Tankerhoosen River Watershed Management Plan

Friends of the Hockanum River Linear Park of Vernon, Inc.

In Association with:

Town of Vernon
North Central Conservation District
Rivers Alliance of Connecticut
Hockanum River Watershed Association
Belding Wildlife Management Area

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Executive Summary

E.1 The Tankerhoosen – A Key Inland Watershed

The upper Tankerhoosen River is a cold water stream supporting self-sustaining native trout populations that rank among the best of their kind in the state.

The Tankerhoosen River watershed is an approximately 12.9 square-mile sub-regional basin within the larger Hockanum River and Connecticut River watersheds in north-central Connecticut. Approximately 70% of the watershed is located within the Town of Vernon, with the remaining portions within the Towns of Tolland, Bolton, and Manchester.

The Tankerhoosen River has long been recognized as an important natural resource and a key inland watershed critical to the health of Long Island Sound. The high water quality (classified as A) in the upper regions of the Tankerhoosen River sustains a significant natural resource of the State of Connecticut – the Belding Wild Trout Management Area, one of only two Class I wild trout areas east of the Connecticut River. The importance of these small, high-quality watersheds to the downstream health of the larger river basins, and therefore to Long Island Sound, is well recognized. Of utmost importance to these high quality watersheds is protection of the headwaters regions.

The importance of protecting the Tankerhoosen is recognized by both local and state agencies. The State Plan of Conservation and Development identifies the riverway as a proposed preservation and conservation area. The Vernon Open Space Plan proposes a greenway plan of 2000 preserved acres along the Tankerhoosen. Most recently, The Nature Conservancy has identified several key watersheds in the state that it considers particularly important to the future protection of Long Island Sound, including the Tankerhoosen River watershed.

E.2 Potential Threats to Water Quality

The headwaters region of the Tankerhoosen River is bisected by Interstate 84. Development pressure in this headwaters region at the Exit 67 interchange in Vernon poses a major threat to the long-term health of the watershed. Further stresses on the headwaters have been created by development of an industrial park in Tolland through which a key headwater stream flows, as well as the presence of the highway itself, which continues to generate increasing traffic loads from development along the I-84 corridor. There has also been declining water quality in the lower reaches of the Tankerhoosen River in recent years. The lower region of the watershed is classified as "B", and was cited as impaired in the Connecticut Department of Environmental

Protection's (DEP) most recent list of water bodies not meeting water quality standards.

E.3 The Need for a Comprehensive Watershed Plan

The need for local decision-makers to consider the environmental consequences of development proposals that would impact the Tankerhoosen River has been expressed by the watershed towns, local advocacy groups including the Friends of the Hockanum River Linear Park and the Hockanum River Watershed Association, The Nature Conservancy, and the DEP.

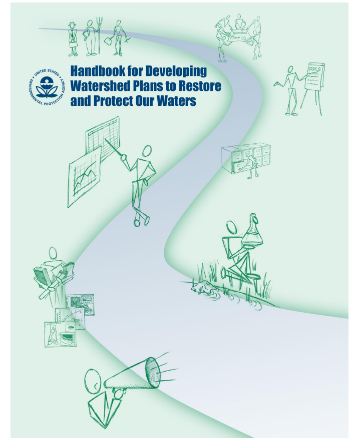
An informal partnership was formed in 2005 to build upon the successful community-based river monitoring and assessment program of the Connecticut River Watch Program and the Hockanum River Watch Program. Led by the Friends of the Hockanum River Linear Park, this group also included representatives of the Hockanum River Watershed Association, the Belding Wildlife Management Area, the North Central Conservation District, the Town of Vernon, and other local volunteers. Their objective was to address the immediate and long-term threats to water quality and natural resources in the Tankerhoosen River watershed by developing and implementing a comprehensive, scientifically-based watershed management plan.

In 2007, the Friends of the Hockanum River Linear Park retained Fuss & O'Neill, Inc. to develop a management plan for the Tankerhoosen River watershed. The goal of the watershed management plan is to identify recommendations that will help maintain and enhance water quality and ecological health in and along the Tankerhoosen River and its tributaries. Funding for the project has been provided by the National Fish and Wildlife Foundation, Long Island Sound Futures Fund, Rivers Alliance of Connecticut, and the Town of Vernon. A Technical Advisory Committee was also formed to guide the development of the plan, including representatives of the previously mentioned groups. This plan reflects the combined efforts of Fuss & O'Neill, the Technical Advisory Committee, stakeholders, and state and local resource agencies.

E.4 Plan Development Process

The Tankerhoosen River Watershed Management Plan is the culmination of desktop analyses and field assessments performed by the project team under the direction of the Technical Advisory Committee. The plan synthesizes information from earlier studies and reports on the watershed, Geographical Information System (GIS) mapping and analyses, review of land use regulations, and detailed field assessments to document baseline watershed conditions, the potential impacts of future development in the watershed, and recommended actions to protect and restore water quality and natural resources.

The plan has also been developed consistent with EPA's guidance for the development of watershed-based plans, which includes nine key elements that establish the structure of the plan. These nine elements include specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act



The management plan was developed to satisfy EPA's criteria for watershed-based plans.

Development of the watershed management plan consisted of the following five major tasks:

1. Assessment of baseline and potential future watershed conditions,
2. Review of land use regulations in the watershed,
3. Field inventories of stream corridors and upland areas in the watershed,
4. Identification of watershed management goals, objectives, and potential management strategies to address watershed issues,
5. Development of watershed-wide, targeted, and site-specific watershed management recommendations.

The initial task was to develop an understanding of the current conditions of the Tankerhoosen River watershed. To accomplish this, the project team reviewed existing watershed data, studies, and reports; compiled and analyzed GIS mapping of the watershed and various subwatersheds; and developed pollutant loading and impervious cover models to evaluate areas in the watershed that are most at-risk from future development.

A comparative subwatershed analysis was also performed to identify the Tankerhoosen River subwatersheds that 1) are more sensitive to future development and should be the focus of watershed conservation efforts to maintain existing high-quality resources and conditions and 2) are likely to have been impacted and have greater potential for restoration to improve or enhance existing conditions. The results of the baseline assessment were documented in the report, *Baseline Watershed Assessment, Tankerhoosen River Watershed*, dated May 28, 2008 (Fuss & O Neill, Inc.).

The results of the comparative subwatershed analysis were used to target individual subwatersheds for detailed field inventories. Using screening-level assessment procedures developed by the Center for Watershed Protection and EPA, field crews assessed approximately 8.7 miles of stream corridors, potential hotspot land uses, and representative residential neighborhoods, streets, and storm drainage systems. The field inventories identified a number of common issues and problems, as well as potential candidate sites for stormwater retrofits, stream restoration, and other targeted projects.

The project team also reviewed municipal land use regulations and planning documents within the watershed towns, focusing on Vernon and Tolland, which comprise the majority of the land area in the Tankerhoosen River watershed and have the greatest potential for future development. The land use regulatory review identified a number of recommendations to improve stormwater management, encourage or require the use of Low Impact Development (LID), reduce the amount of impervious cover generated by future development, and better protect watercourses, wetlands, and riparian areas.

The combined results of the watershed field inventories and land use regulatory review are described in the report, *Watershed Field Inventories and Land Use Regulatory Review, Tankerhoosen River Watershed*, dated October 2008 (Fuss & O Neill, Inc.).

The project team then developed a series of goals, objectives, and potential management strategies for the watershed based upon the results of the watershed inventory and evaluation phases of the project. Potential management strategies were further refined with input from the Technical Advisory Committee, culminating in the plan recommendations that are presented in this document.

E.5 Watershed Management Goals

The Tankerhoosen River Watershed Management Plan is intended to be an affordable and effective plan that can be implemented by the watershed municipalities, residents, and other stakeholders. The overall goal of the plan is to maintain and enhance water quality and ecological health in and along the Tankerhoosen River and its tributaries, which is essential to the economic well-being, environmental and public health, recreational opportunities, and quality of life for the residents, local governments, and visitors of the Tankerhoosen River watershed. This can be achieved by:

- Protecting the upper region of the Tankerhoosen River watershed, including high-quality headwater streams that sustain significant natural resources such as the Belding Wild Trout Management Area, from existing pollutant sources and future threats related to new development and redevelopment.

- Restoring and enhancing the water quality and ecological health of impacted portions of the Tankerhoosen River and its tributaries to support designated uses for fish and wildlife habitat and recreational uses.

E.6 Plan Recommendations

A set of specific objectives and recommended actions were developed to satisfy the management goals for the watershed. The plan recommendations include watershed-wide recommendations that can be implemented throughout the Tankerhoosen River watershed, targeted recommendations that are tailored to issues within specific subwatersheds or areas, and site-specific recommendations to address issues at selected sites that were identified during the watershed field inventories. Recommendations can be viewed as short-term, mid-term, and long-term according to their implementation priority.

- *Short-Term Recommendations* are initial actions to be accomplished within the first one to two years of plan implementation. These actions establish the framework for implementing subsequent plan recommendations. Such actions include development of local regulations and stormwater design guidance, discharge investigations, education program planning, and field inventories within previously unassessed subwatersheds. Small demonstration restoration projects could be completed during this phase, however construction of larger retrofit practices and stream restoration projects requiring extensive design, engineering, and permitting should be planned for later implementation.

- *Mid-Term Recommendations* involve continued programmatic and operational measures, delivery of educational and outreach materials, and construction of one or two larger retrofit and/or stream restoration projects over the next two to four years. Progress on land conservation, LID implementation, and discharge investigation follow-up activities should be completed during this period, as well as project monitoring and tracking.

- *Long-Term Recommendations* consist of continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed management plan. Long-term recommendations are intended to be completed during the next 5- to 10-year timeframe and beyond.

Table ES-1 summarizes the management recommendations for the Tankerhoosen River watershed. The recommendations are organized by implementation priority (short-, mid-, and long-term) and scale/location (watershed, targeted, or site-specific). Successful implementation of this plan will require a cooperative effort and commitment from the key watershed stakeholders, including a recommended watershed coalition consisting of the Friends of the Hockanum River Linear Park and other members of the Technical Advisory Committee, the watershed municipalities and citizens, state and federal agencies, and other groups. The table also identifies the watershed stakeholders who should be involved in implementing the plan recommendations in either a lead or support role.

Table ES-1. Watershed Management Plan Recommendations Summary

Key Actions	Priority	Scale/Location	Who Should be Involved (L = lead, A = assist)											
			Watershed Towns	Friends of HRLP	Watershed Coalition	Landowners	NCCD	HRWA	Belding WMA	ConnDOT	CTDEP	NRCS	USEPA	Citizens/Volunteers
Objective 1. Build a Foundation for Implementing the Plan														
Form sustainable partnership or coalition	S	W	A	L			A	A	A		A			
Adopt watershed management plan	S	W	L		A									
Identify potential funding sources and submit grant applications	S	W	L		L	A	A	A	A	A	A	A		
Objective 2. Enhance In-Stream and Riparian Habitat														
Conduct fish passage assessments	S	T	A		L		A	A						
Revise local stream crossing & stormwater design standards	S	W	L											
Belding Pond Dam removal feasibility evaluation	S	T			A						A	L		
Conduct aquatic invasive species study	S	S	A		L									
Priority stream restoration projects	M/L	S	A		L							A		
Objective 3. Protect/Restore Riparian Buffers														
Priority riparian buffer restoration projects	M/L	S	A		L	A			A			A		
Adopt stream buffer regulations, pending enabling legislation	M	W	L											
Revise riparian buffer recommendations (Tolland)	S	W	L											
Incorporate invasive species management measures	M	T			L			A	A		A			
Objective 4. Identify and Eliminate Illicit Discharges														
Targeted illicit discharge investigations	S	T	L		A		A							
Implement municipal IDDE programs	M	W	L											
Priority stream cleanup efforts	S	S			L			A						A
Develop education/outreach materials	S	W			L		A				A			
Deliver education/outreach to the public	M	W	L				A							
Objective 5. Residential Management Practices														
Increase watershed stewardship signage in residential areas	M	W	L		A		A	A						A
Encourage disconnection of rooftop runoff	M	W	L		A		A							
Develop education/outreach materials	S	W			L		A							
Deliver education/outreach to the public	M	W	L				A							
Objective 6. Municipal and Business Management Practices														
Review municipal facility compliance	S	W	L											
Improve municipal stormwater management programs	S/M	W	L											
Implement street sweeping and catch basin cleaning	M	W	L							L				
Develop education/outreach materials	S	W			L		A							

