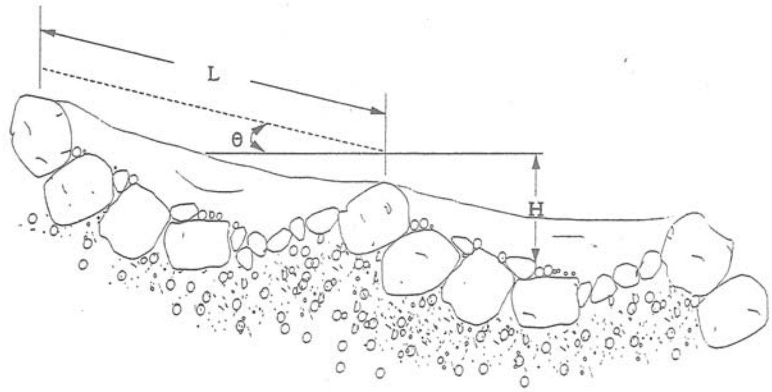
6. Once construction is completed, the diversion should be removed from upstream to downstream. Sediment control devices, including perimeter erosion controls, are to remain in place until all disturbed areas are stabilized in accordance with an approved sediment and erosion control plan and the inspection authority approves their removal.

Maryland's Guidelines To Waterway Construction

DETAIL 3.9(a): STEP POOLS

Adapted From Abrahams et al. (1995)

DEFINITION SKETCH:
STEP POOL

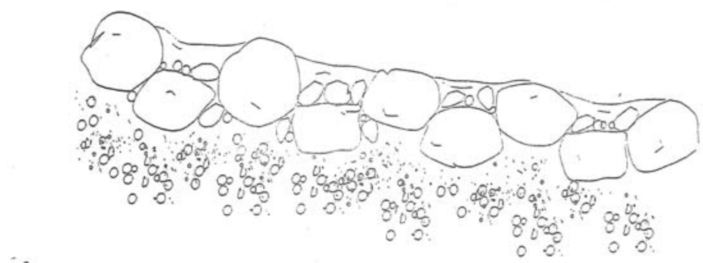


Note: L is measured parallel to the bed slope (tan θ)
H is measured perpendicular to the horizontal

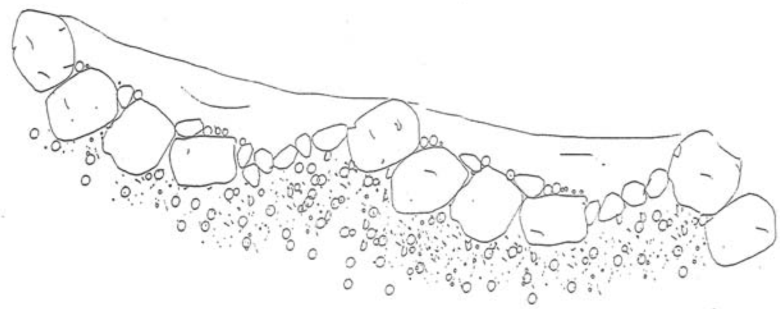
DETAIL 3.9(b): STEP POOLS

Adapted From Montgomery and Buffington (1997)

PROFILE VIEW:
CASCADE & STEP POOL MORPHOLOGIES



Approximate channel slope: >0.065	Typical pool spacing: <1 channel width	Average step height (Abrahams et al., 1995) $1 \leq \{(H/L)_{AVE}/S\} \leq 2$



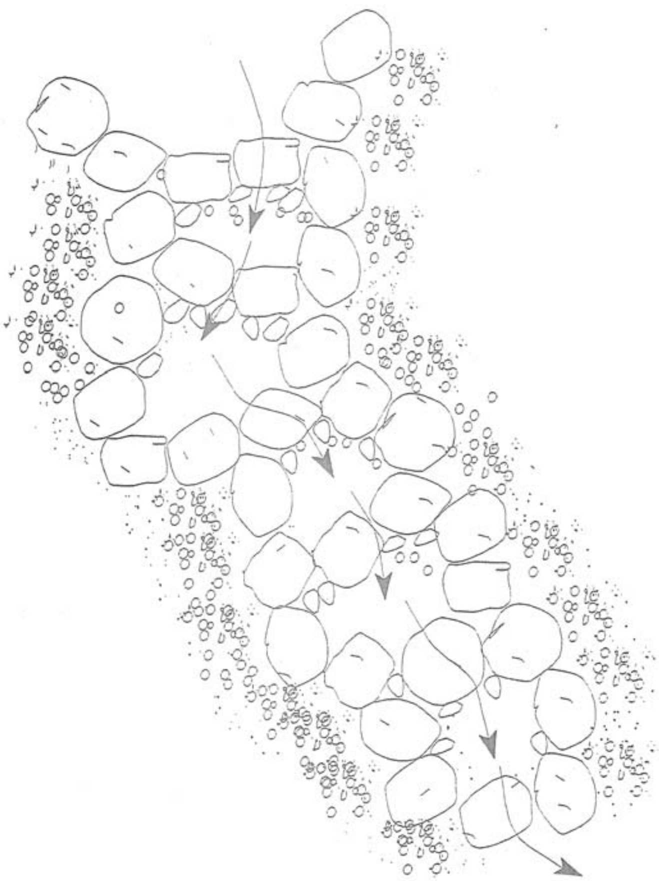
Approximate channel slope: 0.030–0.065	Typical pool spacing: 1–4 channel widths	Average step height (Abrahams et al., 1995) $1 \leq \{(H/L)_{AVE}/S\} \leq 2$

Maryland's Guidelines To Waterway Construction

DETAIL 3.9(c): STEP POOLS

Section & Plan Views Adapted From Rosgen (1996)

PLAN VIEW: STEP POOL



CABLED LOG JAMS

Description of installation

ENGINEERED LOG JAM

Description

Engineered log jams are collections of large woody debris that create or redirect flow and provide stability to a downstream bar or island. Engineered-log-jam constructions are patterned after stable, natural log jams and can be either unanchored or anchored in place using man-made materials. Naturally occurring log jams in alluvial channels are usually formed by one or several key members, consisting of large trees with rootwads attached, that stabilize and anchor other debris that is "racked" against the key members.[1] Log jams extend above bankfull water surface and, when connected to a streambank, are hydraulically similar to groins. *Figure 6-1, Engineered log jams* shows examples of engineered log jams.

Naturally occurring log jams may start as a single, large tree, as a large number of trees drifting together or as an undercut, timbered bank giving way and the trees coming with it. Over the years, people have removed many of these naturally formed structures for navigation, firewood and flood-control purposes. However, log jams provide habitat for a wide variety of fish species during most of their life stages. Engineered log jams are also fundamental to the dynamics of a healthy, forested, river ecosystems.[2] Engineered log jams as a bank-protection treatment are still considered experimental, but they are becoming increasingly popular as bank protection because they integrate fish-habitat restoration with bank protection.

Application

Prior to extensive logging activities in the past century, log jams were common throughout many of our streams. These accumulations of woody material helped create stable stream channels and habitat for fish and wildlife. Only in recent years have engineers and scientists begun studying the role of log jams in stabilizing streambanks. Mimicking how these accumulations form and function is the basis for the concept and design of engineered log jams.

Engineered log jams are used to realign a channel or redirect flow away from a streambank to protect it from erosional forces. They are also used to increase channel roughness to reduce flow velocities and shear stress along eroding banks. Large-woody-debris jams create a hydraulic shadow, a low-velocity zone for some distance downstream that allows sediment to settle out and stabilize. By locating a log jam along an eroding bank, the bank downstream of the jam becomes a deposition zone rather than an erosion zone. The deposition zone tends to become vegetated and continues to grow in volume over time.

Prior to designing and constructing an engineered log jam as a bank-protection technique, it is important to understand the existing physical characteristics and geomorphic processes present at a potential project site and along the reach (see Chapter 2, *Site Assessment* and Chapter 3, *Reach Assessment* for guidance).

Engineered log jams are best applied on long, uniform bends in alluvial channels. They are also appropriate when the mechanism of failure is toe erosion since they provide roughness and redirect erosive flows away from an eroding bank. When applied along a bend, they are apt to grow significantly as they recruit wood, so changes to the opposite bank should be expected. Engineered log jams are also useful in degrading channels for capturing and storing sediment and large woody material.[3] They can slow the rate of erosion in an equilibrium channel that is migrating laterally or where there is potential for a chute-cutoff, though they still allow for gradual meander migration. Large-woody-debris jams occur naturally at the inlet of many side channels. Jams can be assembled at the inlet of pre-existing or constructed side channels to regulate the amount of flood flow entering the side channel. This protects the banks in the side channel, prevents the side channel from capturing the main channel and protects existing spawning and rearing habitat in the side channel.

Engineered log jams may be appropriate when the mechanism of failure is scour. They should be placed upstream from the scour hole to redirect flow away from the obstacle that is creating the scour or to dissipate some of the energy that is causing the scour. They should not be placed directly in a scour hole. In tight-radius bends or other constricted reaches, they may not be very effective, and their application can further exacerbate existing erosion problems or move them upstream. Care in sizing and spacing engineered log jams is crucial to avoid creating a constriction.

In aggrading channels, engineered log jams may be appropriate, depending upon the severity of aggradation. They can be effective strategically if placed in a mildly aggrading channel where they can collect and store sediment. Their presence in such circumstances will better define the low-flow channel. Engineered log jams also recruit floating, large woody debris, which reduces the likelihood of the jam becoming buried and ineffective over time. When a channel has been disturbed and is carrying a high bedload, jams can be constructed in upstream reaches to stabilize sediment movement. Over the long term, engineered log jams reduce aggradation and erosion in the downstream reach. These jams can be placed either at the bank or in midchannel.

Engineered log jams provide excellent fish habitat by developing deep scour pools and associated tailout spawning areas, as well as complex cover. The structural complexity and hydraulic diversity associated with log jams provide ideal habitat for a variety of life stages and species of fish. For these reasons, engineered log jams receive high marks as a habitat-restoration and mitigation tool.

To learn more about the applicability of engineered log jams based on the mechanism of failure and causes of streambank erosion, review the selection matrices found in Chapter 5, *Identify and Select Solutions*.

Emergency

Engineered log jams are not appropriate for emergency situations. They cannot be constructed quickly, nor can they be assembled during high-flow events.

Effects

Depending upon their size relative to the channel, the constriction caused by an engineered log jam may result in scour at the opposite bank or point bar. Engineered log jams generally produce scour adjacent to themselves. The scour at the margin of the jam, and the associated downstream deposition, moves the location of the thalweg away from an eroding bank. One observed effect is the tendency for a side channel to form on the back side of the jam, against the bank.[1] This is a result of the jam causing an obstruction to flows above the bankfull elevation. Jams tend to split the flow, and the flow directed along the bank may create a side channel. If side-channel development is anticipated and undesirable, extend the jam into the bank and floodplain, and anchor it to a stable location.

Engineered log jams offer a distinct advantage over most rock structures such as barbs and groins. As scour holes develop adjacent to the log jam, the interlocking nature of log jams allow them to deform and settle; effectively retaining the structural integrity of the structure.[2]

Design

Conceptual design drawings of engineered log jams are shown in *Figure 6-2, Engineered Log Jams* and *Figure 6-3, Engineered Log Jams.*

Stability

The design of an engineered log jam requires a thorough analysis of channel hydraulics, which should be conducted by a qualified engineer. Engineered log jams can be designed with or without the use of anchoring hardware. Properly designed and located log jams can be very stable with life expectancies equal to or exceeding the design life of traditional bank protection techniques (e.g., groins, drop structures, revetments).[2]

Stabilizing key members (large logs with rootwads attached) can be accomplished at most flows by the ballasting effect of large logs and/or boulders.[2] Determining the necessary ballast mass requires a detailed stability analysis of fluid drag, buoyancy, lift and friction-resisting forces, and weight of the ballast logs and/or boulders.[2] A structure is stable when the sum of the resisting forces exceeds the sum of the driving forces (e.g., drag, lift, and buoyancy). Hydraulic conditions often result in sediment deposition on the downstream side of a log jam. This deposition buries much of the wood and will increase the effective weight and, hence, the stability of the log jam. The process of deposition can occur naturally or be accelerated by placing excavated sediments during initial construction to bury the key members.[2]

Designing an unanchored, engineered log jam requires excavating the streambed to provide a trench for the key member(s). The depth of excavation depends on channel hydraulics, substrate characteristics, channel dimensions and the size of wood. Once a key member is placed in a trench, the trench is covered with excavated sediment to provide additional ballast and frictional resistance to drag forces. Large woody material (whole trees with rootwads attached) are stacked (stacked members) on the key members for ballast. Next, whole trees, logs and/or rootwads are racked (racked members) on the upstream side of the key-piece rootwad(s) The number of pieces racked against the rootwad(s) depends upon the need for immediate protection, channel dimensions and hydraulics, and the likelihood of recruiting additional debris.

Unanchored, engineered log jams must be dense, with racked and stacked pieces carefully interlocked. The more dense the rack, the less flow will pass through it, thereby increasing the stability of the log jam. Scour under part of a loosely assembled structure may destabilize it and allow portions to be washed away. Dense structures, on the other hand, act as a unit. They settle uniformly and hold ballast well.

Engineered log jams can be anchored with pilings (see *Figure 6-2, Engineered Log Jams*). In small-grained substrates, a row of log pilings can be driven vertically into the streambed using the excavator bucket. In larger substrate, pile-driving equipment may be required, as well as steel tips on the logs. The logs need to be long enough to extend below estimated scour depths. A second row of pilings should be driven into the streambed at least 20 feet downstream, and brace logs should be anchored between them. Large woody debris is then racked against the upstream side of the brace logs and the first row of pilings, just as they are for unanchored engineered log jams. The braces are needed because there is a limit to the size and, consequently, the strength of logs that can be driven with an excavator. The braces distribute the shearing force of the racked logs between the two rows of pilings. The upstream row of piles is in the area where scour will form around the log jam. The downstream row is positioned in the deposition zone, safe from the undermining effects of scour.