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Deliver education/outreach to the public	M	W	L				A							
Increase watershed stewardship signage in commercial areas	M	W	L		A		A	A						A
Objective 7. Implement Water Quality Monitoring Program														
Develop and implement long-term monitoring program	S	W			L		A	A			A			A
Field monitoring study of LID effectiveness	M	W	A		L		A							
Objective 8. Protect Open Space														
Priority land acquisitions	S/M	T	L		A	A			A		A			
Continue to implement municipal open space plans	S	T	L											
Seek alternative funding sources for open space acquisition	S/M	T	L		A									
Promote use of open space through trail maps and events	S/M	T			L			A	A					
Develop and implement invasive species management plan	M	T			L			A			A			A
Objective 9. Promote LID and Sustainable Site Design														
Monitor effectiveness of LID regulations (Tolland)	S/M	W	L											
Revise Inland Wetland regulations for consistency (Tolland)	S	W	L											
Develop and implement new stormwater/LID regulations (Vernon)	S	W	L											
Form advisory committee	S	W	L											
Develop Town stormwater/LID manual and/or guidance	S	W	L											
Update existing zoning, subdivision, wetlands regulations	S	W	L											
Priority stormwater retrofits	M/L	S	A		L		A			A				
Incorporate LID into Town projects	M	W	L											
LID demonstration projects (green roads, public works, schools)	S	S	L		A		A							
Develop education/outreach materials	S	W			L		A				A			
Deliver education/outreach to the public	M	W	L				A							
Objective 10. Assess Additional Subwatersheds														
Perform stream and upland assessments	S	T			L		A	A	A					A

Priority Abbreviations: S = short-term, M = mid-term, L = long-term Scale/Location Abbreviations: W = watershed-wide, T = targeted, S = site-specific
HRLP – Hockanum River Linear Park, NCCD – North Central Conservation District, HRWA – Hockanum River Watershed Association, ConnDOT – Connecticut Department of Transportation, CTDEP – Connecticut Department of Environmental Protection, NRCS – Natural Resource Conservation Service, USGS – United States Geological Survey, USEPA – U.S. Environmental Protection Agency, Belding WMA – Belding Wildlife Management Area

1 Introduction

1.1 The Call for a Comprehensive Watershed-Based Plan

The Tankerhoosen – A Key Inland Watershed

The Tankerhoosen River watershed is an approximately 12.9 square-mile sub-regional basin within the larger Hockanum River and Connecticut River watersheds in north-central Connecticut. Approximately 70% of the watershed is located within the Town of Vernon, with the remaining portions within the Towns of Tolland, Bolton, and Manchester.

The upper Tankerhoosen River is a cold water stream supporting self-sustaining native trout populations that rank among the best of their kind in the state.

The Tankerhoosen River has long been recognized as an important natural resource and a key inland watershed critical to the health of Long Island Sound. The high water quality (classified as A) in the upper regions of the Tankerhoosen River sustains a significant natural resource of the State of Connecticut – the Belding Wild Trout Management Area, one of only two Class I wild trout areas east of the Connecticut River. The importance of these small, high-quality watersheds to the downstream health of the larger river basins, and therefore to Long Island Sound, is well recognized. Of utmost importance to these high quality watersheds is protection of the headwaters regions.

The importance of protecting the Tankerhoosen is recognized by both local and state agencies. The State Plan of Conservation and Development identifies the riverway as a proposed preservation and conservation area. The Vernon Open Space Plan proposes a greenway plan of 2000 preserved acres along the Tankerhoosen. Most recently, The Nature Conservancy has identified several key watersheds in the state that it considers particularly important to the future protection of Long Island Sound, including the Tankerhoosen River watershed.

Potential Threats to Water Quality

The headwaters region of the Tankerhoosen River is bisected by Interstate 84. Development pressure in this headwaters region at the Exit 67 interchange in Vernon poses a major threat to the long-term health of the watershed. Further stresses on the headwaters have been created by development of an industrial park in Tolland through which a key headwater stream flows, as well as the presence of the highway itself, which continues to generate increasing traffic loads from development along the I-84 corridor. There has also been declining water quality in the lower reaches of the Tankerhoosen River in recent years. The lower region of the watershed is classified as "B", and was cited as impaired in the Connecticut Department of Environmental

Protection's (DEP) most recent list of water bodies not meeting water quality standards.

The Need for a Comprehensive Watershed Plan

The need for local decision-makers to consider the environmental consequences of development proposals that would impact the Tankerhoosen River has been expressed by the watershed towns, local advocacy groups including the Friends of the Hockanum River Linear Park and the Hockanum River Watershed Association, The Nature Conservancy, and the DEP.

An informal partnership was formed in 2005 to build upon the successful community-based river monitoring and assessment program of the Connecticut River Watch Program and the Hockanum River Watch Program. Led by the Friends of the Hockanum River Linear Park, this group also included representatives of the Hockanum River Watershed Association, the Belding Wildlife Management Area, the North Central Conservation District, the Town of Vernon, and other local volunteers. Their objective was to address the immediate and long-term threats to water quality and natural resources in the Tankerhoosen River watershed by developing and implementing a comprehensive, scientifically-based watershed management plan.

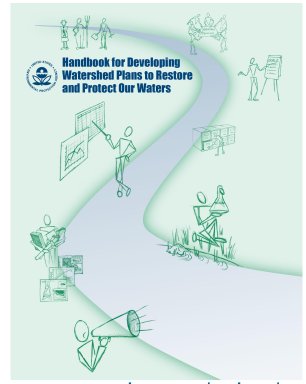
In 2007, the Friends of the Hockanum River Linear Park retained Fuss & O'Neill, Inc. to develop a management plan for the Tankerhoosen River watershed. Funding for the project has been provided by the National Fish and Wildlife Foundation, Long Island Sound Futures Fund, Rivers Alliance of Connecticut, and the Town of Vernon. A Technical Advisory Committee was also formed to guide the development of the plan, including representatives of the previously mentioned groups. This plan is the culmination of efforts between Fuss & O'Neill, the Technical Advisory Committee, stakeholders, and state and local resource agencies.

The goal of the watershed management plan is to identify recommendations that will maintain and enhance water quality and ecological health in and along the Tankerhoosen River and its tributaries, including protection of high-quality natural resources and restoration or enhancement of the water quality and ecological health of impacted portions of the Tankerhoosen River. This plan also describes a replicable approach to watershed-based planning, which satisfies the guidance set forth by the U.S. Environmental Protection Agency (EPA) in Section 319 of the Clean Water Act for developing watershed-based plans, thus enabling implementation projects under this plan to be considered for Section 319 funds.

1.2 Plan Development Process

The Tankerhoosen River Watershed Management Plan is the culmination of desktop analyses and field assessments performed by the project team under the direction of the Technical Advisory Committee. The plan synthesizes information from earlier studies and reports on the watershed, Geographical Information System (GIS) mapping and analyses, review of land use regulations, and detailed field assessments to document baseline watershed conditions, the potential impacts of future development in the watershed, and recommended actions to protect and restore water quality and natural resources.

The plan has also been developed consistent with EPA's guidance for the development of watershed-based plans, which includes nine key elements that establish the structure of the plan. These nine elements include specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act



The management plan was developed to satisfy EPA's criteria for watershed-based plans.

Development of the watershed management plan consisted of the following five major tasks:

1. Assessment of baseline and potential future watershed conditions,
2. Review of land use regulations in the watershed,
3. Field inventories of stream corridors and upland areas in the watershed,
4. Identification of watershed management goals, objectives, and potential management strategies to address watershed issues,
5. Development of watershed-wide, targeted, and site-specific watershed management recommendations.

The initial task was to develop an understanding of the current conditions of the Tankerhoosen River watershed. To accomplish this, the project team reviewed existing watershed data, studies, and reports; compiled and analyzed GIS mapping of the watershed and various subwatersheds; and developed pollutant loading and impervious cover models to evaluate areas in the watershed that are most at-risk from future development.

A comparative subwatershed analysis was also performed to identify the Tankerhoosen River subwatersheds that 1) are more sensitive to future development and should be the focus of watershed conservation efforts to maintain existing high-quality resources and conditions and 2) are likely to have been impacted and have greater potential for restoration to improve or enhance existing conditions. The results of the baseline assessment were documented in the report, *Baseline Watershed Assessment, Tankerhoosen River Watershed*, dated May 28, 2008 (Fuss & O'Neill, Inc.), a copy of which is provided on CD-ROM in Appendix A of this plan.

The results of the comparative subwatershed analysis were used to target individual subwatersheds for detailed field inventories. Using screening-level assessment procedures developed by the Center for Watershed Protection and EPA, field crews assessed approximately 8.7 miles of stream corridors, potential hotspot land uses, and representative residential neighborhoods, streets, and storm drainage systems. The field inventories identified a number of common issues and problems, as well as potential candidate sites for stormwater retrofits, stream restoration, and other targeted projects.

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The combined results of the watershed field inventories and land use regulatory review are described in the report, *Watershed Field Inventories and Land Use Regulatory Review, Tankerhoosen River Watershed*, dated October 2008 (Fuss & O Neill, Inc.), a copy of which is provided on CD-ROM in Appendix A of this plan.

The project team then developed a series of goals, objectives, and potential management strategies for the watershed based upon the results of the watershed inventory and evaluation phases of the project. Potential management strategies were further refined with input from the Technical Advisory Committee, culminating in the plan recommendations that are presented in this document.

2 Baseline Watershed Conditions

This section describes the current conditions in the Tankerhoosen River watershed. The information is based upon a review of existing watershed data, studies, and reports; preparation and analysis of watershed GIS mapping; and pollutant loading and impervious cover models to evaluate areas in the watershed that are most at-risk from future development. More detailed information on the baseline assessment is available in *Baseline Watershed Assessment, Tankerhoosen River Watershed* (Fuss & O Neill, Inc., May 28, 2008), a copy of which is provided on CD-ROM in Appendix A of this watershed management plan.

2.1 Watershed Description

The Tankerhoosen River watershed is a small but very important 12.85 square-mile sub-regional basin within the Hockanum River watershed (Figure 2-1). Approximately 70% of the watershed is located within the Town of Vernon, with the remaining portions within the Towns of Tolland, Bolton, and Manchester (Table 2-1).

Table 2-1. Distribution of Municipalities in the Tankerhoosen River Watershed

Town Name	Town Acreage	Acreage in Watershed	% of Town in Watershed	% of Watershed
Manchester	17,408	461	2.7	5.6
Vernon	11,904	5,572	46.8	67.7
Tolland	25,856	1,547	5.9	18.8
Bolton	9,920	646	6.5	7.9
Totals	**65,088**	**8,226**		**100.0**

A basic profile of the watershed is provided in Table 2-2. Later sections of this document provide more detailed information on these watershed characteristics.

Table 2-2. Profile of the Tankerhoosen River Watershed

Area	12.85 square miles (8,226 acres)
Stream Length	approximately 17.2 miles
Subwatersheds	10 subwatersheds
Jurisdictions	4 towns
Water Quality	DEP Impaired Waters List for habitat for fish and other aquatic life
Current Impervious Cover	9.8%
Subwatersheds Selected for Detailed Assessment Based on Vulnerability Assessment	Clarks Brook Gages Brook Gages Brook South Tributary Lower Tankerhoosen River Walker Reservoir
Subwatersheds Selected for Detailed Assessment Based on Restoration Potential	Clarks Brook Gages Brook Lower Tankerhoosen River Middle Tankerhoosen River Tucker Brook
Major Transportation Routes	Interstates 84 and 384 U.S. Routes 6 and 44 State Routes 30 and 31

Table 2-2. Profile of the Tankerhoosen River Watershed

Significant Natural and Historic Features	Belding Wildlife Management Area Valley Falls Park Webster-Knapp Preserve Bolton Notch Pond Walker Reservoir Talcottville Historic District

The high water quality (classified as A) in the upper regions of the Tankerhoosen River sustains a significant natural resource of the State of Connecticut – the Belding Wild Trout Management Area, one of only two Class I wild trout areas east of the Connecticut River. The importance of these small, high quality watersheds to the downstream health of the larger river basins, and therefore to Long Island Sound, is well recognized. Of utmost importance to these high quality watersheds is protection of the headwaters regions.

The headwaters region of the Tankerhoosen River is bisected by Interstate 84. Development pressure in this headwaters region at the Exit 67 interchange in Vernon poses a major threat to the long-term health of the watershed. Further stresses on the headwaters have been created by development of an industrial park in Tolland through which a key headwater stream flows, as well as the presence of the highway itself, which continues to generate increasing traffic loads from development along the I-84 corridor. There has also been declining water quality in the lower reaches of the Tankerhoosen River in recent years. The lower region of the watershed is classified as "B", and was cited as impaired in the Connecticut Department of Environmental Protection's (DEP) *2006 List of Connecticut Waterbodies Not Meeting Water Quality Standards.*

The importance of protecting the pristine upper region of the Tankerhoosen is recognized by both local and state agencies. The State Plan of Conservation and Development identifies the riverway as a proposed preservation and conservation area. The Vernon Open Space Plan proposes a greenway plan of 2000 preserved acres along the Tankerhoosen. Most recently, The Nature Conservancy (TNC) has identified several key watersheds in the state that it considers particularly important to the future protection of Long Island Sound, including the Tankerhoosen River watershed. The need for local decision-makers to give utmost consideration to the environmental consequences of development proposals that would impact the River, has been expressed by TNC and by the DEP.

Figure 2-1: Tankerhoosen River Watershed

2.2 Geologic and Historical Perspective

2.2.1 Geology

The State of Connecticut is comprised of three distinct geologic units divided longitudinally across the state. These three units are known as the Western Uplands, the Central Valley, and the Eastern Uplands. The Western and Eastern Uplands are comprised of metamorphic rocks – rocks subjected to intense heat and pressure of the Earth's interior – while the Central Valley is a younger unit comprised of sedimentary rocks. The Central Valley began forming about 225 million years ago when the super-continent Pangaea began to break apart. A large rift formed a long, narrow valley through the middle of the state, eventually filling with sediments from the eroding hills to the east and west (presently known as the Eastern and Western Uplands). The sediments were compacted into soft, easily eroded, red and brown sandstones through which the Connecticut Rivers flows.

The Tankerhoosen River watershed is almost entirely within the Eastern Uplands. The westernmost portion of the watershed is located within the Central Valley. The boundary between the Central Valley and the Eastern Uplands is located near the Vernon-Manchester town line and known as the Bolton Range. The Bolton Range was formed as a result of the different rates of erosion of the less resistant sediments of the Central Valley creating an abrupt rise into the resistant rocks of the Eastern Uplands.

Drastic changes in the surficial geology have occurred within Connecticut since the formation of these geologic regions. Above the sandstone of the Central Valley and the metamorphic bedrock of the Eastern Uplands lie extensive glacial deposits, or "glacial till," left as the large glaciers receded. Melting glacier ice formed rivers which sorted glacial till into layers of sand and gravel, or "stratified drift." The Tankerhoosen River flows through hills of glacial till in the steep Eastern Uplands and then drops into the stratified drift of the Central Valley (Bell, 1985).

2.2.2 Population and Industry

Beginning about 10,000 years ago, as the last glacial ice retreated from New England, Native American populations settled Connecticut and the areas along the Tankerhoosen River. The river was used by Native Americans as a source of fish and a travel route to the Connecticut River (Hockanum River Watershed Association, 1998). The Podunks of East Hartford and Manchester, the Nipmucks of Ellington and Tolland were among the tribes that farmed corn in the fertile river floodplains of the Tankerhoosen River. In addition to agriculture, the tribes used the land within the watershed for hunting, gathering, and fishing.

European settlers brought a marked change in land use to Connecticut. Land was cleared and agriculture was the primary use through the Revolutionary War era. However, the availability of more fertile lands in western New York, northern Ohio, and Pennsylvania led to the great migration of Connecticut farmers during the 1800s.

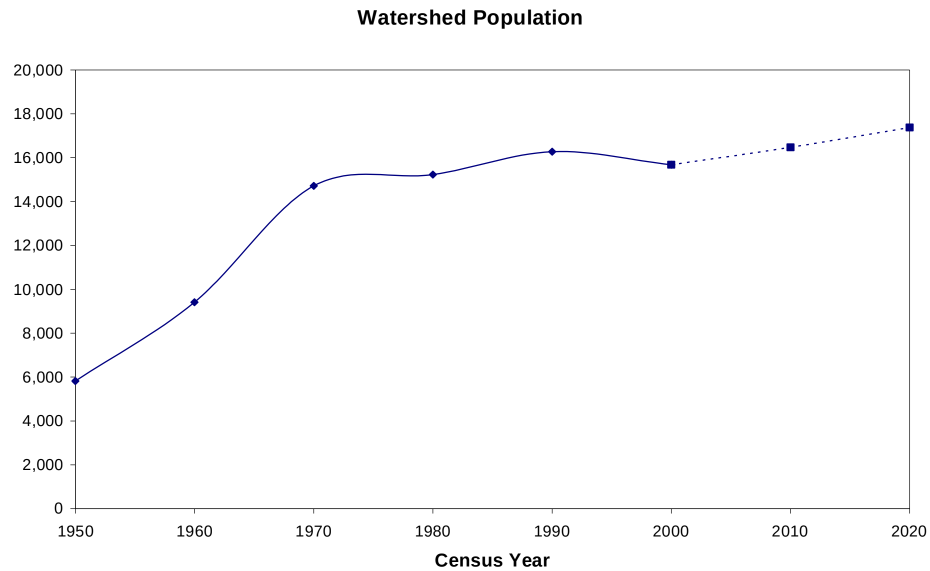
Those who stayed worked in the many factories that arose along the rivers and streams, and manufacturing became a major economic force (Gibbons et al., 1992).

The Tankerhoosen River was no exception to the development patterns across Connecticut. From the headwaters at Gages Brook, the elevation drop of the Tankerhoosen River was ideally suited to power a wide variety of mills. During the eighteenth and nineteenth centuries, several mills associated with the textile, cotton-wool, energy, and paper industries were built near these waterfalls and in other areas in the watershed. The Talcottville Historical District is located in southwestern portion of the Tankerhoosen River watershed near the confluence with the Hockanum River. One of the first cotton mills in America was built by Peter Dobson in the early 1800's in Talcottville. The mill burned down in 1909, not to be rebuilt. Peter Dobson is also famous for early observations that ice may have played a role in the erosion and transport of rock in the region.

The Vernon Depot, located within the watershed on Church Street, was an active transportation center during the early part of the twentieth century. The Hartford, Providence and Fishkill Railroad ran seven times a day at the Depot, with connections to Rockville. The Keystone Arch on Tunnel Road (also known as the Keystone Tunnel) was constructed circa 1850 to allow trains to traverse Tunnel Road without disrupting street traffic toward Vernon Center. The 108-foot long tunnel is constructed of 30 arches, each of which consists of a center keystone with nine stones forming the curves on either side. The tunnel is considered by historians to be a fine piece of historic architecture and as a monument to the integrity and skilled workmanship of its builders.

Valley Falls was the site of the first industry in Vernon, a saw mill, in 1740. Valley Falls Park hosted a small mill complex for flaxseed oil and cotton between 1850 and 1877. Beginning in the mid-1800s until the mid-1900s the property was converted into farmland for producing corn, hay, oats, butter, and cheese. In 2001, the historic farmhouse and six outbuildings were purchased by the Friends of Valley Falls, Inc. to ensure preservation of the historical complex. Alternate forms of manufacturing power put most of the mills out of business by the late 1950s. Dozens of the mill buildings and their associated dams remain an integral component of the river.

Rapid population growth in the post-war era of the 1950s and 1960s slowed significantly as developable land became scare (see Figure 2-2). Today, the population of the Tankerhoosen River watershed is approximately 16,000, which is more than double the population of the watershed in the 1950s. Commercial and residential development has occurred in the watershed since the 1970s, with a continued decline in industrial uses. Significant commercial development along the major transportation corridors and residential development in the watershed has increased watershed impervious coverage and contributed to degraded water quality in portions of the Tankerhoosen River and its tributaries. Numerous historical impoundments within the watershed also continue to serve as barriers to fish passage along the Tankerhoosen River and its tributaries.



Source: Connecticut Population Projections, Series 95.1, Office of Policy and Management, September 1995.

Figure 2-2. Population Trends in the Tankerhoosen River Watershed

2.2.3 Recreation Resources

The Tankerhoosen River provides many opportunities for recreational activities, such as fishing, swimming, and limited boating. Along the river, there are both town and state lands that are preserved for parks, wildlife sanctuaries and rail-trails. Recreational activities in these areas include hiking, biking, cross-country skiing, ice skating, nature observation, and aesthetic enjoyment.

Some of the prominent recreational centers in the watershed include the Walker Reservoir East, the Belding Wildlife Management Area, Valley Falls Park, Bolton Notch Pond, Freja Park, the Rails-to-Trails, and Phoenix Mill Park. Each of these areas provides parking, picnicking, and trails for walking and cross-country skiing. The Belding Wildlife Management Area was the location of the first Class I Trout Management Area in Connecticut. Recreational areas that also have historical significance include the Dobsonville Pond and Talcottville Pond. Additionally, the area associated with the confluence of the Tankerhoosen and Hockanum Rivers includes a privately owned recreational facility and is the starting point for the annual Manchester Canoe and Kayak Race.

2.2.4 Watershed Restoration Efforts

The Connecticut River Watch Program (CRWP), a volunteer water quality monitoring, protection, and improvement program for the Connecticut River and its tributaries, is working closely with the Hockanum River Watch Program (HRWA) and North Central Conservation District to develop and support a community-based river monitoring and assessment program in the Tankerhoosen River watershed. The CRWP monitoring program has included stream walk surveys and rapid bioassessments (cost-effective biological survey techniques) along the Tankerhoosen River, as well as other areas of the larger Hockanum River watershed.

The Connecticut DEP also conducts routine ambient water quality and benthic monitoring at approximately twelve locations along the Hockanum and Tankerhoosen Rivers. The data assist in documenting the chemical and biological quality of surface waters within the watershed and will be used to support the development of a Total Maximum Daily Load (TMDL), which will address sources of water quality impairment in the Hockanum and Tankerhoosen Rivers.

Baystate Environmental Consultants, Inc. (BEC) conducted a feasibility study in 2002 for the dredging of Tankerhoosen Lake and subsequently prepared a Watershed Management Plan for Tankerhoosen Lake in 2004. The plan identified watershed factors that have directly affected or have the potential to affect the water quality and overall health of Tankerhoosen Lake. The project recommended a Town-wide approach for reducing the quantity of pollutants, specifically sediment and nutrients, reaching Tankerhoosen Lake. BEC personnel conducted field observations of the major contributing watercourses and impoundments in the Tankerhoosen Lake watershed to identify point sources of sediment and nutrients as well as nonpoint source pollutants. BEC recommended that the Town of Vernon require the implementation of stormwater best management practices (BMPs) that maximize to the extent practicable, the removal of total suspended solids and nutrients. In addition to the lake dredging project recommended in the feasibility study, BEC also recommended several structural and nonstructural elements, including a sediment trap at the inlet of Tankerhoosen Lake, installation of deep sump catch basins at key locations, maintenance of cross-culverts and drainage structures, and grass swales and vegetated filter strips. None of the BEC recommendations has been implemented to date.

2.3 Natural Resources

2.3.1 Hydrology

The Tankerhoosen River watershed is 12.85 square-miles, with the majority of the watershed (approximately 70 percent) located within the Town of Vernon (Figure 2-1). Gages Brook and its associated southern tributary comprise the headwaters region of the watershed, eventually flowing into Walker Reservoir East. Gages Brook is located in the northwest portion of the Town of Vernon and within the western portion of neighboring Tolland. A few small impoundments are located within the Gages Brook watershed. The brook receives drainage from the I-84 corridor near the Vernon-Tolland town boundary. In Tolland, Gages Brook flows through an industrial park and residential areas.

Walker Reservoir is no longer an active public water supply but rather a recreational resource that attracts hikers, fisherman, and ice skaters. The Tankerhoosen River, which is a moderately sized (16 feet wide) upland stream, originates at the outlet of Walker Reservoir East and bisects the Town of Vernon on the south side of Interstate

84. The river flows southwest for approximately five miles to the Hockanum River in the Talcottville section of Vernon.

Barrows Brook, Rickenback Brook, and several other small tributaries drain the eastern portion of the upper Tankerhoosen River watershed between Walker Reservoir and the confluence with Railroad Brook near Webster Pond. Barrows Brook is the furthest upstream tributary to the Tankerhoosen River and flows through undeveloped, privately owned land. Rickenback Brook flows east to west through a relatively undeveloped portion of Vernon and discharges to the Tankerhoosen River approximately 0.4 miles upstream of the river's confluence with Railroad Brook. Portions of this brook are within the Belding Wildlife Management Area and have been established for catch and release trout fishing (BEC, 2004).

Railroad Brook drains the southern portions of the watershed, beginning at Bolton Notch Pond in Bolton, and flows north through Valley Falls Park and the Belding Wildlife Management Area before joining the Tankerhoosen River. Valley Falls Pond is located along Railroad Brook within the confines of the Valley Falls Park property. Railroad Brook flows through primarily undeveloped land and discharges to the Tankerhoosen River approximately 1.6 miles upstream of Tankerhoosen Lake (BEC, 2004).