In cases where the substrate will not allow logs to be driven, steel pilings can be used. If they can be driven deep enough, a single row may be sufficient. The buildup of debris will eventually hide the pilings from view.

Other methods of anchoring include attaching cable to the key logs and using an adhesive (e.g., epoxy) to glue the cable to boulders for ballast. If possible, the boulders should be buried in the bed to act as deadman anchors. Another approach is to partially bury logs into the bank so that they still extend into the channel, perpendicular to the direction of flow. Logs are then racked against the upstream side of the partially buried log. Some sites may require brace logs and/or a rock toe as additional reinforcement. To learn more about how to anchor large woody debris, refer to Appendix I, *Anchoring and Large-Woody-Debris Placement*.

Dimensions and Orientation

The shape of engineered log jams depends upon channel hydraulics, desired results and cost. In naturally formed jams, the most stable configuration is one where key members are oriented parallel to the high flow, with their rootwads upstream. Racked wood is generally positioned perpendicular to the flow direction. In many cases, debris collects upstream against the bank and forms a concave shape (from plan view) that is more streamlined. Using different methods of anchoring the jam may allow different shapes and alignments to form, and collection of additional wood on the engineered log jam during floods will potentially change the shape and dimensions of the jam.

The correct spacing and dimensions of jams are closely related. When positioning a series of engineered log jams along an eroding channel bend, they should begin below the cross-over riffle at the head of the bend. Spacing should be similar to that recommended for groins, but bear in mind that engineered log jams may become longer than groins as woody material is captured and collected over time. Groins are discussed as a separate technique in this chapter. The effective length (L_e) of an engineered log jam is the distance the structure extends into the channel, measured perpendicular to the bank. It does not include that portion that is keyed into the bank. Effective length must be considered when establishing spacing requirements. The furthest upstream jam in a series should be expected to grow the most as it will intercept additional floating woody material before it reaches subsequent jams. This phenomenon allows increased spacing between the first and second structures. Downstream structures may accumulate debris, but it will probably collect at a slower rate than the first jam in the series. Expect the accumulation to occur in both the upstream direction and laterally. This growth must be anticipated and may present a problem if channel constriction is an issue.

The size of materials used in the engineered log jam will depend upon the method of anchoring. The required size of pieces will be based on the calculations of drag, friction, lift and buoyancy. It's also important to take into consideration the anticipated rate of wood decomposition, wood density and the length of project life. Racked pieces do not usually function as structural members of engineered log jams, so they can be any size, particularly if accumulation of additional debris on the rack is anticipated. Determining the correct size for structural members should be accomplished by a qualified engineer.

Biological Considerations

Mitigation Requirements for the Technique

Engineered log jams provide valuable fish and wildlife habitat. Because they are so valuable to fish and wildlife, only construction impacts need to be mitigated. Immediately following placement of engineered log jams, there may be temporary, short-term impacts on spawning. Existing spawning areas may shift or scour; while others may accrete with fines while new spawning areas are forming. It may take the channel a period of time to adjust to the jams. However, the long-term habitat benefits of engineered log jams far out-weigh these short-term impacts.

Construction-related impacts do, however, require mitigation. Care should be used in gaining equipment access to the site to minimize construction impacts.

Mitigation Benefits Provided by the Technique

The structural and hydraulic diversity that engineered log jams provide creates habitat for a multitude of fish species at nearly every stage of life. Engineered log jams create excellent cover, holding and rearing habitats. At the tailout from the scour hole created by an engineered log jam, spawning habitat may be created. The detritus they accumulate, particularly smaller twigs and leaves that decay rapidly, also serves as a food to some aquatic insects that fish consume.

Risk

Engineered log jams pose inherent risks to infrastructure and human stream users. These risks include:

- safety hazards caused by the log jams or the cables that anchor them (this risk can be somewhat reduced by placing warning signs upstream from the log jams to alert boaters),
- blockage of culverts or bridge openings by large woody debris that has been dislodged from a log jam upstream,
- unanticipated erosion across the channel or to the adjacent streambank,
- increased channel roughness and constriction, and/or
- increased flood stage.

Careful, well-calculated design and positioning of engineered log jams can minimize all of these risks.

Reliability/Uncertainty in Technique

The use of engineering log jams as a streambank-protection technique is relatively new, with little available research information to document their performance. Monitoring and performance reporting is encouraged to aid in further development of this technique by future practitioners. Appendix J, *Monitoring* provides more information on how to observe and record project performance over time.

Construction Considerations

Equipment and Materials Required

Large woody debris should be of a size (length and width) and species that can remain intact and stable for many years. Avoid using hardwood species such as alder or cottonwood, which decay rapidly. Coniferous species such as cedar, fir and pine are better choices. If sufficiently large key members are not available or can not be transported in one piece to the site, several trees could be cabled or pinned together to form a composite key member. Large and long logs imported from off-site locations may need to be cut into pieces for transport and then reassembled on site by splicing, gluing and tacking pieces back together. This technique has been tested and refined on the Stillaguamish River in Washington State for limited use.

Use of on-site wood resources can greatly simplify construction and reduce costs. Appropriating single logs from dry gravel bars is an option with minimal short-term impacts. Consider the density or loading of large wood in the reach before deciding to use on-site wood. If the channel is deficient of large wood, it may be necessary to import wood for the structure(s). One of the factors that will help determine whether off-site wood can and should be imported to the site is whether or not equipment can move wood of the required size and length from a distant site to the work site.

Wood buoyancy can be a problem during construction since much of the log needs to be installed below the water surface. To address this problem, the site may need to be dewatered to allow for placement and anchoring of large pieces. The use of previously saturated wood can simplify construction by reducing buoyancy problems during installation. See Appendix M, *Construction Considerations* for information about dewatering.

Turbidity may be a significant problem during installation due to the amount of digging in the channel bed required during installation. This can be avoided by dewatering the installation site, or by creating a coffer system that isolates the immediate site from flowing water.

Protection of the existing riparian zone is a high priority, particularly in drier climates where replacement of the canopy can take decades. The use of walking excavators, winches and hand labor may be required at some sites.

Timing Considerations

Construction should be conducted during a period where impacts to critical salmonid life cycles, such as spawning or migration, are avoided and when dewatering for construction is possible. Low-flow conditions are ideal for the placement of engineered log jams and may be essential for dewatering efforts. Dewatering eases installation and prevents siltation of the stream during construction. In-stream work windows vary among fish species and streams. Contact the Washington Department of Fish and Wildlife's Area Habitat Biologist for information on work windows (see Appendix B, *Washington Department of Fish and Wildlife Contact Information*). Further discussion of construction timing and dewatering can be found in Appendix M, *Construction Considerations.*

Cost

Costs for installing engineered log jams are site-specific and are affected primarily by availability of wood materials, dewatering capabilities and equipment access. Engineered log jams constructed in Washington State have ranged in cost between $1,800 to $80,000 to install.

Large woody debris can vary considerably in cost from virtually free (as locally salvaged wood), to quite costly (large-diameter, full-length cedar trees that may have to be sawn for transport and later re-assembled). Large woody debris can cost between a few hundred dollars to a thousand dollars per piece. Equipment costs can also be substantial, especially when specialized equipment is required, such as helicopters for wood delivery, spider hoes for access and considerable manual labor for installation. Appendix L, *Cost of Techniques,* provides additional information and a case study on estimating project costs.

Operation and Maintenance

Maintenance of engineered log jams includes replacement, realignment or removal of pieces following storm events equal to or greater than what they were designed to withstand. If anchored, the anchoring hardware may also need to be readjusted or replaced. Any biotechnical bank protection between the log jams will also need maintenance.

Monitoring

Monitoring engineered jams should determine if the structures are performing in accordance with design flow criteria and whether they are providing the habitat and bank protection desired. Because large-woody-debris projects generally involve impacts to the channel and banks, they will require comprehensive monitoring of both channel and bank features, with particular attention to habitat monitoring. For a comprehensive review of habitat-monitoring protocols, refer to *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest –Directory and Synthesis of Protocols and Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia.*[4] Habitat-monitoring protocols will likely require a monitoring schedule that is more comprehensive than that required for the integrity of the structure.

Monitoring to evaluate structural integrity should be conducted annually and following any flow events that meet or exceed design flow events. This can be accomplished by surveying precise locations of key members relative to a stationary point on shore by determining whether the jam has lost key members and by conducting a visual inspection of anchoring systems.

Details on how to develop a monitoring plan can be found in Appendix 10, *Monitoring*.

Examples

References

[1]Abbe, T. B. and D. R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research and Management,

[2]Abbe, T. B, D. R. Montgomery, C. Petroff. 1997 Design of Stable In-Channel Wood Debris Structures for Bank Protection and Habitat Restoration: An Example from the Cowlitz River, WA. Manuscript submitted to proceedings of the conference on Management of Landscapes Disturbed by Channel Incision.

[3]Shields F. D., N. Morin, C. M. Cooper. March 2001. Design of Large Woody Debris Structures for Channel Rehabilitation. Proceedings of the Seventh Federal Interagency Sedimentation Conference. Reno, Nevada. Pg 42-49.

[4]D'Aoust, S., R. G. Millar. 2000. Stability of Ballasted Woody Debris Habitat Structures. Journal of Hydraulic Engineering.

[5]Johnson, D., J. A. Silver, N. Pittman, E. Wilder, R. W. Plotnikoff, B. C. Mason, K. K. Jones, P. Roger, T. A. O'Neil, and C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest-Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, WA.

Examples of naturally occurring log jams.

Section Three.

This section includes the Naugatuck River mainstem from the John Toro Sports Complex downstream to the Route 118 bridge crossing, Harwinton. The river reach overall is in a natural condition however, several river reaches apparently have been altered likely from sand or gravel excavation. Large habitat features (e.g. boulders) are notably lacking. There is light to moderate development within the riparian corridor. The following habitat enhancement measures are recommended for Section Three:

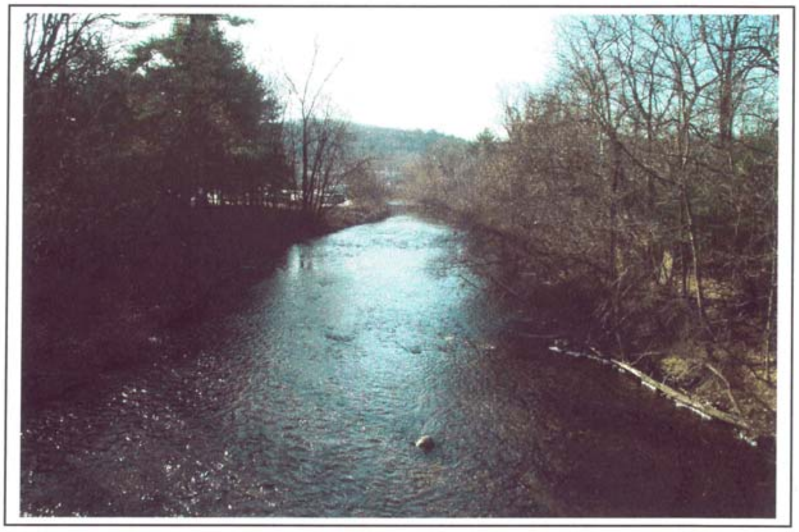
- Install random boulders or boulder clusters in sections of the river which are moderate in grade and have surface flow of shallow or deep riffle. The boulders will diversify instream habitat and water flow patterns. Design typicals for random boulders follow.

- Place J-Hook structures alternating along the river banks to create sinuosity to the river channel and to force the development of a low flow channel. The J-Hook structures should be used in conjunction with the random boulders being placed in sections of the river which are moderate in grade and have surface flow of shallow or deep riffle. Design typicals for J-Hook structures follow.

- Extensive deposits of sand are found within a long section of the Naugatuck River immediately upstream of the Route 118 crossing. The river channel width should be narrowed to increase scour of the sand deposits. Conifer tree revetments placed in an alternate or opposing would be well suited to the site. Design typicals for conifer tree revetments follow.

- Land along the river corridor should either be purchased or be preserved by easement to maintain or to provide an opportunity to enhance the integrity of the riparian habitat.

The following photographs depict conditions along and within the Naugatuck River through *Section Three*.



Naugatuck River downstream of the Bogue Road bridge, Torrington.

Naugatuck River downstream of the Bogue Road bridge, Torrington.

Naugatuck River immediately upstream of the Route 118 crossing, Harwinton.

Naugatuck River immediately upstream of the Route 118 crossing, Harwinton.

RANDOM BOULDER PLACEMENT

Design typicals for construction

MGWC 3.1: BOULDER PLACEMENT

Improvement/creation of aquatic habitat

DESCRIPTION

The work should consist of placing boulders in stream channels to encourage riffles and pools and to provide habitat and spawning areas for aquatic life.

EFFECTIVE USES & LIMITATIONS

When properly utilized, boulder placements create small scour pools and eddies which can be used as rearing areas for salmonids and other fish. Additionally, they are sometimes used to restore meanders and pools in channelized reaches and to protect eroding streambanks by deflecting flow. Boulder placements are most effective when used in the following conditions:

- moderately wide, shallow, high velocity streams with gravel or cobble beds;
- stream reaches with pool densities less than 20 percent; and
- Rosgen stream types B3 and B4.

Boulder placements should be avoided in the following areas:

- channels which do not have sufficient particle size ranges to develop armor layers such as streams with fine, noncohesive bed material such as sand or small gravel that will scour deeply and rapidly, thereby undermining and burying boulder groups,
- channels with highly erodible embankment soils or soils with an extreme excess of one texture or size range unless measures are taken to adequately reinforce the banks;
- low-velocity streams with a mean velocity of less than about 2 feet (0.6 meters) per second, since sufficient scour pools cannot be developed;
- newly formed stream curvatures since boulder clusters can alter natural patterns of stream meander resulting in erosion and scour problems;
- and overwide streams or streams with large bedload.