Clarks Brook and Tunnel Brook join the Tankerhoosen River in the middle portion of the watershed prior to the river's confluence with the DEP-owned Tankerhoosen Lake, the first of three DEP-owned run-of-river ponds. Clarks Brook originates north of I-84 and drains primarily industrial/commercial and undeveloped land within the Town of Vernon. Clarks Brook discharges to the Tankerhoosen River approximately 0.5 miles upstream of the river's confluence with Tunnel Brook. Tunnel Brook is located in the central portion of Vernon, flowing north to south and crossing the I-84 corridor. The brook empties into the Tankerhoosen River approximately 0.65 miles upstream of the inlet to Tankerhoosen Lake (BEC, 2004).

Dobsonville Pond is located just downstream of Tankerhoosen Lake. Tucker Brook, which drains the southeastern portion of the watershed and a residential section of the Town of Manchester, joins the Tankerhoosen River immediately upstream of Dobsonville Reservoir dam. Further downstream are Talcottville Pond and the confluence with the Hockanum River near the Vernon/Manchester town line.

Overall the Tankerhoosen River is comprised of a large percentage of first and second order (i.e., headwater) streams according to the Strahler Stream Order classification system. Stream hydrology and water quality in headwater streams are important components of ecosystem health because they are a critical food source for the entire river, influence downstream conditions, and support biodiversity.

Ten subwatersheds within the Tankerhoosen River watershed have been delineated for the purposes of this assessment. The subwatershed delineations are based on the CTDEP local basin delineations, modified slightly based on surface water hydrology and grouped accordingly to facilitate assessment and development of watershed management plan recommendations. Figure 2-3 depicts the subwatersheds identified in this assessment, and Table 2-3 summarizes the basic characteristics of the subwatersheds.

Table 2-3. Tankerhoosen River Subwatersheds

Subwatershed	Acronym	Area (acres)	Area (square miles)
Bolton Notch Pond	BNP	344	0.54
Clarks Brook	CB	647	1.01
Gages Brook	GB	695	1.09
Gages Brook South Tributary	GBST	680	1.06
Lower Tankerhoosen River	LTR	321	0.5
Middle Tankerhoosen River	MTR	1,578	2.46
Railroad Brook	RB	1,208	1.89
Tucker Brook	TB	934	1.46
Upper Tankerhoosen River	UTR	1472	2.3
Walker Reservoir	WR	347	0.54
Tankerhoosen River Watershed		**8,226**	**12.85**

The Tankerhoosen River Watershed is located in an area with a temperate and humid climate. Based on historical climate information available from the NOAA National Weather Service weather station in Harford/Bradley International Airport in Windsor Locks, Connecticut, precipitation is generally well-distributed throughout the year with the wettest conditions in August and November and driest in February (worldclimate.com for Hartford/Bradley International Airport, Hartford County). In Windsor Locks, the mean annual precipitation over a 41-year period of record is 44.4 inches, and the 24-hour average temperature ranges from a high of 73.6°F in July to a low of 24.6°F in January.

Generally, the designated 100-year floodplain of the Tankerhoosen River is confined along a narrow corridor (<500 feet wide) surrounding the river. The entire length of the Tankerhoosen River is within the Federal Emergency Management Agency (FEMA) designated 100-year floodplain, with the exception of a small reach near the river's headwaters, between Reservoir Road and Fish and Game Road. The lower reach of Railroad Brook (below Valley Falls Pond including the pond) is also within the 100-year floodplain. Walker Reservoir West and East and portions of Gages Brook also lie within the designated 100-year floodplain (BEC, 2004).

Figure 2-3: Tankerhoosen River Subwatersheds

2.4 Water Quality

2.4.1 Classifications and Impairments

The Federal Clean Water Act (CWA) was developed to protect the nation's surface waters. Through authorization of the CWA, the United States Congress declared as a national goal "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water wherever attainable". Connecticut Water Quality Standards are established in accordance with Section 22a-426 of the Connecticut General Statutes and Section 303 of the CWA. The Water Quality Standards are used to establish priorities for pollution abatement efforts. Based on the Water Quality Standards, Water Quality Classifications establish designated uses for surface and ground waters and identify the criteria necessary to support these uses. The Water Quality Classification system classifies inland surface waters into four different categories ranging from Class AA to D. Table 2-4 summarizes the Connecticut Surface Water Quality Classifications.

Table 2-4. Connecticut Inland Surface Water Quality Classifications

<table>
<tr><th>Designated Use</th><th>Class AA</th><th>Class A</th><th>Class B</th><th>Class C</th><th>Class D</th></tr>
<tr><td>Existing/proposed drinking water supply</td><td>•</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Potential drinking water supply</td><td>•</td><td>•</td><td></td><td></td><td></td></tr>
<tr><td>Fish and wildlife habitat</td><td>•</td><td>•</td><td>•</td><td></td><td></td></tr>
<tr><td>Recreational use</td><td>•</td><td>•</td><td>•</td><td colspan="2" rowspan="2">Class C and D waters may be suitable for certain fish and wildlife habitat, certain recreational activities, industrial use, and navigation</td></tr>
<tr><td>Agricultural and industrial use</td><td>•</td><td>•</td><td>•</td></tr>
</table>

Source: DEP Surface Water Quality Standards, December 17, 2002

Figure 2-4 depicts the Water Quality Classifications of surface waters in the Tankerhoosen River watershed. Surface waters throughout the Tankerhoosen River watershed are classified as Class A with the exception of the Tankerhoosen Lake, Dobsonville Pond, and Talcottville Pond which are classified as Class B/A.

The CWA (Federal Clean Water Act) requires states to:

1. Adopt Water Quality Standards,
2. Assess surface waters to evaluate compliance with Water Quality Standards,
3. Identify those waters not currently meeting Water Quality Standards, and
4. Develop Total Maximum Daily Load (TMDL) analysis and other management plans to bring water bodies into compliance with Water Quality Standards.

Figure 2-4. Water Quality Classifications

A portion of the Tankerhoosen River does not meet Water Quality Standards for at least one of the designated uses. The impaired segment consists of the lower 1.51 miles of the Tankerhoosen River from Tankerhoosen Lakes to its confluence with the Hockanum River. The impaired uses include habitat for fish, other aquatic life, and wildlife. The causes and sources of impairment in the lower reaches of the Tankerhoosen River have not been identified and are currently listed as "unknown." TMDLs provide the framework to restore impaired waters by establishing the maximum amount of a pollutant that a water body can assimilate without adverse impact to aquatic life, recreation, or other public uses. The *2006 List of Connecticut Waterbodies Not Meeting Water Quality Standards* includes a priority ranking system for development of a TMDL specific to the contaminants in each impaired segment: high (H), medium (M), low (L), or under study (T). DEP has identified the impaired segment of the Tankerhoosen River as a high priority for development of a TMDL to restore the impairment. Table 2-5 summarizes the location and nature of the impairment.

Table 2-5. Tankerhoosen River Watershed Impaired Waters

Location Description	Waterbody Segment Length	Impaired Designated Use	Use Support	Cause	TMDL Priority	Potential Source
From mouth at Hockanum River, upstream to Tankerhoosen Lake	1.51 miles	Habitat for Fish, Other Aquatic Life and Wildlife	P	Impairment Unknown	H	Source Unknown

Source: DEP, 2006
H – high priority for which there is assessment information that suggests that a TMDL may be needed to restore the water quality impairment.
P – partially supporting

2.4.2 Tankerhoosen River Watershed Water Quality Monitoring Study

A water quality monitoring study was conducted in October and November 2006 to establish current baseline water quality conditions in the watershed, identify water quality impacts, and begin to develop a water quality database for the watershed (Fuss & O'Neill, 2007). Chemical water quality monitoring and biological assessments were conducted during dry and wet weather conditions. Samples were collected from fourteen locations throughout the watershed on four occasions (Figure 2-4). A variety of parameters were measured including pH, temperature, dissolved oxygen, and conductivity, which all reported values within normal ranges. These results indicate that the water quality of the watershed is generally good. However, some of the measured parameters including turbidity, metals, nitrogen, phosphorus, and bacteria highlighted some of water quality issues in the watershed. A brief discussion of the water quality parameters and identified issues is provided below:

Turbidity

Based on the wet weather monitoring results, excessive turbidity is a water quality issue in the Tankerhoosen River and its tributaries, particularly Gages Brook (Figure 2-5). Stream channel erosion and stormwater runoff from impervious surfaces and construction sites are potential sources of the observed turbidity during large precipitation events such as the August 2006 wet weather monitoring event, although it is difficult to attribute the turbidity excursions to a particular source. During the August 2006 wet weather monitoring event, turbidity measurements generally exhibited a declining trend from upstream to downstream within the watershed. Elevated levels of indicator bacteria (total coliform and *E. coli*) were measured at all monitoring locations during the October 2006 wet weather monitoring event, suggesting stormwater runoff and other non-point sources (pet waste, waterfowl, septic systems, etc.) as likely contributors of elevated pathogen levels in the Tankerhoosen River and its tributaries.

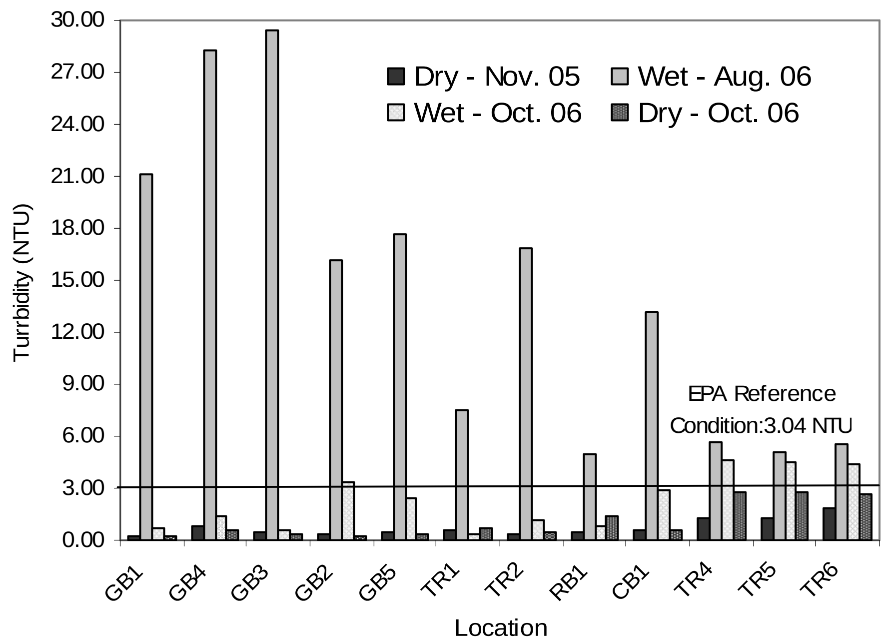


Figure 2-5. Turbidity – Tankerhoosen River Watershed

Metals

The monitoring data suggest a wet weather source of metals to Gages Brook (Figure 2-6 and Figure 2-7). Results from the August 2006 monitoring event indicate a wet weather source of metals close to the I-84 crossing of Gages Brook, as the dissolved copper concentration was consistently below detection limits at the Gages Brook headwaters monitoring location (GB1) and in excess of the chronic aquatic life criterion at several of the downstream Gages Brook locations. The highest wet weather lead concentration was measured in the Gages Brook monitoring location immediately downstream of I-84, which further suggests that highway runoff is a likely source of metals to Gages Brook. Exceedances of the CT WQS for lead were also measured along the Tankerhoosen River at the Fish and Game Road. (TR1) and Bolton Road (TR2) monitoring locations. Elevated dissolved copper and lead concentrations were also measured at the Clarks Brook monitoring location. The data suggest that metals are a potential source of impairment in Gages Brook, Clarks Brook, and the Tankerhoosen River during wet weather. The November 2005 results also indicate dry weather sources of dissolved copper to Gages Brook between the headwaters monitoring location (GB1) and the monitoring location behind the Tolland Agricultural Center (GB2).

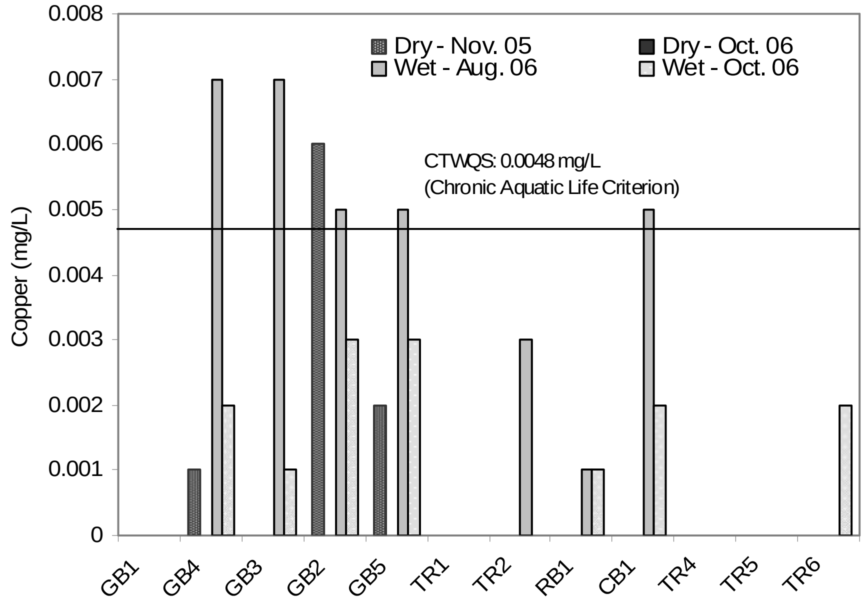


Figure 2-6. Dissolved Copper – Tankerhoosen River Watershed

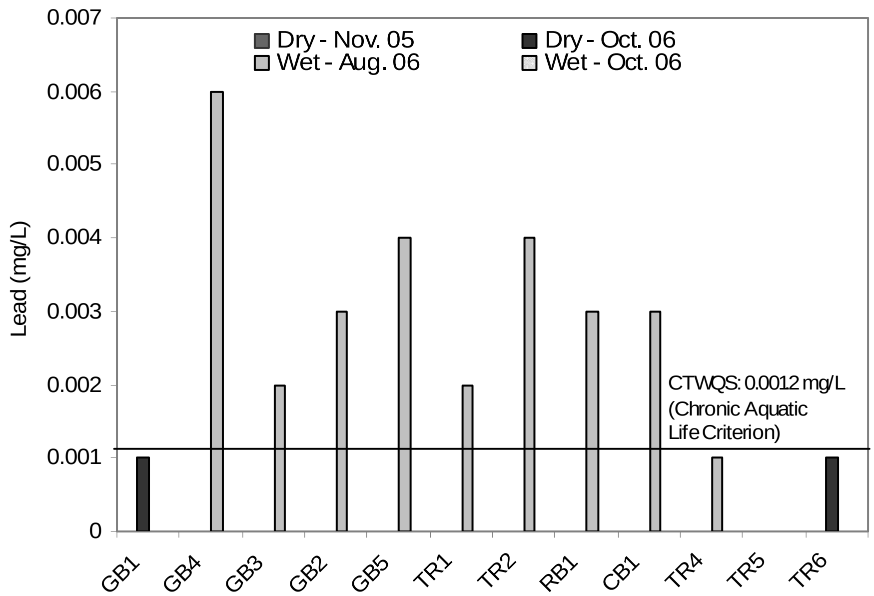


Figure 2-7. Lead – Tankerhoosen River Watershed

Nutrients

Many of the monitoring locations exceeded the EPA recommended Total Nitrogen criterion for rivers in Ecoregion XIV of 0.71 mg/L (Figure 2-8). Nitrogen concentrations were consistently higher at the Gages Brook monitoring locations than the other monitoring locations in both wet and dry weather.

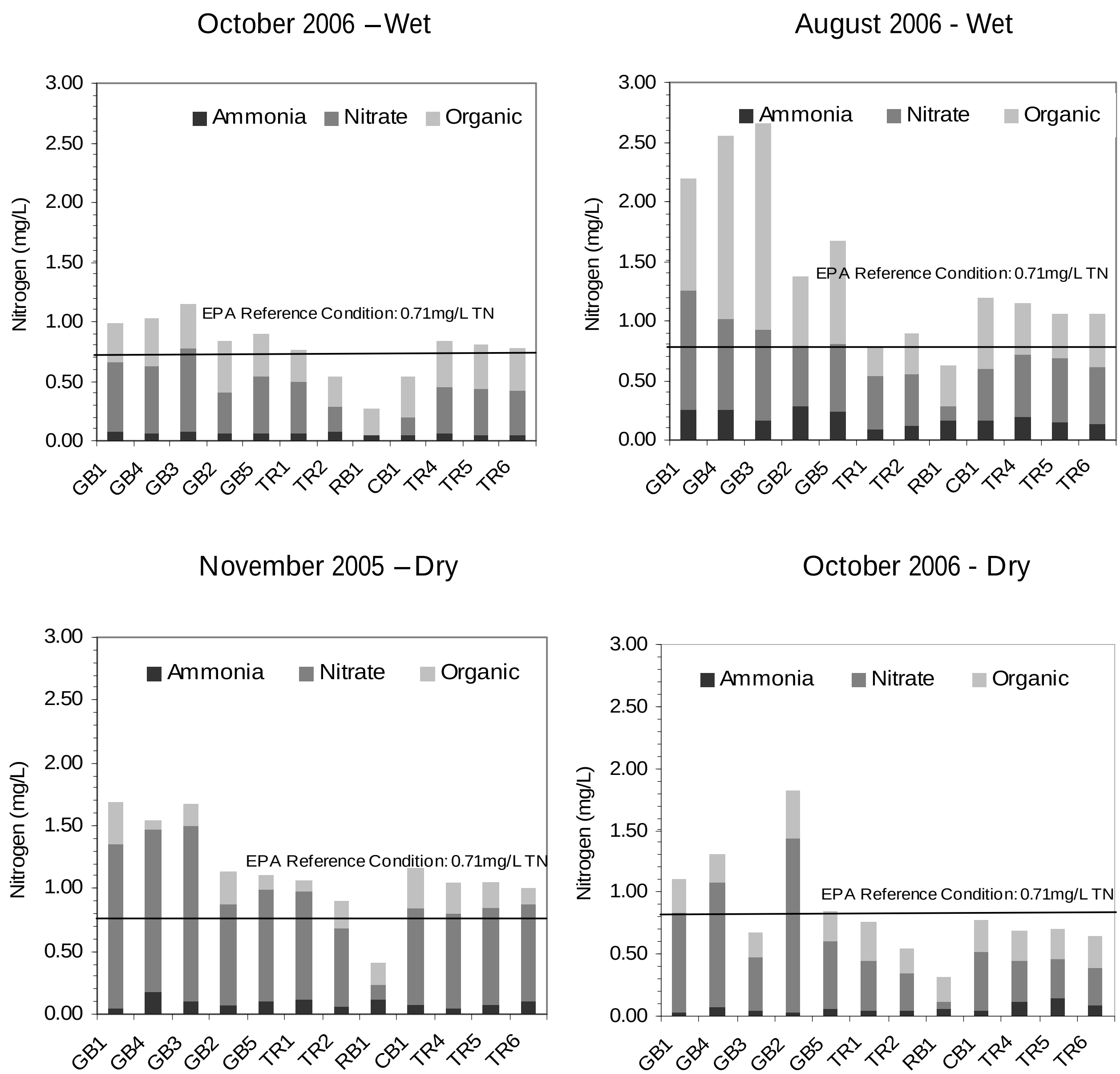


Figure 2-8. Nitrogen Species – Tankerhoosen River Watershed

Phosphorus concentrations measured during the wet and dry weather events significantly exceeded the CT WQS and EPA criterion at most locations (Figure 2-9). The elevated phosphorus levels are an indicator of potential organic enrichment and algal growth in water bodies along the Tankerhoosen River and its tributaries, which could impair aquatic life support and contact recreation under certain conditions.

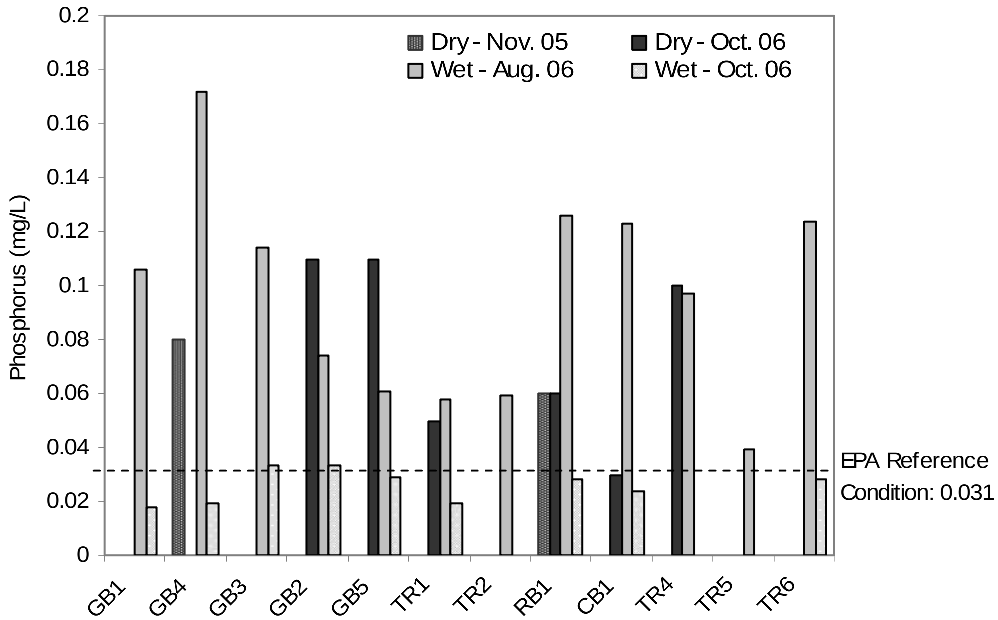


Figure 2-9. Phosphorus – Tankerhoosen River Watershed

Indicator Bacteria

Elevated levels of indicator bacteria (total coliform and *E. coli*) were measured at all monitoring locations during the October 2006 wet weather monitoring event, suggesting stormwater runoff and other non-point sources (pet waste, waterfowl, septic systems, etc.) as likely contributors of elevated pathogen levels in the Tankerhoosen River and its tributaries. Dry weather indicator bacteria concentrations were much lower than wet weather. Natural sources of indicator bacteria such as waterfowl or wildlife may have contributed to several dry weather exceedances of the CT WQS for total coliform at the Gages Brook monitoring location behind the Tolland Agricultural Center and at the Tankerhoosen River monitoring location just upstream of Fish and Game Road.

Bioassessments

The 2006 bioassessment data (RBV and Fuss & O Neill data collectively) vary considerably by site, but generally indicate very good water quality at most of the monitoring locations, with the exception of the lower Tankerhoosen River near the confluence with the Hockanum River and downstream of Dobsonville Pond. This finding is consistent with previous impairments identified in the lower reaches of the

Tankerhoosen River by the CTDEP. Despite the water quality issues identified in Gages Brook, Clarks Brook, and in certain reaches of the Tankerhoosen River (i.e., heavy metals, turbidity and suspended solids, and potential nutrient enrichment), the 2006 bioassessment data indicate little or no impairment to the benthic communities at the monitored locations.

2.5 Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands and buffer zones between watercourses and developed areas help to preserve stream water quality by filtering pollutants, encouraging infiltration of stormwater runoff, and protecting against stream bank erosion.

Wetlands in Connecticut are designated by soil classification. Figure 2-10 depicts the extent and distribution of wetland soils in the Tankerhoosen River watershed based on Natural Resources Conservation Service soil classifications. Figure 2-10 also depicts wetland mapping available from the U.S. Fish & Wildlife Service National Wetlands Inventory. Wetlands soils comprise 11.3% of the overall watershed (approximately 926 acres), while 4% of the watershed area (approximately 320 acres) is mapped as freshwater emergent wetlands or freshwater forested/shrub wetlands. The concentration of wetland soils is generally higher in the undeveloped portions of the watershed. Mapped wetland soils are generally located in riparian and floodplain areas along the Tankerhoosen River and its major tributaries. Table 2-6 summarizes wetland soils coverage by subwatershed.

Table 2-6. Wetland Soils Coverage in the Tankerhoosen River Watershed

Subwatershed Name	Wetland Soils Area (ac)	% of Subwatershed
Bolton Notch Pond	20	5.8 %
Clarks Brook	101	15.5 %
Gages Brook	111	15.9 %
Gages Brook South Tributary	34	5.1 %
Lower Tankerhoosen River	7	2.3 %
Middle Tankerhoosen River	188	11.9 %
Railroad Brook	136	11.3 %
Tucker Brook	109	11.7 %
Upper Tankerhoosen River	193	13.1 %
Walker Reservoir	27	7.6 %
Tankerhoosen River Watershed	**926**	**11.3%**

At least twenty vernal pools have been identified within the Tankerhoosen watershed by certified scientists (see Figure 2-10). The majority of these were cited by Mr. Ed Pawluk of Connecticut Ecosystems, LLC in a study conducted for the Vernon Conservation Commission. Several of these pools are considered exemplary vernal pools, and as such merit the highest possible level of protection and conservation (Connecticut Ecosystems, LLC, 2005).