MATERIAL SPECIFICATIONS

Boulders should be chosen based upon stream size, flow characteristics, bed stability, desired habitat effects such size and position of resultant scour pools and eddies, and the capacity of available heavy equipment. Boulder diameters of 2 to 5 feet (0.6 to 1.5 meters) and volumes of 35 to 70 cubic feet (1 to 2 cubic meters) have been suggested for this restoration practice. It is recommended, however, that boulders be sized according to guidelines developed for riprap placement found in MGWC 2.1: Riprap and that footers be provided. However, boulders should not be more than 25 to 30% of bankfull depth after partial embedment. Blocky, angular rock should be used in place of round rock when feasible.

Boulder diameters should be no more than 1/8 the width of the stream. If a larger size is to be used, bank stabilization measures should be considered.

Approximate Cost ($1999): $583 per ten boulders

MGWC 3.1: BOULDER PLACEMENT

INSTALLATION GUIDELINES

All erosion and sediment control devices, including dewatering basins, should be implemented as the first order of business according to a plan approved by the WMA or local authority. Boulder placement should proceed as follows (refer to Detail 3.1):

1) Complete the work during periods of low flow to ensure proper location within the stream channel and to facilitate the movement of heavy equipment.

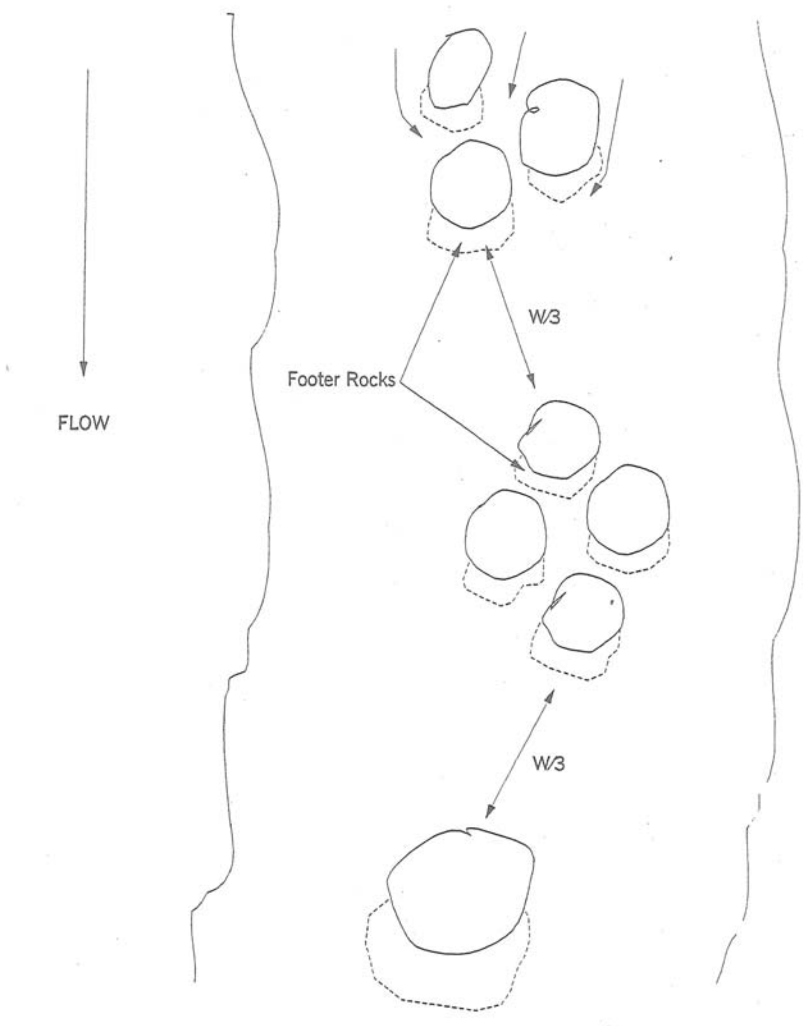
2) Boulders shall be placed on top of footer rocks(s) so that the boulder is offset in the upstream direction.

3) Place clusters comprised of 3 to 5 boulders arranged in a triangular configuration in the downstream half of long riffles, sufficiently far from the associated pool, and embed them in the stream bed to increase the cluster's stability. The substrate in which boulders are placed should be competent enough to resist undercutting.

4) Space multiple boulder clusters constructed in the same stream section a minimum of 1/3 of a stream width apart. Avoid an overabundance of newly placed boulders since this can inhibit the natural process of sediment flushing.

Maryland's Guidelines To Waterway Construction

DETAIL 3.1: BOULDER PLACEMENT



J-HOOK STRUCTURES

Design typicals for construction

MGWC 3.4: J-Hook Vanes

Rigid engineering techniques for bank stability and creation of flow diversity

Description

The work should consist of installing rock vanes to direct normal flows away from unstable stream banks and to improve/create aquatic habitat by enhancing flow diversity through the formation of scour pools.

Effective Uses & Limitations

J-hook vanes are single-arm structures whose tip is placed in a "J" configuration and partially embedded in the streambed such that they are submerged even during low flows. When properly positioned, J-hook vanes induce secondary circulation of the flow thereby promoting the development of scour pools. J-hook vanes can also be paired and positioned in a channel reach to initiate meander development or migration.

Additionally, the following limitations apply to J-hook vanes:

- J-hook vanes should not be used in unstable streams unless measures have been taken to promote stream stability so that it may retain a constant planform and dimension without signs of migration or incision
- J-hook vanes are ineffective in bedrock channels since minimal bed scouring occurs. Conversely, streams with fine sand, silt, or otherwise unstable substrate should be avoided since significant undercutting can destroy these measures.
- J-hook vanes should not be used in stream reaches which exceed a 3% gradient.
- J-hook vanes should not be used in streams with large sediment or debris loads.
- J-hook vanes are best suited to Rosgen types B2-B5 and C2-C4.
- Banks opposite these structures should be monitored for excessive erosion.

Material Specifications

Materials for vanes should meet the following requirements:

Large Rocks: Large rocks for vane construction should be sized to withstand the design flood according to MGWC 2.1: Riprap and Figure 2.1. In general, rock sizes should have a minimum of 2.5 median diameter or weigh a minimum of 200 pounds. Footer rocks should be long and flat.

Installation Guidelines

All erosion and sediment control devices, including dewatering basins, should be implemented as the first order of business according to a plan approved by the WMA or local authority. Recommended construction requirements for J-hook vanes are as follows (refer to Detail 3.4):

1. The stream should be diverted according to an approved practice, and the construction area should be dewatered.

2. Combinations of J-hook vanes should be installed according to a plan approved by the WMA. When placed to initiate meander development, vanes should be spaced 5 to 7 bankfull widths apart and arranged on alternating banks. Vanes used for habitat creation should be spaced 1 or more channel widths apart depending upon the pattern of scour pools in natural reference reaches. Additionally, the following primary design criteria need to be satisfied: shape and orientation, height, and length.

MGWC 3.4: J-HOOK VANES

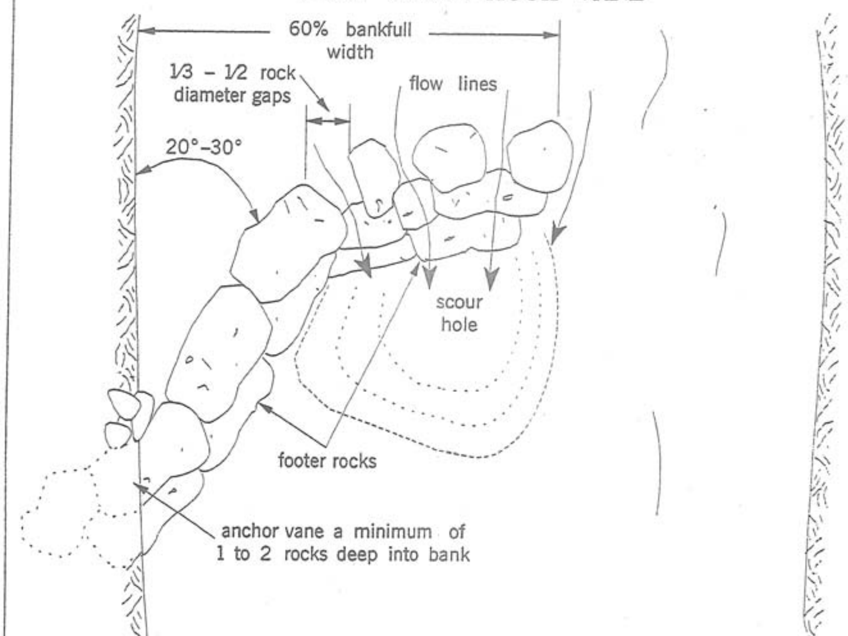
- *Shape and orientation.* Vanes should be angled 20 to 30 degrees from the upstream bank.
- *Height.* The bank-end of the vane should be at the bankfull elevation and the tip of vane should be partially embedded in the streambed such that it is submerged even during low flows. This tip should be placed to form a semi-circular structure at the streambed. The vane arm should be placed at a vertical angle of 3% to 7%.
- *Length.* Vanes should span a maximum of 1/3 of the channel width, depending on the channel size. J-hooks may span up to 60% of the channel width. The larger the channel, the shorter the vane should be relative to the channel width.

3. When installing vanes, the bank end of the structure should be firmly anchored a minimum of 1-2 rocks into the bank.
4. Vane rocks should be placed on top of footer rocks such that each vane rock touches adjacent rocks and rests upon two halves of each footer rock below it, and so that the vane rock is offset in the upstream direction. Vane rocks shall be shingled upstream.
5. All disturbed areas should be permanently stabilized in accordance with an approved sediment and erosion control plan.

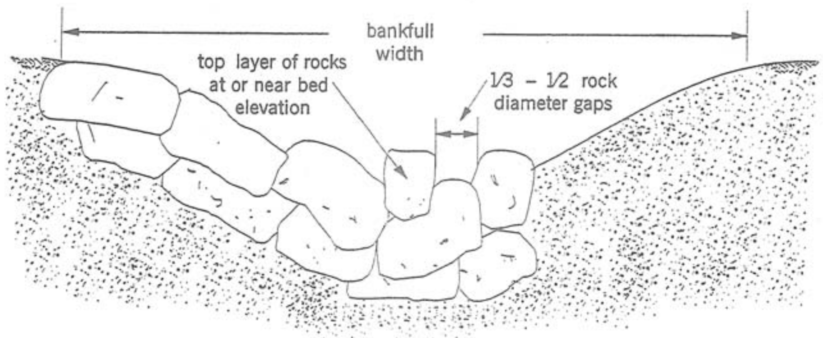
Maryland's Guidelines To Waterway Construction
DETAIL 3.4(a): J-HOOK VANES

Section & Plan Views Adapted From Rosgen (1999)

PLAN VIEW: J-HOOK VANE



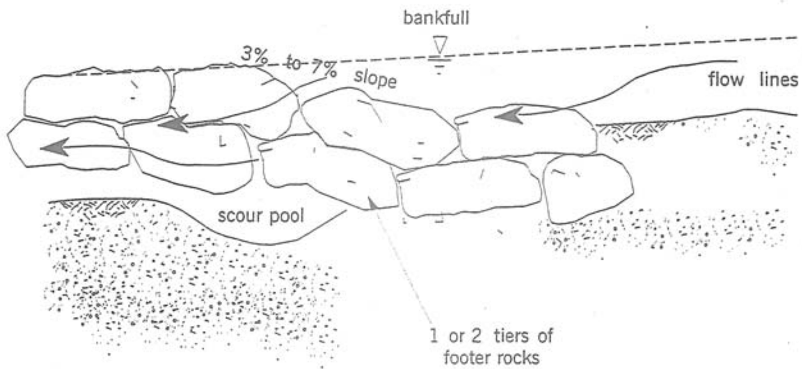
SECTION VIEW: J-HOOK VANE



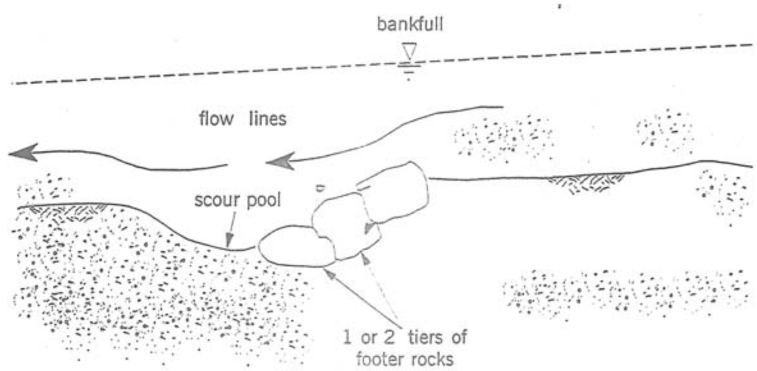
Maryland's Guidelines To Waterway Construction
DETAIL 3.4(b): J-HOOK VANES

Section & Plan Views Adapted From Rosgen (1999)

PROFILE VIEW OF VANE ARM



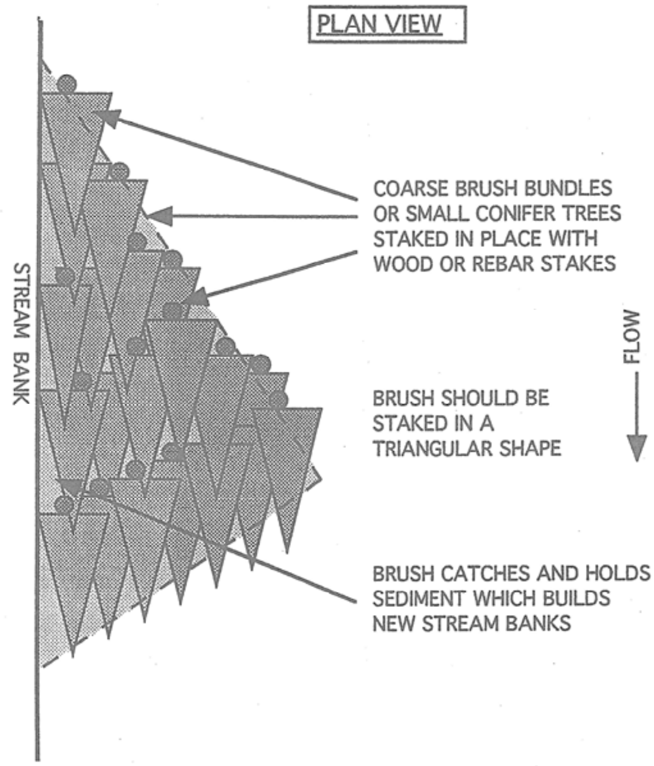
PROFILE VIEW OF J-HOOK

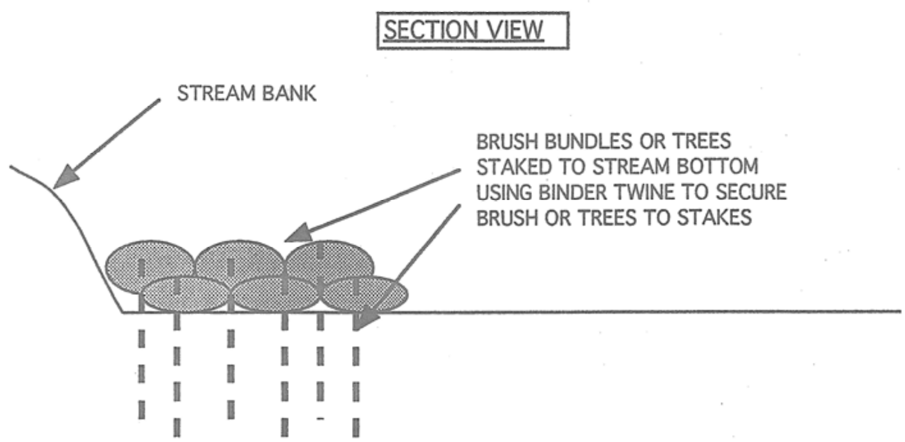


CONIFER TREE REVETMENT

Design typicals for construction

BRUSH DEFLECTOR





Wildlife Habitat

Wildlife Habitat

Introduction

This section will address the wildlife habitat quality, habitat enhancement opportunities, potential wildlife impacts, and reducing wildlife-related impacts along the Torrington stretch of the Naugatuck river.

Property along rivers including its vegetation, soil characteristics, patch size and human disturbance factors weighs heavily on the quantity and quality of wildlife species that utilize it. In urbanized cities such as Torrington, direct impacts to wildlife in and along the Naugatuck river have included bankside vegetation removal and alteration, channelization, floodplain filling, culverting, invasive non-native plant establishment, urban runoff, littering and roaming unleashed house pets.

Site Inspection Findings

The following animals were recorded from direct and indirect observations of their presence during two field inspections during the winter season:

- **In the river:** common merganser, mallard, Canada geese
- **Along the river (<50 feet from river edge):** American robin, Northern cardinal, black-capped chickadee, tufted titmouse, white-breasted nuthatch, downy woodpecker, mourning dove, red-tailed hawk, turkey vulture, American crow, ring-billed gull, house sparrow, European starling, Pigeon, white-tailed deer, gray squirrel, eastern coyote, cottontail rabbit, and meadow vole.

If wildlife surveys are conducted during other seasons of the year the species list would undoubtedly grow, especially during spring and fall bird migration.

Discussion of Habitat Conditions

Section 1-A
Stillwater Pond to Route 4

The eastern side of the river has a continuous forested area. This forest area of softwoods and mixed hardwood has a large potential for interior forest songbird nesting habitat and migration stopover habitat. See the forestry section for woody plant species composition.

Habitat Management Issues for Section 1-A

Issue 1 - Eastern Hemlock decline due to woolly adelgid and elongated hemlock scale. Loss of evergreen cover from the defoliation of hemlock degrades the value of this habitat for winter cover, predator cover and early spring nesting habitat for some wildlife especially songbirds and owls.
Issue 2 - Natural habitat on the western side of the river has been heavily developed with buildings and associated land clearing and filling.

Habitat Management Strategies for Section l-A

Management Strategy 1- As the hemlock in this area decline or die off, there are several options that the landowner can employ.

A-Doing nothing and allowing the hemlock to die or decline will benefit wildlife that depend on cavities and decayed wood. On the negative side, too many trees dying in an area may cause danger for hikers and steeply sloped areas can experience increased soil erosion.

B-Employ a professional forester to inventory hemlocks and prescribe a salvage cut for hemlocks. A minimum of three to five snags should be left per acre of forest for cavity-dependent wildlife.

C-Encourage white pine through the use of forest thinnings can help maintain an evergreen forest component. White pine is not as shade tolerant and doesn't maintain its needles on lower limbs but in areas where hardwood competition is relieved they can get quite dense. Timing of forest thinnings with good pine cone years can help recruitment of pine seedlings for the future forest.

D-Plant evergreens in clusters of 5 to 9 to create dense small patches of evergreen in suitable soils and light conditions. Evergreen species such as white pine, white spruce, Norway spruce, red cedar, or white cedar. These plantings can help mitigate the loss of hemlock cover.

Management Strategy 2 - Properties along the western borders can employ naturalistic landscape management techniques to improve habitat conditions.

A- Maintain a vegetative buffer (whatever a landowner is willing to give) along the river's edge. Create a vegetative buffer of native trees, shrubs and wildflowers. A common practice in the past was to remove native vegetation along the river and plant lawn down to the rivers edge. When this practice was repeated along a river, it ultimately caused weakening of the river's banks, increased runoff and reduction in the diversity wildlife habitat. Landowners who are amenable to reducing lawn and recreating a wooded buffer or, at the minimum, a wildflower meadow that is mowed one a year can help improve habitat conditions along this stretch of the river.

B- Plant a variety of native trees, shrubs and wildflowers along the river in open areas to re-establish a wooded buffer to the river.

Riparian Zone along River

Plant natives such as:

Silver maple *(Acer saccharinum)*
Red Maple *(Acer rubrum)*
American sycamore *(Platanus occidentalis)*
Red Mulberry *(Morus rubra)*
American Basswood *(Tilia americana)*
Eastern cottonwood *(Populus deltoides)*
Swamp White oak *(Quercus bicolor)*
Hornbeam *(Carpinus caroliniana)*
Pin Oak *(Quercus palustris)*

Shagbark hickory *(Carya ovata)*
Silky dogwood *(Cornus amomum)*
Spicebush *(Lindera benzoin)*
Winterberry *(Ilex verticillata)*
Highbush blueberry *(Vaccinium corymbosum)*,
Sweet pepperbush *(Clethra alnifolia)*
Speckled alder *(Alnus rugosa)*
Swamp azalea *(Rhododendron viscosum)*
Arrowwood viburnum *(Viburnum recognitum or dentatum)*
Swamp rose *(Rosa palustris)*
Common elderberry *(Sambucus canadensis)*
Cardinal flower *(Lobelia cardinalis)*
Jewelweed *(Impatiens capensis)*
Joe-Pye weed purple *(Eupatorium purpuleum)*
Joe-Pye weed spotted *(Eupatorium maculatum)*
New York Ironweed *(Veronia noveboracensis)*
Blueflag iris *(Iris versicolor)*
Wild bergamont *(Monarda fistulosa)*
Turtlehead *(Chelone glabra)*
Tussock sedge *(Carex stricta)*.

Section 1- B
Route 4 to Wolcott Avenue Bridge

This area is predominantly developed with small pockets of forest cover. The eastern side has the largest forest patch. This section contains non-native invasives including Norway maple *(Acer platanoides)*, tree of heaven *(Ailanthus altissima)*, Black locust *(Robinia pseudoacacia)*, White mulberry *(Morus alba)*, winged euonymus *(Euonymus alata)*, Autumn Olive *(Elaeagnus umbellata)*, Tartarian honeysuckle *(Lonicera tartarica)*, Japanese barberry *(Berberis thunbergii)*, Oriental bittersweet *(Celastrus scandens)*, Multiflora rose *(Rosa multiflora)*, Japanese knotweed *(Fallopia japonica)*, and Garlic mustard *(Alliaria petiolata)*.

Habitat Management Issues for Section 1-B

Issue 1 - Invasive non-natives are found throughout and displacing native vegetation.

Issue 2 - Limited undeveloped areas along river.

Habitat Management Strategies for Section 1-B

Management Strategy 1- With landowner's consent, a plant inventory of the river's banks and land adjoining it (up to 100 feet away) should be done to ascertain the location of invasives and plotted accurately on maps. Non-native invasive plants should be marked in the field using paint and/or ribbon to demarcate them. A plan for removal using mechanical or chemical means should be developed to manage and reduce the amount of invasives in the river corridor. "Seed" plants should be targeted first for removal or deadening in place using axe or herbicide. [More information regarding vegetation management using herbicides can be obtained from Dr. Todd Mervosh of the CT Agricultural Experiment Station in Windsor]. Planting or seeding in native trees, shrubs and herbaceous materials can be used to restore areas where invasives were removed. In the case of the use of mechanical removal of stumps or vegetation, quick soil stabilization should be a priority, followed by native plant restoration.

Management Strategy 2 - Protect remaining undeveloped land adjoining river using purchase of development rights, conservation easements, and land purchases. Long range protection of the river will depend greatly on preventing future disturbances and loss of habitat. A mailed survey to landowners of the adjoining land of the river may help to ascertain their willingness to permit conservation measures on their properties up to and including conservation easements. Conservation easements should be written to allow proper vegetative management and modern wildlife management practices to occur on the land. This will allow the ability to manage future issues that may come up that aren't around now.

Management strategy 2 for subsection 1-A to create better buffers along the river applies to this section as well..

Section 2

Wolcott Avenue Bridge to Palmer Bridge Road in Torrington

Subsection 2-A
Wolcott Avenue Bridge to Church Street Bridge

Habitat Management Issues for Section 2-A

Issue 1- This section is intensely developed with densely packed housing and commercial development along the banks of the river.
Issue 2- Restoration or improvement of riparian habitat is very limited.

Habitat Management Strategies for Subsection 2-A

Management Strategy 1- Educate landowners along the river to reduce or strictly monitor fertilization of lawns to reduce nutrient runoff into river.

Management Strategy 2 - Only 10 percent of this area is forested (according to Team forester's report). Inventory and management of invasive non-native plants should continue in this section like other sections. Landowner education seminars may be needed to help get conservation ideas and measures incorporated into their properties.

Subsection 2-B Church Street Bridge to Palmer Street Bridge

Habitat Management Issues for Subsection 2-B

Issue 1- This section is intensely developed with densely packed housing and commercial development along the banks of the river.
Issue 2- Restoration or improvement of riparian habitat is very limited.

Habitat Management Strategies for Section 2-B

Management Strategy 1- Educate landowners along the river to reduce or strictly monitor fertilization of lawns to reduce nutrient runoff into river.

Management Strategy 2 - Inventory and management of invasive non-native plants should continue in this section like other sections. Landowner education seminars may be needed to help get conservation ideas and measures incorporated into their properties. Wherever possible seek opportunities to replant some of the river's edges with native vegetation and create wooded buffers or wildflower patches.

Section 3
Palmer Road Bridge in Torrington to Route 118 in Litchfield

Section 3-A and 3-B Palmer Road Bridge to Route 118 in Litchfield

Habitat Management Issues for Subsection 3-A and 3-B

Issue 1- Municipal recreation area with limited vegetative woody cover along river.
Issue 2- All-terrain vehicle abuse of adjoining properties and river buffer.

Habitat Management Strategies for Section 3-A and 3-B

Management Strategy 1- On municipally-owned property, woody vegetation can be restored along river edges to improve habitat and attenuate potential runoff.

Management Strategy 2 - Landowner participation is necessary in order to tackle illegal ATV problems. Is the use of the properties being sanctioned by the landowner? Is it an absentee landowner? Has the landowner requested assistance to curtail ATV use of the properties involved? Enforcement by local authorities may be limited, however collaboration between the various departments of the town may be needed to get a handle on the extent of the illegal use of the properties involved and enforcement of trespass laws. Educating ATV users about limiting the number of trails and using only those trails outside of the regulated areas may also be a strategy to gain compliance. Soil erosion can be reduced using various techniques including revegetation and/or trail dressing with gravel or other appropriate materials. Limiting access using barriers of wood, boulders or earth piles. Once trail use of regulated areas is reduced or eliminated then revegetation of those areas can be started using grasses and clovers to quickly establish vegetation followed by planting trees and shrubs to impacted areas.

Discussion and Conclusion

River buffers also known as river greenways, provide a multitude of environmental benefits. For wildlife, they can serve as pathways for spring and fall migration. They can provide resting, feeding and shelter during the migration period. For local wildlife, river buffers may be a major part of their warm season nesting habitat. River buffers that have been disturbed, degraded or altered can be restored by replanting with native vegetation or allowing natural succession to occur through abandonment of mowing. An inventory of non-native invasive vegetation and their selective removal using mechanical or herbicidal control may be necessary in some segments of the river's adjoining habitats in order to restore habitat quality. Riparian buffers play an important role in the maintenance of water quality, aquatic habitat, and quality habitat (Thomas et al. 1979, Naiman et al. 1993, Stocek 1994). Opportunistically improving habitat along the Naugatuck will benefit a variety of wildlife species including migratory and resident species. Combining an inventory of existing conditions and opportunistically improving habitat conditions for wildlife using native plantings, managing invasive nonnative vegetation, and habitat protection using conservation easements will improve biodiversity and environmental conditions of this stretch of the Naugatuck river.

Time constraints did not allow for a more thorough investigation of the river area. Local, more site specific recommendations for habitat enhancement can be made available upon request.

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Thomas, J.W., C. Maser, ad J.E. Rodiek. 1979. Riparian zones. Pages 40-47 n J.W. Thomas, Editor. Wildlife Habitats in managed forests: the Blue Mountains of Oregon and Washington, U.S . Forest Service Agricultural Handbook 553.