Figure 2-10. Wetland Soils – Tankerhoosen River Watershed

In 1993, a comprehensive survey of plant life was conducted in the 1,400-acre watershed from Valley Falls Park in Vernon to Bolton Notch State Park in Bolton (Sexton, 1993). The study was sponsored by the Town of Bolton Conservation Commission and the Town of Vernon Conservation Commission. A total of 345 species representing 82 families were identified. A small band of marble exists a short distance north and south of the cut at Bolton Notch. A plant species unique to this area includes the Yellow Lady's Slipper. Marble is rare east of the Connecticut River and supports additional plants preferring more basic soil including the purple cliff-brake and maidenhair fern (Sexton, 1993).

2.6 Fish and Wildlife Resources

Portions of the Tankerhoosen River have abundant habitats supportive of a variety of fish and wildlife. Various waterbodies, wetlands, and upland areas provide habitat to fish, mammals, amphibians, and birds.

Particularly notable is the 282-acre Belding Wildlife Management Area located in the central portion of the Tankerhoosen River watershed. The Belding Wildlife Management Area is a significant natural resource of undeveloped land owned by the State of Connecticut and managed by the DEP. A 1.4-mile section of the Tankerhoosen River within the Belding Wildlife Management Area is managed as a Class 1 Wild Trout Management Area and is one of only two such areas in eastern Connecticut. This section of stream is characterized by natural reproduction sufficient to produce robust populations of native brook trout (up to 8-10 inches) and wild brown trout (up to 10-11 inches) exhibiting above average growth rates (DEP correspondence, 2003).

Areas in the Tankerhoosen River watershed that provide significant habitat are summarized in Table 2-7. These areas provide habitat for some of the most valuable or unique natural resources or ecosystems in their respective communities. Other open space areas are described in the Land Use and Land Cover section of this report.

Table 2-7. Areas Providing Habitat for Valuable or Unique Natural Resources

Town	Areas
Vernon	• Vernal Pools on Box Mountain • Tancanhoosen LLC Parcel • Talcottville Gorge • Belding Wildlife Management Area • Belding Wild Trout Management Area • Valley Falls Park • Rambling Ridge Property • Webster-Knapp Preserve
Tolland	• Tolland and Charter Marshes
Bolton	• Freja Park • Bolton Notch State Park

Source: Hockanum River – State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005; amended in 2008.

Freja Park is a 21-acre, wooded town-owned area located west of Bolton Notch Pond. Freja Park serves as a gateway for the 1,400-acre Bolton Notch/Valley Falls watershed area. The town of Bolton originally acquired the property in 1968, but the park suffered from abuse and neglect. Beginning in March 1998, restoration efforts have been underway including numerous Earth Day Clean-up events with the help of volunteers, Boy Scouts, Conservation Commission members. A total of over two tons of litter have been removed from the park.

2.6.1 Fisheries

The Tankerhoosen River historically hosted large runs of many anadromous fish species. Development of the river with dams from 1700 to the 1920s created barriers to fish migration, which extirpated the salmon run and severely limited the upstream habitat for shad and river herring. Despite these obstacles, the Tankerhoosen River and its tributaries support a variety of fish species as detailed in Table 2-8.

The Tankerhoosen River is a cold water stream starting only a short distance below Walker Reservoir. The generally cold water temperatures in the Tankerhoosen are the result of extensive spring water inputs (DEP correspondence, 2008).

As indicated previously, the Belding Wild Trout Management Area in the upper portions of the Tankerhoosen River watershed is a Class 1 Wild Trout Management Area with self-sustaining native trout populations that rank among the best of their kind in the state. Portions of the remainder of the Tankerhoosen River are stocked annually by the DEP Inland Fisheries Division. Valley Falls Park Pond is stocked in the spring and winter with about 4,400 rainbow trout and generates between 7,500-8,000 angler hours of fishing annually. Walker Reservoir, upstream of the Belding Wildlife Management Area, is stocked each spring with over 1,800 adult brown and rainbow trout (DEP correspondence, 2003).

Table 2-8. Fish Species

	Bolton Notch Pond	Gages Brook	Lower Tank. River	Middle Tank. River	Upper Tank. River	Railroad Brook
American Eel				X	X	X
Brown Bullhead	X					X
Black Crappie	X				X	
Blacknose Dace		X		X	X	X
Brook Trout		X		X	X	X
Brown Trout			X	X	X	X
Bluegill	X		X	X	X	X
Chain Pickerel	X		X	X		
Common Shiner				X	X	X
Creek Chub				X	X	
Fallfish				X	X	
Fathead Minnow		X				
Golden Shiner	X			X	X	
Longnose Dace				X	X	
Largemouth Bass		X	X	X	X	X
Pumpkinseed Sunfish	X	X	X	X	X	X
Rainbow Trout				X	X	X
Rockbass			X			
Smallmouth Bass			X			
Tessellated Darter			X	X	X	

Table 2-8. Fish Species

	Bolton Notch Pond	Gages Brook	Lower Tank. River	Middle Tank. River	Upper Tank. River	Railroad Brook
White Sucker		X		X	X	X
Yellow Perch	X			X		X
Tiger Trout					Stocked in Pond	
Golden Trout					Stocked in Pond	

2.6.2 Birds

Bird surveys were conducted in 2004 at the Tancanhoosen LLC property, within Valley Falls Park, and at various Town of Vernon properties, including areas around Walker Reservoir East and on the Connecticut Light & Power line site.

Eighty bird species were detected during the 2004 surveys. Seventy four species were counted during standardized bird counts at 24 count points, and 6 more were detected as incidental observations. The greatest number of species occurred at Walker Reservoir, while the former gravel pit on the Tancanhoosen LLC property contained the most uncommon birds. Prairie warbler, field sparrow, brown thrasher and eastern towhee were detected on the Tancanhoosen LLC property throughout the breeding season. Populations of these species are declining and brown thrasher is on Connecticut's list of Species of Special Concern. These birds are dependent on early successional habitats such as grassland and shrubland. These habitat types have been lost to reforestation and human development. The gravel pit is at an early successional stage with open, grassy habitat and short, scattered pine trees. This site will eventually revert to a forested habitat unless actively managed to maintain early successional habitat. Once the site is reforested, early successional species will disappear from this site (Seymour, 2004).

The Tankerhoosen River watershed also supports a wide range of bird of species. Surveys performed in 2003 and 2004 reported evidence of great blue heron, wood duck, willow flycatcher, hermit thrush, black-throated blue warbler, broad-winged hawk, hairy woodpecker, pileated woodpecker, olive-sided flycatcher, yellow-throated vireo, red-breasted nuthatch, blue-gray gnatcatcher, Nashville warbler, pine warbler, blackpoll warbler, blackburnian warbler, cerulean warbler, worm-eating warbler, and Canada warbler. European starling and house sparrow, two introduced invasive species, were also identified (Seymour, 2004). A complete species list is provided in the *Baseline Watershed Assessment* (Fuss & O Neill, May 28, 2008).

During 1999, a bird survey was completed to determine the species diversity and the relative abundance of breeding landbirds within Freja Park and Bolton Notch State Park (Comins, 1999). Of the total 55 species were recorded, 51 were likely nesting species and four were probably non-nesting visitors or migrants. An additional fourteen species were not recorded on the survey, but were identified as likely to occur during the nesting season. Another twenty-nine species have reasonable possibility of occurring in the nesting season from time to time or could be attracted to the area.

Two Connecticut State Species of Special Concern were recorded; six species were listed as National Audubon Society Watch List High Conservation Priority species in Connecticut were recorded; an additional six species not listed as watch species were listed by Partners in Flight as High Conservation Priority Species in Connecticut; fourteen species that were uncommon nesters in the Hartford area were recorded (Comins, 1999). See report for additional listing of specific species.

2.6.3 Amphibians & Reptiles

Amphibian and reptile surveys were conducted in 2004 within the Tankerhoosen River watershed, including the Belding Wildlife Management Area, Barrows Brook, and Railroad Brook. Some of the species identified included Northern redback salamander, Northern two-lined salamander, Spotted salamander, American toad, Northern spring peeper, Gray treefrog, Wood frog, Green frog, Pickerel frog, Painted turtle, and Garter snake. The most abundant amphibian species detected during this study was the northern redback salamander. A complete list of the identified amphibian and reptile species is provided in the *Baseline Watershed Assessment* (Fuss & O Neill, May 28, 2008). A previously undocumented vernal pool was discovered between Reservoir Road and Walker Reservoir West. Additional vernal pools were identified on Bolton Road and above Valley Falls Park (Seymour, 2004).

2.6.4 Threatened and Endangered Species

The DEP Natural Diversity Data Base (NDDB) maintains information on the location and status of endangered, threatened, and special concern species in Connecticut. Figure 2-11 displays the generalized areas of endangered, threatened, and special concern species in the Tankerhoosen River watershed. The areas represent a buffered zone around known species or community locations. The locations of species and natural community occurrences depicted on the NDDB mapping are based on data collected over the years by the Environmental and Geographic Information Center s Geologic and Natural History Survey, other units of the DEP, conservation groups, and the scientific community. Approximately ten such areas were identified throughout the watershed. Because new information is continually being added to the Natural Diversity Database and existing information updated, the areas are reviewed on an annual basis by the DEP. Areas can be removed or added based upon the results of the review.

Table 2-9. Endangered, Threatened, and Special Concern Species

Common Name	Scientific Name	Status
	Flora	
Climbing fern	*Lygodium palmatum*	Special Concern
Sphagnum	*Sphagnum pulchrum*	--
Beaked sedge	*Carex rostrata*	--
Leatherleaf	*Chamaedaphne calyculata*	--
	Fauna	
Eastern pearlshell	*Margaritifera margaritifera*	Special Concern
Brown thrasher	*Toxostoma rufum*	Special Concern
Southern bog lemming	*Synaptomys cooperi*	Special Concern
Wood turtle	*Clemmys insculpta*	Special Concern
Purple martin	*Progne subis*	Threatened

Table 2-9. Endangered, Threatened, and Special Concern Species

Common Name	Scientific Name	Status
Eastern box turtle	*Terrapene c. carolina*	Special Concern
Habitats		
Medium fen	--	--
Subacidic rocky summit/outcrop	--	--

Source: DEP Natural Diversity Data Base, 2008.

- "Endangered Species" means any native species documented by biological research and inventory to be in danger of extirpation (local extinction) throughout all or a significant portion of its range within Connecticut and to have no more than five occurrences in the state.
- "Threatened Species" means any native species documented by biological research and inventory to be likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range within Connecticut and to have no more than nine occurrences in the state.
- "Species of Special Concern" means any native plant or any native nonharvested wildlife species documented to have a naturally restricted range or habitat in the state, to be at a low population level, to be in such high demand by man that its unregulated taking would be detrimental to the conservation of its population, or has become locally extinct in Connecticut.

2.7 Watershed Modifications

2.7.1 Dams, Impoundments, & Water Supply

The historical industrial use of the Tankerhoosen River and its major tributaries has left behind many small dams and impoundments. Most of this infrastructure is no longer used for power generation, and many of these impoundments currently provide aquatic and wildlife habitat and recreational opportunities. Many of the dams in the watershed are also an impediment to fish migration.

According to the DEP Dam Safety Regulations, the hazard classification of a dam is based on the damage potential from failure of the structure. Figure 2-12 shows the location and hazard classification of the identified dams within the watershed. Some of the dams which no longer serve an integral function to industry or public use have fallen into disrepair and pose a potential hazard to downstream properties.

Table 2-10 lists the major drinking water supplies within the Tankerhoosen River watershed that are regulated under the DEP Water Diversion program.

Table 2-10. Major Drinking Water Supplies

Name	Name of Diversion	MGD	Town
Connecticut Water Company	Vernon Well #1	0.1728	Vernon
	Vernon Well #2	0.1728	Vernon
	Vernon Well #3	0.1440	Vernon
	Vernon Well #4	0.1728	Vernon
	Vernon Well #5	0.4320	Vernon
Manchester Water Department	New Bolton Well Field, Well #1,2,3	Various	Bolton

Figure 2-11. DEP Natural Diversity Database Areas
– Tankerhoosen River Watershed

Figure 2-12: DEP Regulated Dams – Tankerhoosen River Watershed

The DEP, with Cooperation from the Connecticut Water Company, has identified two preliminary (Level B) Aquifer Protection Areas associated with these wells within the Tankerhoosen River watershed, as shown in Figure 2-13. Aquifer Protection Areas are designated around active well fields in sand and gravel aquifers that serve more than 1,000 people. Level B mapping identifies the general area of aquifer recharge based primarily on topography. The watershed communities are required to establish land use regulations for these areas to limit potential contamination to public groundwater supplies. Private groundwater supply wells are also prevalent throughout areas of the watershed that are not served by public water supplies.

2.7.2 Wastewater Discharges

As summarized in Table 2-11, there are number of industrial, commercial, and municipal facilities in the Tankerhoosen River Watershed with surface water discharges regulated under the National Pollutant Discharge Elimination System (NPDES) permit program, which is administered by the Connecticut DEP. The facilities listed in Table 2-5 have either permitted wastewater or stormwater discharges to surface waters. The majority of these facilities are located in Vernon. There are no municipal wastewater treatment plants located within the Tankerhoosen River watershed.

Table 2-11. NPDES Regulated Facilities

Town	Facility	Location	Permit Number
Vernon	Carpenter's Mobil	447 Hartford Turnpike	GVS000915
	Company 1 Firehouse	724 Hartford Turnpike	GVM000592
	Connecticut Golfland	95 Hartford Turnpike	GPL000108
	First Student	25 Whitney Ferguson Road	GSI001217
	Motiva Enterprises LLC	444 Hartford Turnpike	GGR001404
	Moore's Automotive	1245 Hartford Turnpike	GVM000806
	Mount Vernon Apartments	1120 Hartford Turnpike	GVS000863
	Oakland Meadows	1158 Hartford Turnpike	GSN001098
	Tighitco, Inc.	101-77 Industrial Park Road	GSI001599
	Vernon Maintenance	37 Campbell Avenue	GVS000988
			GSI000074
	VMS Construction Company	120 Bolton Road	GVM000980
Bolton	Transportation Facility	326 Boston Turnpike	GSI001179
	Hull's Autobody	299-301 Boston Turnpike	GVM000800
Tolland	Dari Farms	Gerber Drive	GSN000814
	Mr. Sparkle Car Wash	157 Hartford Turnpike	GVM000646
	Connecticut Light & Power Co.	45 Tolland Stage Road	GVS001027
	Gerber Scientific Inc.	24 Industrial Park Road West	GSI000914
	Standard Register Co.	259 Hartford Turnpike	GPP000152
			GPH000345
	CNC Software Inc.	671 Old Post Road	GSN000070
	Belvedere Ridge	601 Old Post Road	GSN001308

Source: DEP, December 2007

Figure 2-13: DEP Aquifer Protection Areas – Tankerhoosen River Watershed

Figure 2-14 depicts sewer service areas in the watershed. Areas outside of the mapped sewer service areas are presumed to be on individual sewage disposal (i.e., septic) systems. Approximately 23% of the overall Tankerhoosen River watershed area is served by municipal sanitary sewers.

Historical and current industrial and commercial development within the Tankerhoosen River watershed poses a potential threat to surface water and groundwater supplies in the watershed. Illegal waste disposal, improper use and disposal of chemicals such as used oil, pesticides, and herbicides, and chemical spills are potential sources of contaminants from industrial and commercial facilities. As summarized in Table 2-12, several hazardous waste generators and other regulated sites are located within the watershed. These facilities are located in both Vernon and Tolland in the central and upper portions of the watershed.

Table 2-12. Summary of Regulated Sites

Site Type	Number of Sites	
	Vernon	Tolland
Hazardous Waste Generator	5	6
Air Emissions	1	2
CERCLA Site	1 (1 on Final NPL)	0

There is one site that is listed as potential hazardous waste site that EPA has evaluated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), otherwise known as "Superfund." This site, Precision Plating Corporation, is located in the Hillside Industrial Park in Vernon and is currently on the Final National Priorities List (NPL). Chromium contaminated groundwater at the site is being remediated under the direction of the DEP.

2.8 Land Use and Land Cover

The type and distribution of land use within a watershed have direct impact on nonpoint sources of pollution and water quality. This section describes the land use and land cover patterns in the Tankerhoosen River watershed.

2.8.1 Current Conditions

Land Use

Figure 2-15 depicts general land use patterns in the Tankerhoosen River watershed. The data in Figure 2-15 are parcel-based land use categories for the watershed communities, provided by the Capital Region Council of Governments (CRCOG). The land uses in the watershed include 20 land use categories (Table 2-13). Approximately 60% of the watershed consists of developed land uses, with single-family residential comprising the largest percentage (40%). Highway and other road right-of-ways comprise approximately 9% of the watershed area. Approximately 30% is classified as resource/recreation land use, which includes committed and uncommitted open space. Major portions of the riparian areas adjacent to the Tankerhoosen River and its tributaries are located within resource/recreation areas.

Figure 2-14: Sewer Service Areas – Tankerhoosen River Watershed

Figure 2-15: Current Land Use – Tankerhoosen River Watershed

Areas in the northern portion of the watershed are more commercialized and have a greater retail and industrial use, with commercial, retail, and industrial land uses comprising approximately 4% of the watershed area. The majority of the commercial, industrial, and retail areas are located in headwater regions adjacent to the major transportation corridors of I-84/Route 30 and I-384.

Table 2-13. Current Land Use – Tankerhoosen River Watershed

Land Use Type	Acres	Percent of Watershed
Agriculture	103	1%
One Family	3160	38%
Two Family	48	<1 %
Three Family	2	<1 %
Multi Family	39	<1 %
Condominium	165	2%
Group Quarters	12	<1 %
Commercial	110	1%
Retail	88	1%
Mixed Use	3	<1 %
Industrial	183	2%
Government/Non-Profit	102	1%
School	26	<1 %
Cemetery	22	<1 %
Health/Medical	6	<1 %
Resource/Recreation	2398	29%
Undeveloped	851	10%
Right-of-way	770	9%
Water	77	<1 %
Unknown	61	<1 %

In the Tankerhoosen River watershed, several tracts of potentially developable land have been permanently preserved as "committed" open space. Committed open space parcels in the Town of Vernon and the Town of Bolton were identified through available land use mapping and confirmed by members of the Technical Advisory Committee and the Bolton Conservation Commission. Committed open space parcels in Tolland and Manchester were determined through available mapping from each Town's Plan of Conservation and Development (POCD) and from the Connecticut Office of Policy and Management Municipal Plans of Conservation and Development. In general, the committed open space areas include deeded open space that is privately owned, parcels owned by land trusts, land owned by the State of Connecticut as well as parks owned by the Town of Vernon and Town of Bolton, including the Hop River State Park Trail, Valley Falls Park, Freja Park, and Bolton Notch State Park. This land is protected against future development and is generally located in the central and southern portion of the watershed. Figure 2-16 identifies the committed open space land in the watershed.

In addition, several parcels within the watershed are designated for agricultural or forestry use under Public Act 490. While development is not prohibited on this land, this program reduces the tax burden on this land, thereby relieving some of the pressure to develop the land and allows it to continue to serve as open space.

Figure 2-16: Committed Open Space – Tankerhoosen River Watershed

Zoning

Figure 2-17 depicts the zoning designations in the Tankerhoosen River watershed. The data in Figure 2-17 are also parcel-based and provided by CRCOG. The majority of the Tankerhoosen River watershed is zoned for residential uses. Commercial and industrial zones associated with the I-384 and I-84 corridors are located in the southern and northern portions of the watershed, respectively.

Land Cover

Figure 2-18 depicts the general land cover in the Tankerhoosen River watershed. Data shown in Figure 2-18 are land cover categories derived from 2002 Landsat satellite imagery with ground resolution of 30 meters. The land cover data in the watershed are summarized into ten categories (Table 2-8). These ten categories are those used in the Connecticut Land Cover Map Series and are described following the table (University of Connecticut Center for Land Use Education and Research).

Table 2-14. Land Cover – Tankerhoosen River Watershed

Land Cover Type	1985		2002		Relative Percent Change[1]	Relative Percent Change[2]
	Acres	Percent of Watershed	Acres	Percent of Watershed		
Barren	91	1%	162	2%	1%	78%
Coniferous Forest	454	6%	430	5%	-1%	-5%
Deciduous Forest	4581	56%	4085	50%	-6%	-11%
Developed	1793	22%	2201	27%	5%	23%
Forested Wetland	192	2%	175	2%	0	-9%
Non-Forested Wetland	2	< 1 %	19	<1 %	0	912%
Other Grasses and Agriculture	551	7%	603	7%	0	9%
Turf and grass	448	5%	447	5%	0	0%
Utility Right of Way	19	< 1 %	17	<1 %	0	-12%
Water	95	2%	88	1%	1%	-7%

[1]Calculation = % land cover 2002 - % land cover 1985

[2]Calculation = (acres land cover 2002 – acres land cover 1985) / acres land cover 1985

Source: University of Connecticut's Center for Land Use Education and Research (CLEAR)

- Barren – Mostly non-agricultural areas free from vegetation, such as sand, sand and gravel operations, bare exposed rock, mines, and quarries. Also includes some urban areas where the composition of construction materials spectrally resembles more natural materials. Also includes some bare soil agricultural fields.
- Coniferous Forest – Includes Southern New England mixed softwood forests. May include isolated low density residential areas.
- Deciduous Forest – Includes Southern New England mixed hardwood forests. Also includes scrub areas characterized by patches of dense woody vegetation. May include isolated low density residential areas.
- Developed – High density built-up areas typically associated with commercial, industrial and residential activities and transportation routes. These areas contain a significant amount of impervious surfaces, roofs, roads, and other concrete and asphalt surfaces.
- Forested Wetland – Includes areas depicted as wetland, but with forested cover. Also includes some small watercourses due to spectral characteristics of mixed pixels that include both water and vegetation.
- Non-forested Wetland – Includes areas that predominantly are wet throughout most of the year and that have a detectable vegetative cover (therefore not open water). Also includes some small watercourses due to spectral characteristics of mixed pixels that include both water and vegetation.
- Other Grasses and Agriculture – Includes non-maintained grassy areas commonly found along transportation routes and other developed areas and also agricultural fields used for both crop production and pasture.

Figure 2-17: Watershed Zoning as Defined by CRCOG
– Tankerhoosen River Watershed

Figure 2-18: Land Cover – Tankerhoosen River Watershed

- Turf & Grass – A compound category of undifferentiated maintained grasses associated mostly with developed areas. This class contains cultivated lawns typical of residential neighborhoods, parks, cemeteries, golf courses, turf farms, and other maintained grassy areas. Also includes some agricultural fields due to similar spectral reflectance properties.
- Utility – Includes utility rights-of-way. This category was manually digitized on-screen from rights-of-way visible in the Landsat satellite imagery. The class was digitized within the deciduous and coniferous categories only.
- Water – Open water bodies and watercourses with relatively deep water.

Forest Cover

Forested areas are the predominant land cover type in the Tankerhoosen River watershed. Approximately 55% of the watershed consists of deciduous and coniferous forests, primarily in the central and southern portions of the watershed. Table 2-15 compares the total acres and percent forest cover by subwatershed. The percent forest cover in each subwatershed ranges from approximately 31% in the Walker Reservoir subwatershed to approximately 86% in the Railroad Brook subwatershed. Based on a literature threshold values documented in several studies (CLEAR, 2007), watershed forest cover of 65% or greater is the minimum needed for a healthy aquatic invertebrate community. Only two of the ten subwatersheds, Railroad Brook and the Upper Tankerhoosen River, exceed the threshold value of 65%. Based on a recommendation of the American Forests organization, 40% forest cover is a reasonable threshold goal for urban areas. All but two subwatersheds, Clarks Brook (34.8 %) and Walker Reservoir (31.3 %), both of which are located in the northern and most developed portion of the watershed, meet this goal.

Table 2-15. Forest Cover – Tankerhoosen River Watershed

Subwatershed Name	Forest Cover in Subwatershed (acres)	Percent Forest Cover in each Subwatershed	Developable Forest Cover in Subwatershed (acres)	Forest Cover that is Developable
Bolton Notch Pond	171	49.60%	41	24.00%
Clarks Brook	226	34.80%	70	30.90%
Gages Brook	314	45.20%	134	42.60%
Gages Brook South Tributary	395	58.10%	171	43.30%
Lower Tankerhoosen River	149	46.60%	82	54.90%
Middle Tankerhoosen River	625	39.60%	122	19.60%
Railroad Brook	1043	86.30%	346	33.20%
Tucker Brook	374	40.00%	119	31.80%
Upper Tankerhoosen River	1110	75.40%	278	25.00%
Walker Reservoir	109	31.30%	54	49.20%
Tankerhoosen River Watershed	**4515**	54.90%	1416	31.40%

Table 2-15 also includes a comparison of the amount of forest cover in each subwatershed that could potentially be developed in the future (i.e., "developable"). Refer to Section 2.5.2 for a discussion of the determination of "developable" areas and watershed buildout scenario. The percent of forest cover that is developable for each subwatershed ranges from approximately 20% in the Middle Tankerhoosen River subwatershed and up to approximately 55% in the Lower Tankerhoosen River subwatershed. These results suggest that future development within the watershed has the potential to significantly reduce forest cover and, in some subwatersheds, to below recommended thresholds.