The Natural Diversity Data Base

The Natural Diversity Data Base

The Natural Diversity Data Base and Files regarding the project area have been reviewed. According to our information, there are no known extant populations of Federal, or State Endangered, Threatened or Special concern Species that occur within the project boundaries. However, our information indicates that State Endangered *Pooceetes gramineus* (vesper sparrow) nested in 1984 at a site in close proximity to this proposed greenway corridor.

Natural Diversity Data Base information includes all information regarding critical biological resources available to us at the time of the request. This information is a compilation of data collected over the years by the Natural Resources Center's Geological and Natural History Survey and cooperating units of DEP, private conservation groups and the scientific community. This information is not necessarily the result of comprehensive or site-specific field investigations. Consultations with the Data Base should not be substitutes for on-site surveys required for environmental assessments. Current research projects and new contributors continue to identify additional populations of species and locations of habitats of concern, as well as, enhance existing data. Such new information is incorporated into the Data Base as it becomes available.

Please be advised that this is a preliminary review and not a final determination. A more detailed review may be conducted as part of any subsequent environmental permit applications submitted to DEP for the proposed site.

Forestland Review

Forestland Review

The study area is a 31,680 feet (six miles) by 1,000 foot corridor along the river beginning at the Stillwater Pond Dam in Torrington and ending just south of the Route 118 Bridge in Litchfield. This area totals 731 acres of which 188 acres (26%) can be considered forested. The majority of the forestland is on or adjacent to the riverbank.

The study area is broken down into three sections; each section is further reduced to subsections. A total of eight parcels are defined.

The forest vegetation descriptions for each parcel are as follows:

Section One

Section One begins at the Stillwater Pond Dam on Stillwater Trail and ends at the Wolcott Avenue Bridge in Torrington. The total length of the section is 10,500 feet. The area is 241 acres of which 102 acres (42%) could be considered forested.

Subsection 1-A is a 6,000-foot long portion of the river starting at Stillwater Trail and ending at the Route 4 bridge. The total area of the parcel is 138 acres of which 81 acres (59%) is forested.

The eastern side of the river's corridor contains 69 acres of continuous native forest cover. The cover type is Softwood/Mixed Hardwood. The softwood species are hemlock and scattered white pine. The mixed hardwood species are white ash, aspen, beech, black birch, white birch, yellow birch, black cherry, elm, red maple, sugar maple, chestnut oak, red oak, white oak, yellow poplar and shadbush. The trees are sawtimber size. The shrubs present are mountain laurel and witch hazel. The hemlock trees are infested with elongated hemlock scale and hemlock wooly adelgid; both are exotic sap-sucking insects.

The western side's land-use is predominantly residential. There are 12 acres of non-continuous forest cover. This cover consists of yard and street trees of native and non-native species. The non-native species are black locust, Norway maple, northern catalpa, Norway spruce, blue spruce, and Douglas fir.

Subsection 1-B is a 4,500-foot portion of the river from the Route 4 bridge south to the Wolcott Avenue Bridge. The total area is 103 acres of which 21 acres (20%) is forested. The predominate land use of the area is a mixture of residential, commercial and industrial.

The eastern portion's largest continuous piece of forest cover is a nine-acre plot located between the river and a canal. The cover type is a Mixed Hardwood poletimber stand. The main canopy contains black locust, eastern cottonwood, elm, sycamore, and northern catalpa. The understory contains staghorn sumac. The remaining two acres of tree growth is along the riverbank and scattered around the developed area. The species present are Norway maple, silver maple, sugar maple, red maple, boxelder, white ash, willow, red oak, white oak, aspen, white pine, and hemlock. On the western bank, the largest continuous forest cover is a seven acre parcel on the Charlene Susan Besse Park located on the west side of Riverside Avenue. This parcel contains tree species such as white pine, hemlock, black birch, red oak, red maple, hickory, and sugar maple. The tree size is small sawtimber and poletimber.

Section Two

Section Two begins at the Wolcott Avenue Bridge and ends at Palmer Bridge Road in Torrington. The total length of the section is 10,500 feet. The area is 241 acres of which 26 acres (11%) could be considered forested.

Subsection 2-A is a 3,000-foot portion of the river from the Wolcott Avenue Bridge to the Church Street Bridge. The total area of the parcel is 69 acres of which seven acres (10%) is forested. The predominant land use of the area is residential, commercial and industrial. The eastern portion of the subsection has a five-acre strip of forest cover along the riverbank. The Mixed Hardwood forest cover has sawtimber sized trees of black locust, northern catalpa, eastern cottonwood, red maple, sugar maple, Norway maple, silver maple, boxelder, elm, white ash, willow, and red oak. The western portion of the subsection has a two-acre strip of forest cover between the riverbank and Riverside Avenue. The trees are of the same type and size as the eastern portion.

Subsection 2-B is a 4,500-foot portion of the river from the Church Street Bridge to the East Albert Street Bridge. The total area of the subsection is 103 acres of which six acres (6%) could be considered forested.

The land use of the area is highly urbanized. After the 1955 Flood the U.S. Army Corps of Engineers (ACE) channeled and contained the river by constructing concrete walls and earthen dikes. The ACE requires the City of Torrington to maintain the integrity of the flood control structures by periodically cutting the woody growth. This maintenance regime has given rise to a sapling sized tree cover in a narrow strip along the banks. The tree species noted were elm, aspen, black locust, eastern cottonwood, northern catalpa, black cherry, pin cherry, willow, sycamore, white ash, red maple, sugar maple, Norway maple, boxelder, scarlet oak, and gray birch. Shrub species present are staghorn sumac, dogwood, and multiflora rose. Vine species present are grape, and Asiatic bittersweet.

Subsection 2-C is a 3,000-foot portion of the river from the East Albert Street Bridge to Palmer Bridge Road. The total area of the subsection is 68 acres of which 13 acres (19%) could be considered forested.

The land use of the area is residential, commercial, and industrial. Flood control dikes that are periodically cleared of woody vegetation also contain the riverbed in this area. There are 10 acres of Mixed Hardwood sapling sized forest cover between the dikes. The species composition is the same as found in Subsection 2-B. Beyond the dikes, there are three acres of Mixed Hardwood and Softwood sawtimber sized tree cover in and around the developed area. The tree species present are Norway maple, black locust, eastern cottonwood, white oak, sugar maple, hemlock, and white pine.

Section Three

Section Three begins at Palmer Bridge Road in Torrington and ends just south of the Route 118 Bridge in Litchfield. The total length of the section is 11,000 feet. The total area of the section is 252 acres of which 60 acres (24%) could be considered forested.

Subsection 3-A is a 1250-foot portion of the river from Palmer Bridge Road to the sewer line crossing at the Toro Sport Complex. The total area of the subsection is 29 acres of which seven acres (24%) could be considered forested. The land use of the area is residential, commercial, industrial, and a municipal recreation area. The riverbed in this subsection is the same as in Subsection 2-C. There are seven acres of Mixed Hardwood sapling-sized forest cover between the dikes. The tree species present are elm, aspen, black locust, eastern cottonwood, northern catalpa, black cherry, pin cherry, willow, sycamore, white ash, red maple, sugar maple, Norway maple, silver maple, boxelder, scarlet oak, red oak, white oak, gray birch, white birch, and flowering dogwood. Shrub species present are staghorn sumac, multiflora rose, and Japanese barberry. Vine species present are Asiatic bittersweet, grape, and poison ivy.

Subsection 3-B is a 4,250-foot portion of the river from the sewer line crossing at the Toro Sports Complex in Torrington to the Bouge Road Bridge in Harwinton. The total area of the subsection is 97 acres of which 25 acres (26%) could be considered forested. The land use of the area is residential, commercial, and industrial, including a private cemetery, a wood waste processing facility, a municipal recreation area, and a municipal sewage treatment plant. There are two distinct forest cover types in this subsection, the Floodplain forest and the Mixed Hardwood and Softwood forest.

The Floodplain forest is comprised of seven acres of Mixed Hardwood sawtimber sized trees that are tolerant of seasonal flooding and poorly drained soils. These tree species are silver maple, red maple, Norway maple, boxelder, elm, eastern cottonwood, northern catalpa, and black willow. Shrub species present are speckled alder, dogwood, willow, multiflora rose, and winged euonymus. Vine species present are Asiatic bittersweet, grape, and poison ivy.

The Mixed Hardwood and Softwood forest contains 18 acres of small sawtimber and poletimber sized trees. The mixed hardwood species are aspen, black locust, red maple, sugar maple, white ash, sycamore, hickory, black cherry, red oak, scarlet oak, white oak, white birch, gray birch, black birch, eastern cottonwood, boxwood, sassafras, and shadbush. The softwood species are hemlock, white pine, and pitch pine. Softwood species that were planted are Norway spruce, white spruce, and Scotch pine. The lower canopy contained trees and shrubs species such as American hornbeam, dogwood, witch hazel, winterberry, staghorn sumac, multiflora rose, Japanese barberry, winged euonymus, autumn olive, spicebush, and yew. The vine species present are Asiatic bittersweet, poison ivy, grape, and Virginia creeper.

There is a considerable amount of All Terrain Vehicle (ATV) use in this subsection. There are trails on both sides of the river and several crossings of the river.

Subsection 3-C is a 5,500 foot section of the river starting at the Bouge Road Bridge in Harwinton and ending just south of the Route 118 Bridge in Litchfield. The total area of the subsection is 126 acres of which 28 acres (22%) could be considered forested. The primary land use on the western side of the river is commercial, industrial, and residential. The eastern side's primary land use is a sand and gravel operation and the Route 8 corridor. There are two forest cover types in this subsection, the Riverbank forest and the Mixed Hardwood and Softwood forest.

The Riverbank forest is 19 acres of small sawtimber and poletimber sized trees. The species found in this cover type are black locust, eastern cottonwood, northern catalpa, red maple, sugar maple, Norway maple, silver maple, boxelder, black birch, gray birch, white birch, yellow birch, red oak, scarlet oak, white oak, aspen hickory, white ash, black cherry, elm, sycamore, willow, tree-of-heaven, white pine, and Scotch pine. Shrub species present are staghorn sumac, multiflora rose, Japanese barberry, autumn olive, winged euonymus, speckled alder, dogwood, honeysuckle, spicebush, and winterberry. Vine species present are Asiatic bittersweet, poison ivy, Virginia creeper, and grape.

The Mixed Hardwood and Softwood forest is nine acres of small sawtimber and poletimber sized trees. The majority of the type is located east of the Route 8 corridor. The mixed hardwood species present are black oak, red oak, white oak, chestnut oak, scarlet oak, red maple, black birch, hickory, and beech. The softwood species present are hemlock and white pine. Shrub species present are mountain laurel and witch hazel.

Vegetation Management Considerations

It is difficult to make specific management recommendations because of the number of landowners in the study area.

- The largest parcel of continuous forest cover is the 69-acre located in the eastern portion of Subsection 1A. Efforts should be made to retain this parcel as unbroken forest cover.
- The most common tree species found in the study area are black locust, eastern cottonwood, and northern catalpa. The first is considered a non-native invasive species. Control of this species is impractical because it is so well established in the area.
- The use of ATV's in Subsection 3B should be controlled to protect the integrity of the riverbanks and to eliminate a source of erosion.

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section One

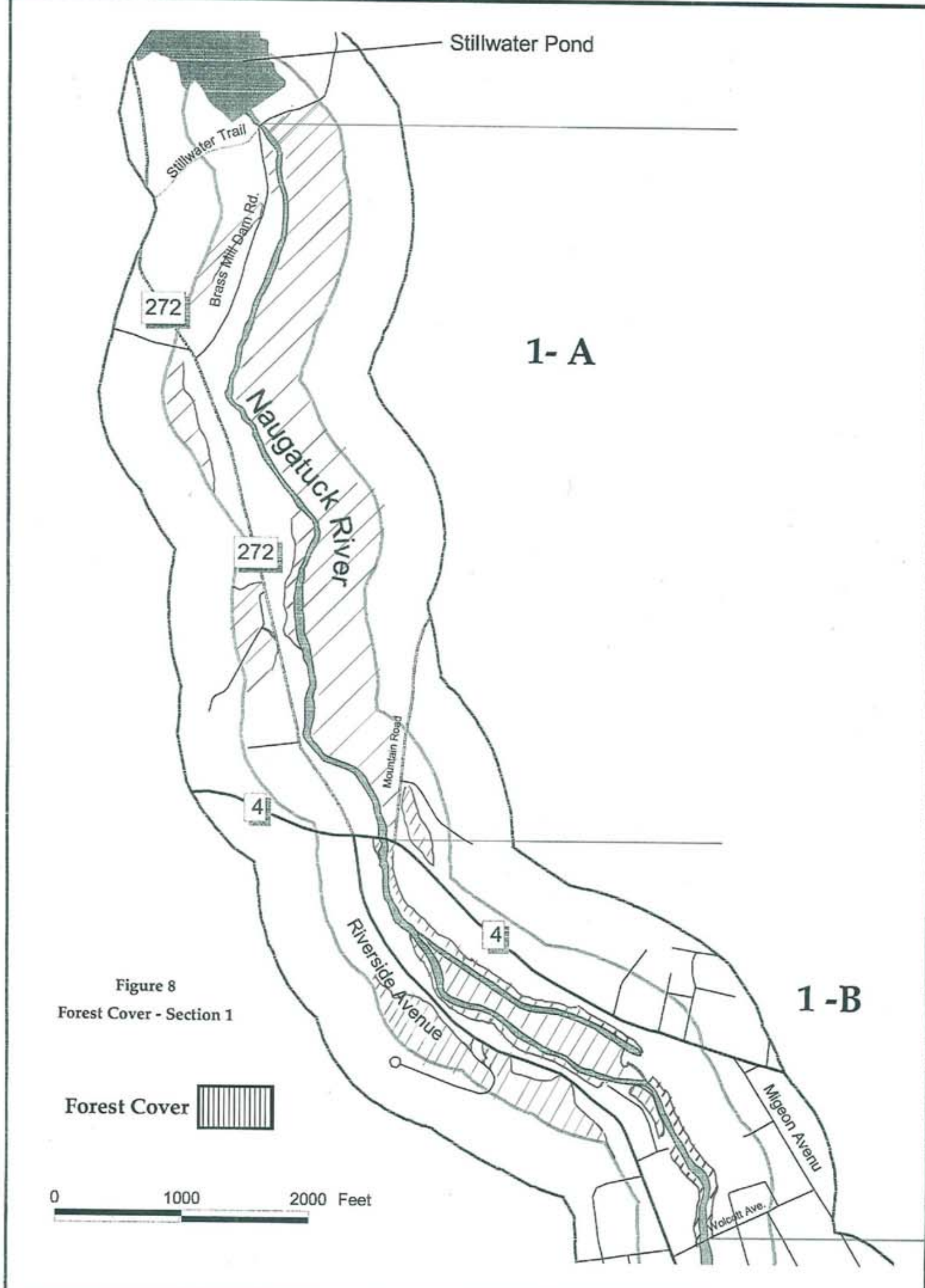

Figure 8
Forest Cover - Section 1

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section Two

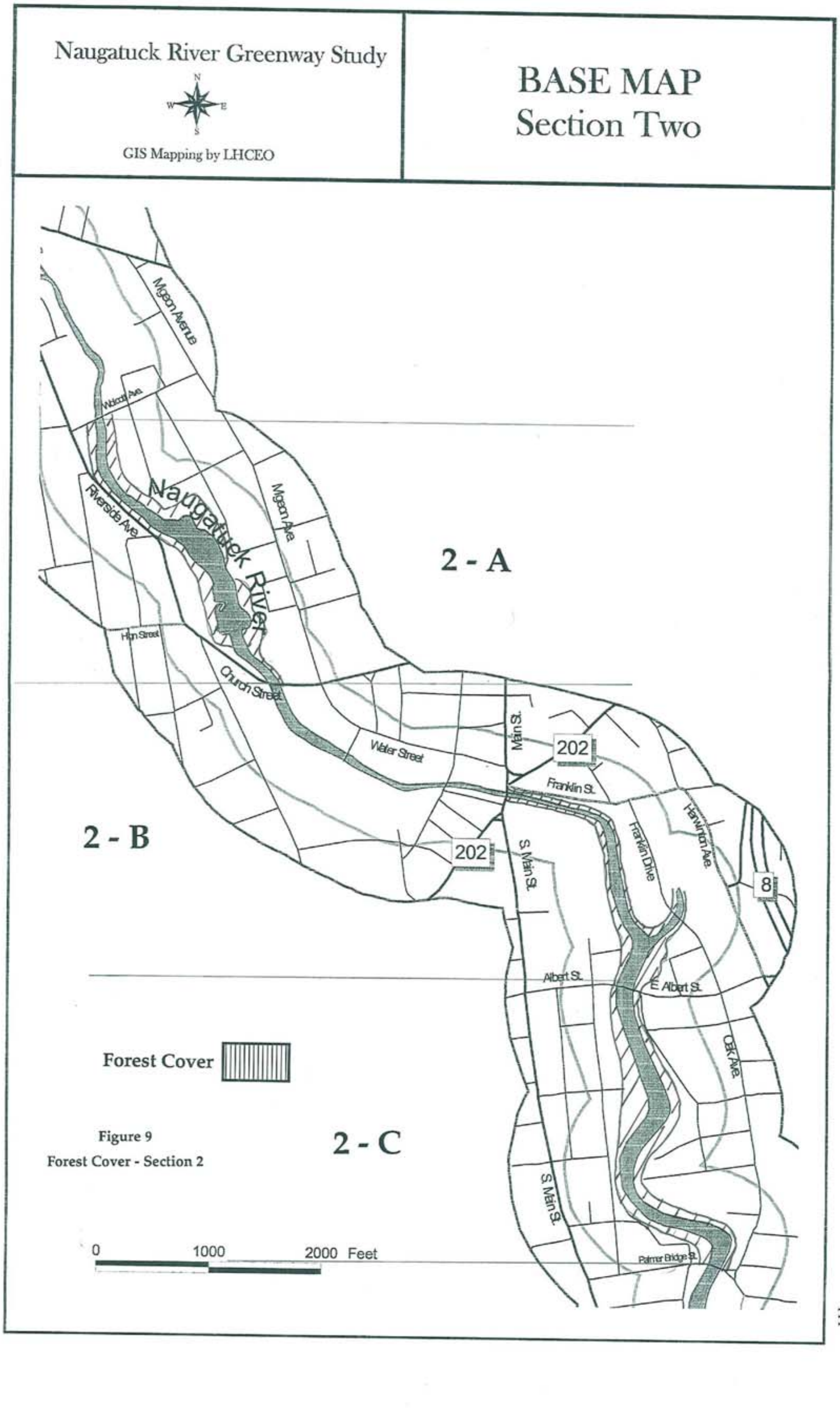

Figure 9
Forest Cover - Section 2

Naugatuck River Greenway Study

GIS Mapping by LHCEO

BASE MAP
Section Three

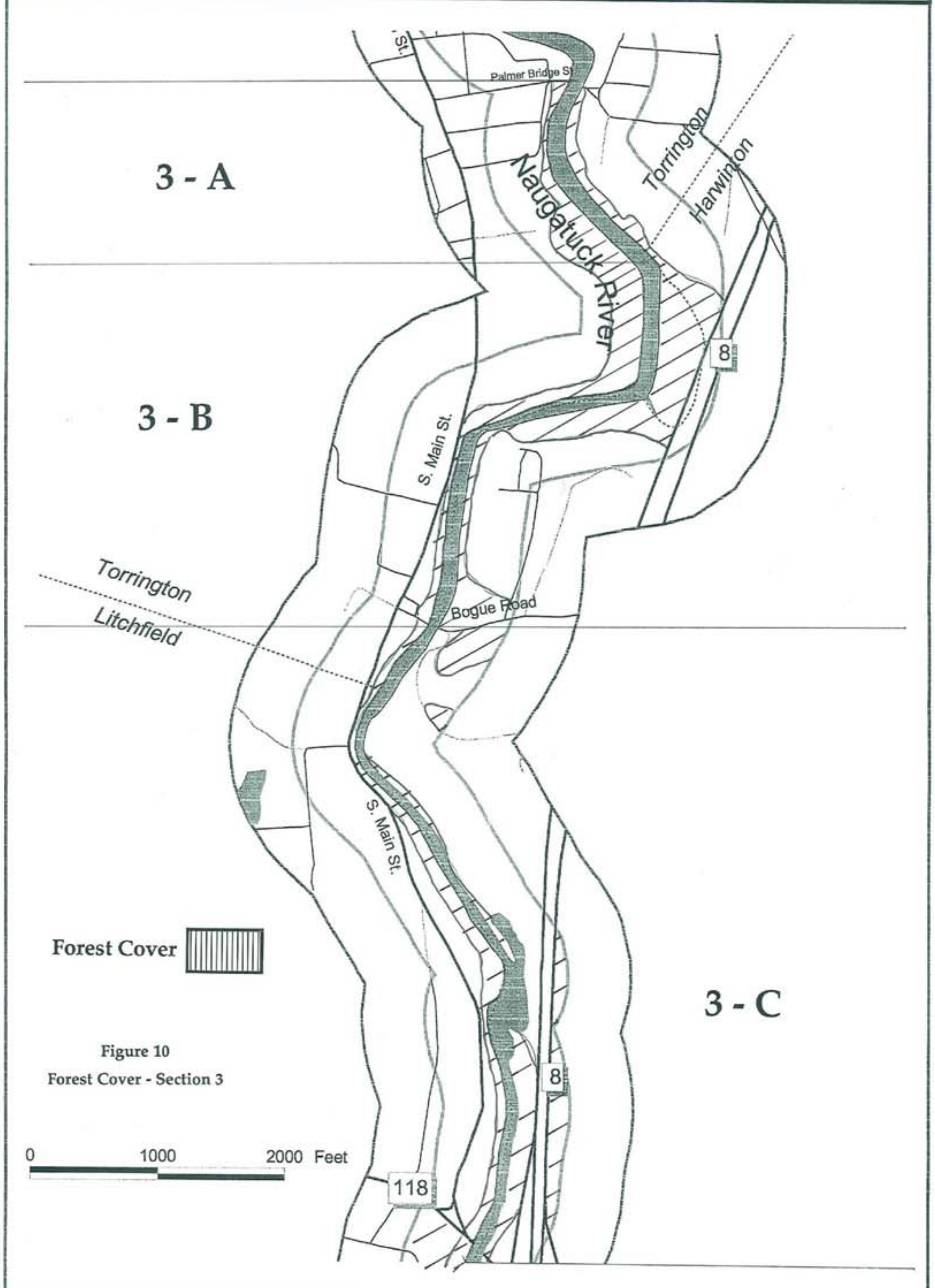

Figure 10
Forest Cover - Section 3

Archaeological Review

Archaeological Review

A review of the State of Connecticut Archaeological Site files and maps shown no known archaeological site in the greenway project area. Field review indicates that topographic and environmental features of the project area suggest a moderate to high sensitivity toward undiscovered archaeological resources.

As the greenway corridor passes through areas of urban development, it should be noted that archaeological remnants of Torrington's industrial past might still be intact along the Naugatuck River. In addition, in rural areas, where secondary streams and brooks enter into the river, there is a high sensitivity for prehistoric Native American campsites. Spruce Brook, in East Litchfield, is a prime example. Archaeological resources associated with a 4,000 year old Indian camp were discovered from this area thirty years ago. The site represents a major base camp of hunting, gathering and fishing activities.

The Office of State Archaeology and the State Historic Preservation Office are prepared to offer the Naugatuck River Greenway Project any technical assistance in identifying and preserving any cultural resources which might exist in the corridor. In addition, the corridor may offer important educational opportunities for the community to develop to learn about cultural adaptations along the Naugatuck River.

Soils Review

Soils Review

Soil Types

The soil types in the Naugatuck River Greenway are shown in the background on the CT Inland Wetland Soils Map in this report. Many of the soil types along the greenway study area are mapped as made land (Udorthents) and urban land, due to the land disturbance and dense urban land use. On site investigation is needed to determine the soil characteristics of these soil mapping units.

Of the areas that are mapped as having natural soils, many are underlain by sand and gravel. These include the 34A, 34B, and 34C soil mapping units (Merrimac soil series), the 38C, 38E, 238A and 238C mapping units (Hinkley soil series).

Additional information on the soils in the greenway study area is available in tables located in the Appendix of this report.

Shallow and Steep Areas

There are two areas between Stillwater Pond and West Torrington, where shallow to bedrock soils are predominant in the greenway study area. These soils are mapped as the 75E mapping unit (Hollis Chatfield-Rock outcrop). There is also a significant area of shallow to bedrock soils at the southern portion of the greenway study area. These are the 75E and 76E (Rock outcrop-Hollis complex) soil mapping units.

The letter in the soil mapping unit abbreviation indicates the land slope. The designation is very steep and slope is a significant limiting factor for land use. Soils with these steep slopes occur between Stillwater Pond and West Torrington in the 75E mapping unit. They also occur near the southern boundary of the greenway study area on mapping units 75E and 76E. These are the same mapping units that have the shallow to bedrock soils. These soils are located on the "Depth to Lithic (Bedrock) Restriction Map".

Wetlands

Inland wetlands have a high water table. Both state and federal law regulate the use of these areas. Inland wetlands in the greenway study area are shown on the CT Inland Wetland Soils Map in this report. There are few Inland Wetlands shown and they are soil mapping units 3 (Ridgebury, Leicester, and Whitman soils), 15 (Scarboro muck), and 109 (Fluvaquents-udifluvents complex, frequently flooded). One wetland is mapped east of the Naugatuck River and east of the New Saint Francis Cemetery. There is also an area of the wetland along the west side of the river, south of Wrightville. These areas should be left undisturbed if possible by any future plans.

The 101(Occum) and 102 (Pootatuck) soil mapping units are also regulated by the state Inland Wetlands and Watercourses Act. These are drier soils formed in floodplains.

Erosion

Any disturbed or bare soil can erode. Land disturbing activities such as forestry operations, road maintenance, and construction can cause soil erosion. Soil conservation practices should be installed and maintained on all sites with land disturbance. The greenway area is so close to the river that sedimentation of the river is likely from eroding sites. All terrain vehicles (ATV's) are currently allowing soil erosion along the west side of the river, south of the Palmer Street Bridge.

Buffers

Waterfront vegetation provides streambank protection, water quality protection fish and wildlife habitat, and scenic beauty. These vegetated areas or "buffers" protect the river from adverse impacts of the developed landscape. Water flowing over parking lots industrial sites, roads, lawns, and landscaped areas, can pick up pollutants and carry them to the river. Streamside vegetation helps to filter out these pollutants. Streamside vegetation also provides food and shelter to aquatic organisms and helps to keep the river water temperature cool.

A buffer width of 35 feet, from the top of the bank, on both sides of the river, is recommended where possible, for water quality protection. This buffer will be most useful if kept in or planted to native trees. A list of recommended trees for riparian forest buffer areas is listed in the Guidelines for Development of Riparian Buffers, pages 4 and 5, Tables 1 and 2 in the Appendix of this report.

Much of the greenway study area is already developed and a 35 foot buffer is not feasible in these sections. Maintaining or adding any vegetation along the edge of the river is beneficial. Even one row of trees can help cool the stream water, provide food and shelter, maintaining a better aquatic habitat in the river.

Ground covers and low growing shrubs help filter pollutants and protect water quality. A list of recommended grasses and legumes for riparian herbaceous buffer areas is listed in the Guidelines for Development of Riparian Buffers, page 6, Table 4, in the Appendix of this report.

Flood control dikes installed along the river protect part of the greenway study area. Tree roots growing in these dikes may cause structural instability. Herbaceous plantings may be more appropriate on the flood control dikes and any change in the planting plan may need to be checked by the city engineer and US Army Corps of Engineers. It may be feasible to plant flood tolerant shrubs at the base of the dikes, at the water's edge. A list of recommended shrubs for riparian buffer areas is listed in the Guidelines for Development of Riparian Buffers, page 6, Table 3, in the Appendix of this report.

Some sections of the riverbank in the greenway study area are supported by retaining walls. For aesthetic purposes, it may be feasible to plant vines to grow over the face of these walls. The effect on structural stability may need to be checked with the city engineer. Virginia Creeper (*Hypericum calycinum*) is a native vine, with bright red fall foliage, that may be suitable for this use. Set plants 18 inches apart for cover in 1-2 years, in well drained to droughty soil.

Passive Recreational Use

A map showing limitations to path and trail construction titled "Paths and Trails" and an interpretative table called Table REC-2 Recreation show areas that may have restrictions for path and trail development.

- A hiking trail is feasible along the east side of the river between Stillwater Pond and Route 4. Most sections within this area are gently sloping and trail construction would be relatively easy. There is one section where the steep slope will be a limitation to trail construction. Trail switchbacks and water diversions are likely to be needed in this area, causing a wider area to be needed for the trail installation and maintenance. There is one stream crossing in this section. This area is currently in private ownership, with no residences or other buildings currently constructed. Ownership and use issues would need to be addressed. Parking would be needed near Stillwater Pond and near Route 4 to facilitate trail use. Highlights along this area are the scenic quality of the river, beauty of the forest and fishing access.

- A trail is also feasible and existing in some sections between Route 4 and to Cherry St. There is very little width between the pond and backyards between Cherry Street and Lake Street adjacent to the Brass Mill Dam. If the dam is removed for fishery habitat restoration, there may be additional space in this area for trail construction. The land is gently sloping in this area.

- There is little space available currently for a trail through the downtown area. If this area is redeveloped in the future a river trail could be a valuable resource. Highlights in this area include the railway station (future Museum site), Christmas Village, Coe Park and Torrington Shopping Center and Farmer's Market. Parking is currently available at Daycoeton Place and at the Torrington Shopping Center.

- A trail is feasible between East Albert Street and Park Avenue near Lawton Street, along the west side of the river. Parking is available near the Armory and at the Senior Center near Palmer Bridge Road. The trail area is gently sloping and well drained. A highlight along this section is Fuessenich Park. A loop trail could be constructed in this section along the east side of the river, along the toe of the river bank. The slope down to the river, narrowness of the trail area, and steep bank north of Palmer Bridge Road are limitations for construing a loop trail. This goes by the City's Public Works Department land. Ownership and use issues would need to be addressed.

- A loop trail is feasible between Palmer Bridge Road and Bogue Road, using both sides of the river. Parking is available near the sewage treatment facility off Bogue Rd, at the Senior Center and at the John Toro Sports Complex. This trail area is currently used by ATV traffic. This trail area is gently sloping in most areas, however, one would need to travel from the top of the flood control dike down to near river level, along the west bank. Odor from the sewage system can be an issue in this section. Ownership and use issues would need to be addressed.

- If the railroad will not be used as a railroad in the future, then a rails-to-trails project may be feasible. The railroad tracks extend from the southern edge of the study area north to Surrey Lane, over the East Branch of the Naugatuck River.

Trail Planning Considerations

The proposed use of the trail should be considered for planning purposes. The land slope and trail surface will vary depending on the proposed use. Some potential uses for a trail include: walking, jogging, bicycling, cross country skiing, mountain biking, roller blading, and horse back riding. Of these, mountain biking and horseback riding may pose the highest risk of erosion and be least compatible in the downtown area. Any of the gently sloping trail areas could be paved to facilitate universal access, roller blading, bicycling etc. These types of passive recreational opportunities can cause a number of people to come to the area. This can be good for local businesses and hard on local residents. Installing a trail system where in informal trail already exists will cause little harm to the environment and may help alleviate existing erosion problems. A trail is a suitable land use within a stream buffer, however, foot and wheel traffic should be kept off unprotected stream banks due to the erosion risk.

Invasive Plants

There are numerous invasive plant species in the greenway corridor. Invasive plants should be removed and managed so that they do not regrow if possible. The invasive species noted include black locust, Japanese knotweed, Norway maple, autumn olive, Japanese barberry, multiflora rose and garlic mustard. Some of these may have seeds that float. They may be carried into and out of the greenway area by the river. Mechanical control (digging, pulling, and mowing) is recommended. Caution should be used to cut brush close to the ground. Leaving longer cut stakes can pose a safety hazard.

Sustainable Landscaping Techniques

Using sustainable landscaping techniques in the greenway will help protect the environment. Pesticides, herbicides, and fertilizers can become potential water pollutants. Use of native plants well adapted to site conditions, soil testing, use of compost, and minimal use of irrigation water, can all help to protect the environment by limiting or avoiding use of the potential pollutants.

Urban soils can be polluted with heavy metals from past industrial use or use of lead based paint. Excess heavy metals can be toxic to humans and other animals. Soils should be tested at any site prior to growing any food producing crops. The greatest risk is in leafy vegetables like lettuce or spinach. It is costly to remove heavy metals from contaminated soil. Some management techniques that can be used to minimize risks with contaminated soils are: remove the contaminated soil, increase soil pH above 6.5, apply phosphate fertilizer, keep soil covered and undisturbed, do not blow leaves or road sand in contaminated soil areas. Physical barriers or an arrangement of site features to minimize human exposure may be needed. Planning of new community garden sites or playgrounds should include a testing program for heavy metals prior to installation.

Soil compaction can be a soil health problem in urban areas. Management practices include increasing the organic matter content of the soil through applications of compost and organic mulch. Irrigation water may need to be applied more slowly to compacted soil areas or runoff will occur. Grass may need to be cut higher, which reduces transpiration losses.

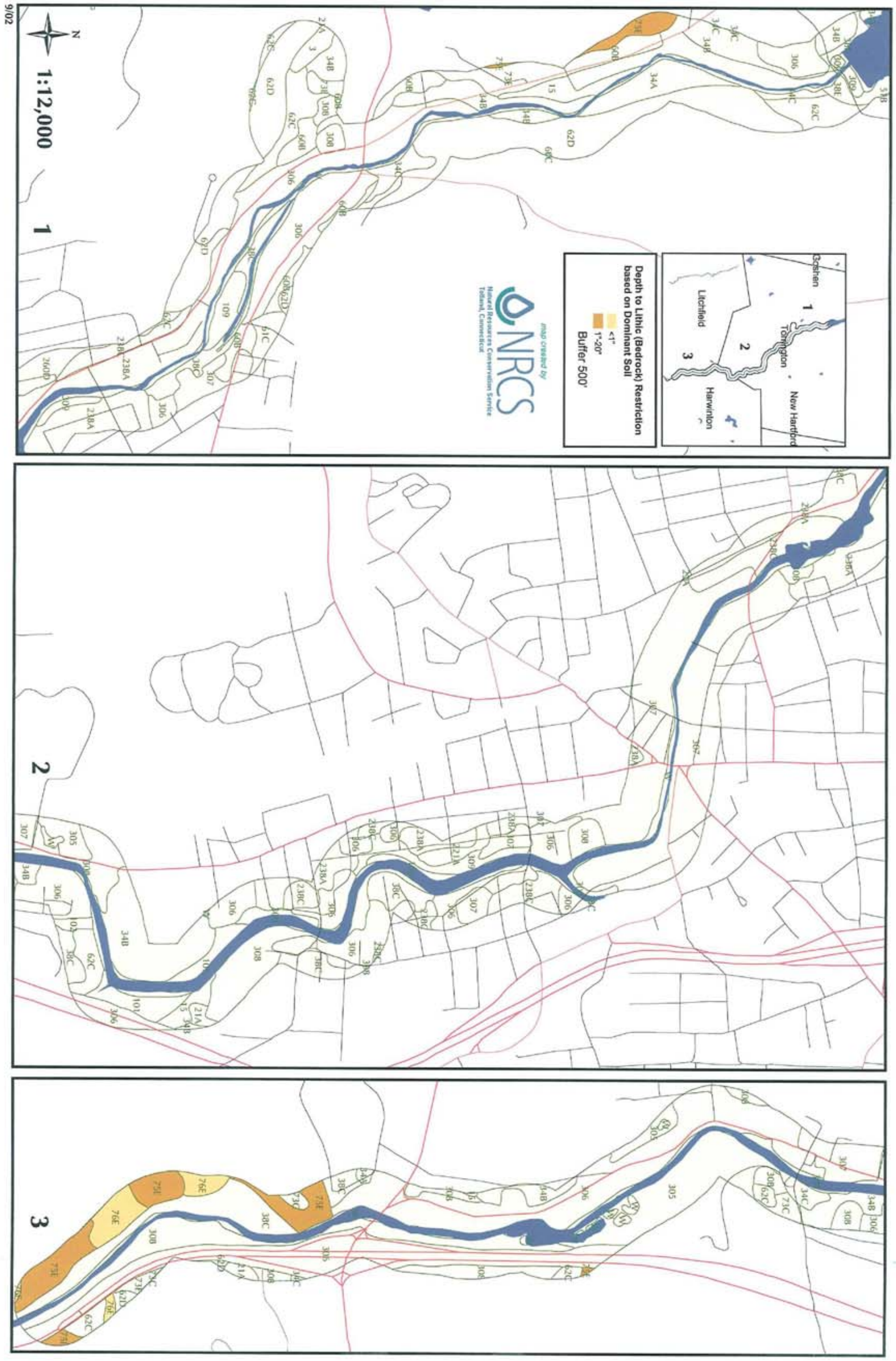

Figure 11
Depth to Bedrock

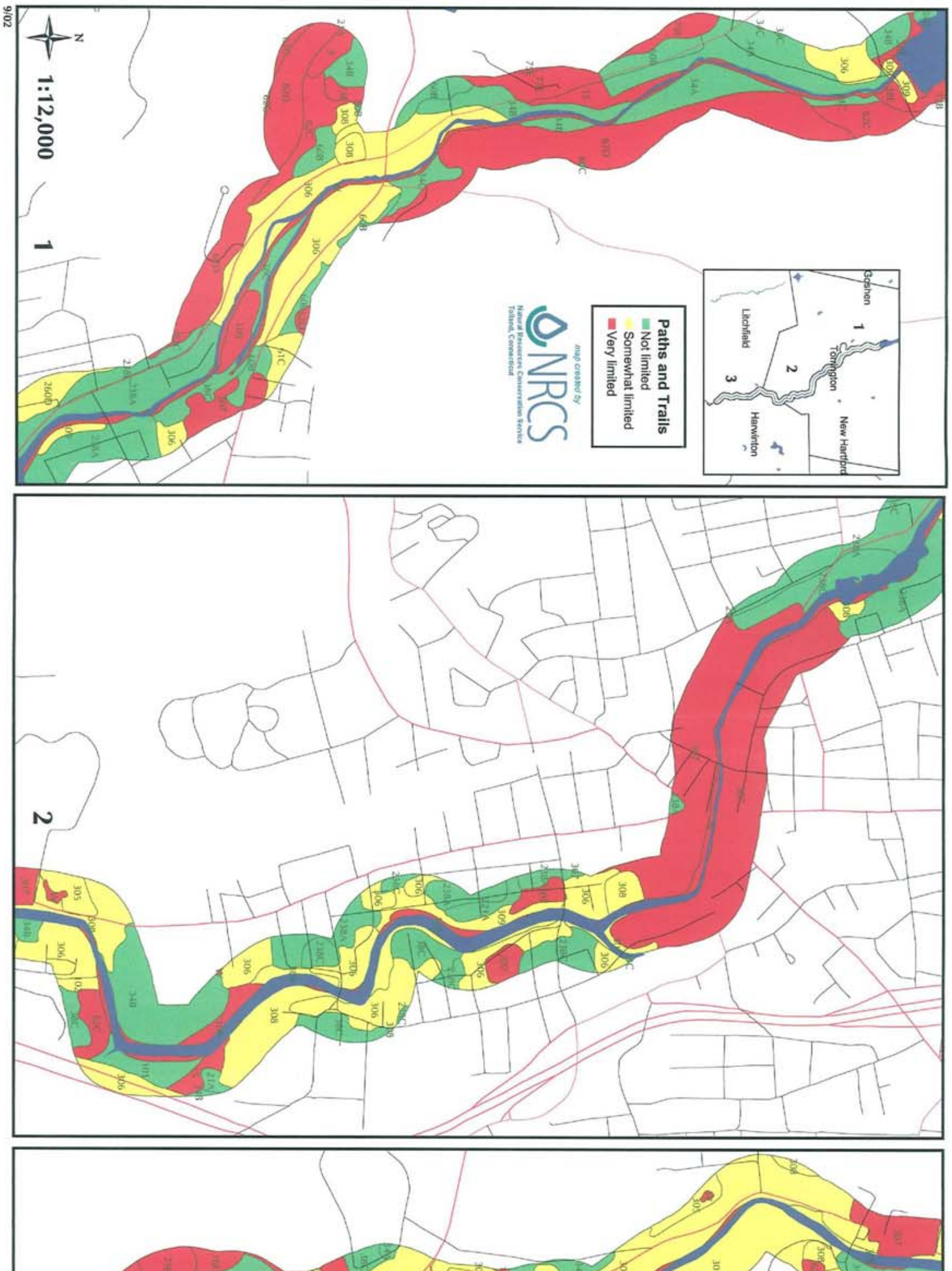

Figure 12
Limitations for Paths and Trails

9/02

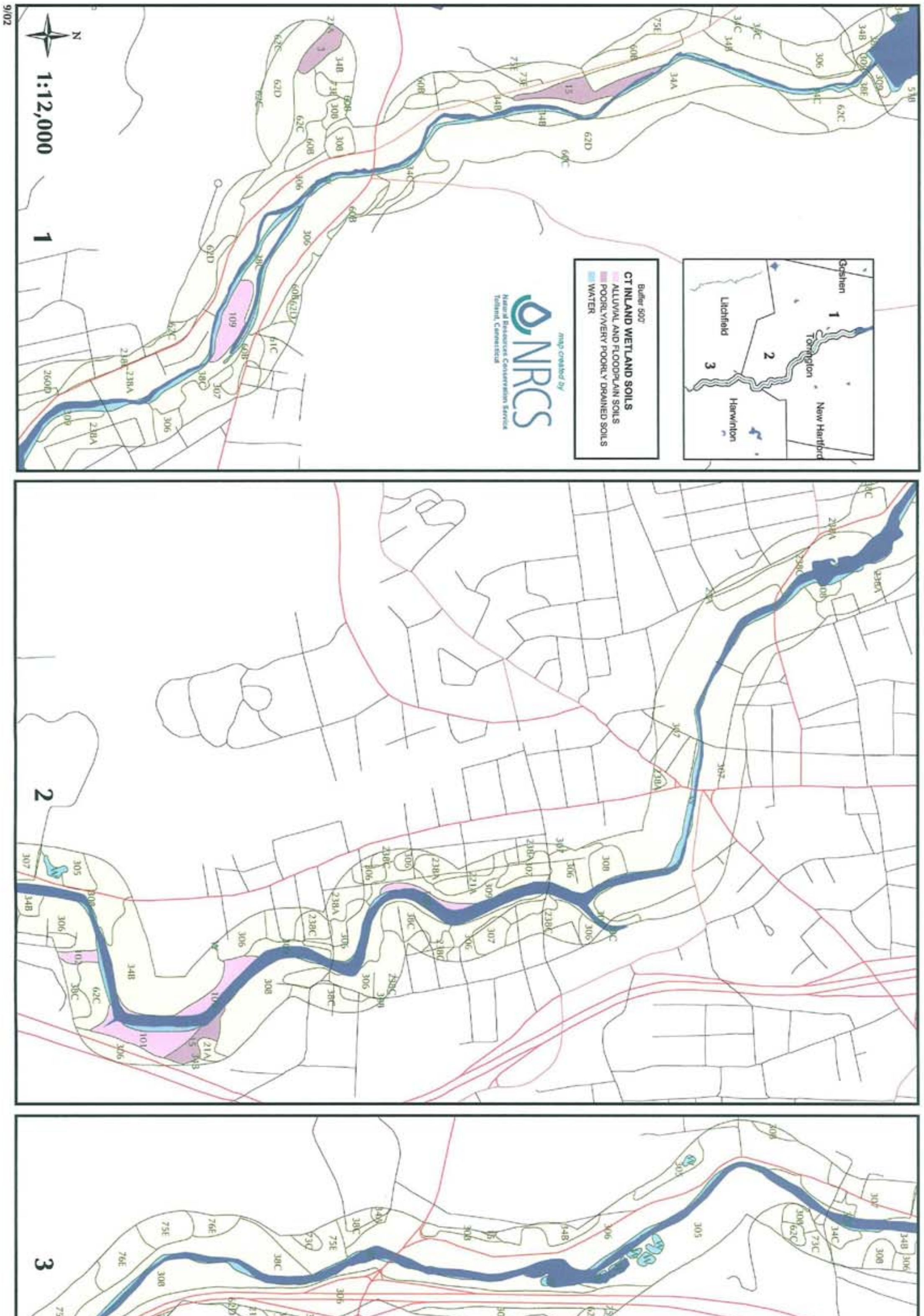

Figure 13

CT Inland Wetland Soils

Primary Greenway/Trail Opportunities

Primary Greenway/Trail Opportunities

Primary Greenway/Trail opportunities appear to include:

1. East Bank between Slitter Pond and Route 4, consisting of large, undeveloped privately owned property. A green belt corridor with trail is physically feasible and should be pursued through acquisition or dedication.

2. East/north bank between Route 4 and the Brunswick Company offers some opportunity as it seems to involve one large undeveloped private property. Greenbelt open space designation would be appropriate. Trail potential needs evaluation in terms of soils suitability and possibility of obtaining access out to Pigeon Avenue to avoid dead end trail. Acquisition or easement should be pursued.

3. The Land Trust's Brass Mill Pond Property between Walkout and Church Streets is suitable basically as a natural area, as it is de facto landlocked, surrounded by developed lots and containing little land available for trail development. Neighborhood sensitivity to any proposed development also should be considered.

4. South Bank between Church and Main Streets offers limited potential west from Main Street on city land including reopening Old Bridge to North Bank as a link to Water Street. Possible extension of riverbank west through Stop and Shop mall property should be explored with mall owners.

5. Main Street - Paler Street

a) **North bank** - adaptive reuse of old riverfront mill should be explored as well as landscaping easterly from Main Street and possibly along West bank of the East Branch.

b) **South/west bank** - utilizing public ownership to develop a riverfront trail from Fuessenich Park to Palmer Street bridge. However, the proximity of many homes and some private encroachment on the flood control-purchased public property could make such action contentious. Fencing in sensitive locations could provide an answer. Also negotiation with mall owners should be explored to provide a continuous riverwalk north from Fuessenich Park to Main Street.

6. Palmer Street Bridge - Route 118

a) **West Bank** - a trail/greenbelt downstream to and around St. Francis Cemetery to Main Street seems feasible and desirable. largely on city-owned property.

b) **East bank** - a trail/greenbelt seems feasible between Palmer Bridge Street and Bogue Road on city owned land and /or Route 8 right-of-way property. From Bogue Road south to Route 118, the Route 8 right-of-way should provide opportunity for a trail, with the section southerly of the O & G Company operation offering a riverside routing to Route 118. Perhaps a small parking lot could be provided off Main Street at its junction with Route 118. However, in the absence of a pedestrian bridge, this would necessitate pedestrian crossing of the highway bridge.

What Does Official Greenway Designation Mean?

In its enabling legislation, the Connecticut Greenways Council was charged with establishing criteria for designating greenways around the state. The Council took some time and thought to evaluate this charge, and the criteria were finalized in 2000. (They are attached for further information.) As part of Greenway Week 2001, the first 18 officially-designated greenways were announced by the Council and Governor Rowland.

What does designation as a greenway mean? For the first designees, it means that the Council, in consultation with the DEP Greenways Assistance Center, has determined that the greenway project has many of the qualities described in the criteria: connectivity, local support, a history of success. In addition, these projects were regional in scope, linking at least two or more towns.

Designation also offers a level of visibility for a greenway project. Each greenway will be listed in the next revision of the State Plan of Conservation and Development as prepared by the Office of Policy and Management. This plan serves as a "blueprint" for state agencies and state-funded projects. Greenways should not be adversely affected by these projects. Conversely, designation should attract state grant monies which may be available in the future. State recognition of greenways may also help in the pursuit of such federal designations and Wild and Scenic Rivers or National Scenic Trails. It should be noted that greenway designations do not restrict private property rights in any way.

In the future, communities will be able to nominate their greenways for official designation. For more information on the process, please contact Leslie Lewis, DEP Greenways Assistance Center, (860) 424-3578.

Criteria for Designation of Connecticut Greenways

In 1995 the Connecticut General Assembly acted upon the recommendations of the Governor's Greenways Committee and passed Public Act 95-335, which institutionalized Connecticut's greenways program. A highlight of this legislation was the establishment of the Connecticut Greenways Council. One of the Council's duties is the development of criteria for the designation of greenways around the state.

The Public Act defines greenway as a "corridor of open space that: 1) may protect natural resources, preserve scenic landscapes and historical resources or offer opportunities for recreation or non-motorized transportation; 2) may connect existing protected areas and provide access to the outdoors; 3) may be located along a defining natural feature, such as a waterway, along a man-made corridor, including an unused right of way, traditional trail routes or historic barge canals; or) may be a green space along a highway or around a village.

In order to meet the criteria for official designation as a greenway, open spaces and/or pathways must fit at least one aspect of this definition. The critical element, however, is connectivity. While a loop trail in a public park may fit many recreational and open space needs, if it offers no opportunities for connecting to a greater system it does not qualify as a greenway. Conversely, a short segment of open space along a ridgeline or waterway may be deemed part of a greenway if future plans include its linkage to a larger system.

The process of greenway designation will require not only the involvement of the Greenways Council. It will also mean that there is a commitment on the local level to a project's long-term success as well. Officially designated recreational greenways will receive special signs to post at trailheads and road crossings; those that serve a resource protection function may also post these signs where appropriate. All of the designated greenways will be forwarded to the Office of Policy and Management for inclusion in future revisions of the State Plan of Conservation and Development, and will also be incorporated into any greenway plans developed by the Department of Environmental Protection.

Greenways can be much more than linear open spaces. They can be the links from city to country, from village to village, from state to state. They can reconnect people to their communities, to rivers, fields, and hillsides, enhancing the sense of place that helps define the quality of life in Connecticut. It has been said that greenways connect the places we live with the places we love. It is the hope of the Connecticut Greenways Council that the designation process will help in the development, enhancement, and preservation of those places.

The following are the suggested criteria for the designation of greenways in Connecticut. The Greenways Council and the Department of Environmental Protection may designate such areas as they deem fit these criteria. Municipalities, non-profits, or other sponsoring agencies may submit projects to the Greenways Council for designation.

Criteria for the Designation of Greenways in Connecticut

In order to be considered for official greenway designation, a project must meet at least one of the following criteria:

1) The corridor connects existing open space, trail segments, historical/cultural assets; provides alternative transportation opportunity; may be of varying lengths, but connects neighborhoods to schools, town centers, parks and recreation areas, transportation centers, or open spaces.

2) If the greenway is a municipal project, it must be included in local plan of Conservation and Development (or in the next revision thereof), and must be endorsed by the local government through a municipal resolution or compact;

3) If the greenway is a regional project, it must be included in plans of relevant Regional Planning Agency, or Council of Governments, with endorsements by the affected municipalities; or, an inter-municipal compact may be developed between towns;

4) If the greenway is a non-governmental project, it must be sponsored by organization with proven record of land use protection/recreational use, or with proven resources needed for project success; licensing, easements, or other agreements for use of state, municipal, or private land must be on file;

5) The segment submitted for designation is a key link in emerging greenway, either for conservation or recreation purposes;

6) Once designated, such greenway shall be reflected in the State Plan of Conservation and Development as revised by the Office of Policy and Management and in any state-wide greenway plan developed by the Department of Environmental Protection.

7) Greenway designation may be revoked for non-performance or for development of the property for uses other than those defined for greenways in state statute.

Nomination for Official Designation of Greenway

Name of Greenway____

Sponsoring Organization____

Contact Name____

Contact Address____

Contact Phone____

Town/Towns in which greenway is located____________________________

Purpose of greenway (resource protection, recreation, etc)__________________

Does the corridor connect existing open space, trail segments, historical/cultural assets; provide alternative transportation opportunities; connect neighborhoods to schools, town centers, parks and recreation areas, transportation centers, or open spaces? Yes ___ No __

If the greenway is a municipal project, is it included in local plan of Conservation and Development?

Has it been endorsed by the local government through a municipal resolution or compact? Yes___ No___ (If yes, please include copy)

If the greenway is a regional project, is it included in plans of relevant Regional Planning Agency, or Council of Governments, with endorsements by the affected municipalities; or, has an inter-municipal compact been developed between towns? Yes___ No___ (If yes, please include copies)

If the greenway is a non-governmental project, is it sponsored by an organization with a proven record of land use protection/recreational use, or with proven resources needed for project success; are licensing, easements, or other agreements for use of state, municipal, or private land on file? Yes___ No___ (If yes, please include copies)
Has it been endorsed by the local government through a municipal resolution or compact? Yes___ No___ (If yes, please include copy)

Is the segment submitted for designation a key link in emerging greenway, either for conservation or recreation purposes? Yes___ No___ (If yes, please provide name and location of said greenway)

Please include a description of the project including a map showing location, connections (existing or potential), and adjacent open space if applicable on a 1:24,000 scale USGS Topographic Map.

Appendix

For Appendix Information Please Contact the ERT Office at 860-345-3977

About the Team

The King's Mark Environmental Review Team (ERT) is a group of environmental professionals drawn together from a variety of federal, state and regional agencies. Specialists on the Team include geologists, biologists, soil scientists, foresters, climatologists and landscape architects, recreational specialists, engineers and planners. The ERT operates with state funding under the aegis of the King's Mark Resource Conservation and Development (RC&D) Area - an 83 town area serving western Connecticut.

As a public service activity, the Team is available to serve towns within the King's Mark RC&D Area - *free of charge*.

Purpose of the Environmental Review Team

The Environmental Review Team is available to assist towns in the review of sites proposed for major land use activities or natural resource inventories for critical areas. For example, the ERT has been involved in the review of a wide range of significant land use activities including subdivisions, sanitary landfills, commercial and industrial developments and recreation/open space projects.

Reviews are conducted in the interest of providing information and analysis that will assist towns and developers in environmentally sound decision making. This is done through identifying the natural resource base of the site and highlighting opportunities and limitations for the proposed land use.

Requesting an Environmental Review

Environmental reviews may be requested by the chief elected official of a municipality or the chairman of an administrative agency such as planning and zoning, conservation or inland wetlands. Environmental Review Request Forms are available at your local Soil and Water Conservation District and through the King's Mark ERT Coordinator. This request form must include a summary of the proposed project, a location map of the project site, written permission from the landowner/developer allowing the Team to enter the property for the purposes of a review and a statement identifying the specific areas of concern the Team members should investigate. When this request is reviewed by the local Soil and Water Conservation District and approved by the King's Mark RC&D Executive Council, the Team will undertake the review. At present, the ERT can undertake approximately two reviews per month depending on scheduling and Team member availability.

For additional information regarding the Environmental Review Team, please contact the King's Mark ERT Coordinator, Connecticut Environmental Review Team, P.O. Box 70, Haddam, CT 06438. The telephone number is 860-345-3977.