Riparian Vegetation

Riparian, or streamside, corridors are critical areas important to stream stability, pollutant removal, and wildlife habitat. These areas are also sometimes called "buffer" areas, but are not to be confused with regulatory review zones, which are often also called buffers (CLEAR 2007). A stream walk survey of the Tankerhoosen River conducted in 1999 revealed that riparian buffers of 100 feet are common between the river and developed areas. However, some areas along the lower reaches of the Tankerhoosen River were identified as having stream buffers of less than 25 feet, according to the results of a 2000 stream walk survey of the Tankerhoosen River.

In order to assess the status and of the riparian corridors in the Tankerhoosen River watershed, the acreage of forest cover within the riparian area (defined as a 200-foot buffer on both sides of streams and a 200-foot buffer from waterbody shorelines) was calculated for each of the ten subwatersheds based on the 2002 Center for Land Use Education and Research (CLEAR) forest land cover classes (coniferous and deciduous forest). The results are provided in Table 2-16.

Table 2-16. Forest Cover in Riparian Corridors

Subwatershed Name	Forest Cover in 200-foot Riparian Corridor (acres)	Percent of 200-foot Riparian Corridor that is Forested
Bolton Notch Pond	19	34.90%
Clarks Brook	42	46.30%
Gages Brook	85	61.40%
Gages Brook South Tributary	93	62.30%
Lower Tankerhoosen River	31	35.80%
Middle Tankerhoosen River	99	41.80%
Railroad Brook	167	87.20%
Tucker Brook	92	51.80%
Upper Tankerhoosen River	216	80.70%
Walker Reservoir	21	23.10%
Tankerhoosen River Watershed	**866**	**58.30%**

Forest cover within the 200-foot riparian corridor for the overall Tankerhoosen River Watershed is nearly 60%, although the amounts vary considerably by subwatershed. Railroad Brook (87.2%) and the Upper Tankerhoosen River (80.7%) subwatersheds have the highest percentage of forest cover within the 200-foot riparian corridor. Walker Reservoir (23.1%) and Bolton Notch Pond (34.9%) have the lowest percentage of forest cover within the 200-foot riparian corridor. These results indicate that large portions of the watershed streams and waterbodies are well-protected by intact riparian forest cover, although several subwatersheds have significantly lower riparian forest cover.

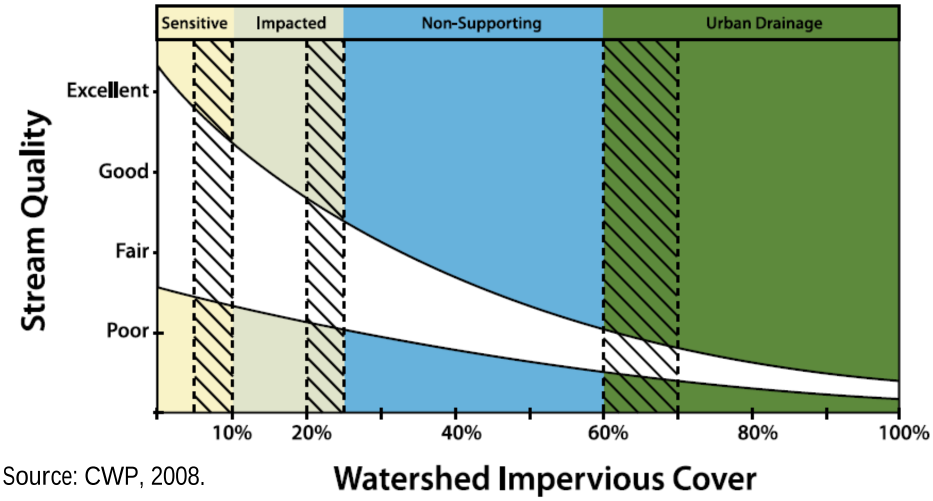
Developed Areas
Developed areas are also a dominant land cover type in the Tankerhoosen River watershed. Approximately 27% of the watershed consists of commercial, industrial, residential, and transportation land cover types (i.e. "developed" category) that follow the major transportation corridors, regional retail and commercial areas, and population centers. Approximately 7% of the watershed consists of other grass and agriculture, although only a small portion of this (approximately 1%) consists of land in active agricultural use.

A comparison of watershed land cover data between 1985 and 2002 (Table 2-14) shows a moderate increase in watershed development during this period (5% increase in developed cover types) and a corresponding loss of coniferous (1% decrease) and deciduous forest (6% decrease).

Impervious Cover
Impervious cover has emerged as a measurable, integrating concept used to assess the overall condition of a watershed. Numerous studies have documented the cumulative effects of urbanization on stream and watershed ecology (Center for Watershed Protection, 2003; Schueler et al., 1992; Schueler, 1994; Schueler, 1995; Booth and Reinelt, 1993, Arnold and Gibbons, 1996; Brant, 1999; Shaver and Maxted, 1996). Research has also demonstrated similar effects of urbanization and watershed impervious cover on downstream receiving waters such as lakes, reservoirs, estuaries, and coastal areas.

The correlation between watershed impervious cover and stream indicators is due to the relationship between impervious cover and stormwater runoff, since streams and receiving water bodies are directly influenced by stormwater quantity and quality. Although well-defined imperviousness thresholds are difficult to recommend, research has generally shown that when impervious cover in a watershed reaches between 10 and 25 percent, ecological stress becomes clearly apparent. Between 25 and 60 percent, stream stability is reduced, habitat is lost, water quality becomes degraded, and biological diversity decreases (NRDC, 1999). Watershed imperviousness in excess of 60 percent is generally indicative of watersheds with significant urban drainage. Figure 2-19 illustrates this effect. These research findings have been integrated into a general watershed planning model known as the impervious cover model (ICM) (CWP, 2003). The ICM has also been confirmed locally in Connecticut by the DEP, which has determined a statewide impervious cover threshold of 12 percent for aquatic life impairment (Belucci, DEP, 2007).

A GIS-based impervious cover analysis was performed for the Hockanum River watershed and including the Tankerhoosen River watershed by staff from the Department of Natural Resources Management and Engineering at the University of Connecticut (Civco, 2005). The satellite-derived land cover data described previously were used in the analysis. This technique, known as "direct impervious surface modeling", extracted impervious surface data directly from 2002 Landsat imagery to estimate the amount of impervious surface within each pixel. The DEP GIS basin layer was used to calculate the percent of imperviousness by basin. Figure 2-19 graphically summarizes the results of this analysis.



Source: Source: CWP, 2008.

Figure 2-19. Conceptual Model Illustrating Relationship Between Watershed Impervious Cover and Stream Quality

The overall imperviousness of the Tankerhoosen River watershed is estimated at approximately 9.7%. This level of impervious cover is slightly below the CTDEP aquatic life impairment threshold of approximately 12%, where ecological stress and stream impacts become apparent. As shown in Figure 2-20 and summarized in Table 2-17, impervious cover in much of the central and southern portions of the watershed (Upper Tankerhoosen River and Railroad Brook watersheds) is less than 5%, consistent with the high percentage of forest cover and conservation land in these areas. The headwater tributaries of the Tankerhoosen River, specifically Gages Brook, are estimated to have approximately 11.5% impervious cover, while localized subwatershed areas around Bolton Notch Pond, Walker Reservoir, and Dobsonville Pond have impervious cover near or above 20%.

Table 2-17. Percent Impervious Cover – Tankerhoosen River Watershed

Subwatershed	Percent Impervious Cover
Bolton Notch Pond	16.60%
Clarks Brook	17.20%
Gages Brook	11.50%
Gages Brook South Tributary	11.30%
Lower Tankerhoosen River	15.80%
Middle Tankerhoosen River	12.90%
Railroad Brook	1.70%
Tucker Brook	8.10%
Upper Tankerhoosen River	4.50%
Walker Reservoir	19.90%
Tankerhoosen River Watershed	**9.70%**

Figure 2-20: Current Impervious Cover – Tankerhoosen River Watershed

The results of this analysis provide an initial diagnosis of potential stream and receiving water quality within the watershed study area. The analysis method and ICM are based on several assumptions and caveats, which limits its application to screening-level evaluations. Some of the assumptions of the ICM include:

- Requires accurate estimates of percent impervious cover, which is defined as the total amount of impervious cover over a subwatershed area. The resolution of the land cover data used in the evaluation is relatively coarse, although sufficient for a screening-level analysis.
- Predicts potential rather than actual stream quality.
- Does not predict the precise score of an individual stream quality indicator but rather predicts the average behavior of a group of indicators over a range of impervious cover.
- The 10 percent and 25 percent thresholds are approximate transitions rather than sharp breakpoints.
- The ICM has not been validated for lakes, reservoirs, aquifers, and estuaries.
- Does not currently predict the impact of watershed best management practices (treatment or non-structural controls).
- Does not consider the geographic distribution of the impervious cover relative to the streams and receiving waters. Effective impervious cover (impervious cover that is hydraulically connected to the drainage system) has been recommended as a better metric, although determining effective impervious cover requires extensive and often subjective judgment as to whether it is connected or not.

Impervious cover is a more robust and reliable indicator of overall stream quality beyond the 10 percent threshold. The influence of impervious cover on stream quality is relatively weak compared to other potential watershed factors such as percent forest cover, riparian community, historical land use, soils, agriculture, etc. for impervious cover less than 10 percent.

2.8.2 Future Conditions

A watershed buildout analysis was also conducted as part of this assessment to assist in the identification of subwatersheds with the highest restoration potential as well as the greatest vulnerability. The purpose of the analysis is to estimate the future land use and impervious cover conditions of the watershed as a result of maximum development allowed by the current zoning within the watershed.

Land Use

Watershed lands that could be developed in the future (i.e., "developable" land) were subdivided into two categories, based on the CRCOG parcel-based land use data:

- *New Development* - areas that are currently undeveloped and could become new developments in the future. Land designated as "new development" includes those parcels that are designated as "undeveloped" and "resource/recreation" in the CROCG land use data and not identified as committed open space.

- *Redevelopment* - areas that are currently underdeveloped and could be redeveloped with a higher intensity land use in the future. Land designated for "redevelopment" were limited to single-family residential parcels in the CRCOG land use data that could be subdivided and/or redeveloped in the future.

Areas having the following physical and/or regulatory constraints were also removed from consideration for future development or redevelopment: water bodies, wetland soils, and soils whose slope characteristics defined by NRCS exceed 15% (i.e., steep slope soils). Resulting fragments of land smaller than ¼-acre in size for new development and 3 acres in size for redevelopment were also removed from the analysis. Table 2-18 and Figure 2-21 summarize the amount of developable land by subwatershed, including the new development and redevelopment categories.

Table 2-18. Developable Land – Tankerhoosen River Watershed

Subwatershed	New Development (acres)	New Development Percent in Subwatershed	Redevelopment (acres)	Redevelopment Percent in Subwatershed
Bolton Notch Pond	49	14.30%	11	3.20%
Clarks Brook	57	8.80%	52	8.10%
Gages Brook	129	18.50%	72	10.30%
Gages Brook South Trib.	123	18.10%	102	15.00%
Lower Tankerhoosen R.	91	28.50%	17	5.40%
Middle Tankerhoosen R.	127	8.00%	141	8.90%
Railroad Brook	212	17.60%	172	14.30%
Tucker Brook	122	13.10%	89	9.50%
Upper Tankerhoosen R.	238	16.10%	150	10.20%
Walker Reservoir	108	31.30%	13	3.80%
Total	**1257**	**15.30%**	**820**	**10.00%**

The future land use buildout scenario was estimated by assigning new land uses to developable areas, while maintaining the existing land uses for developed and unbuildable land (wetland soils, steep slope soils, etc.). The developable areas were assigned a future land use based on maximum degree of development allowed by the existing zoning category. Table 2-19 presents the future land use category assigned to each developable parcel based on the zoning category. This analysis assumes development of Act 490 parcels consistent with the underlying zoning and does not account for future zone changes or future land development regulatory changes.

Table 2-19. Assigned Future Land Use Category

Zoning Category	Future Land Use
1-3 Unit Residential, High Density	Condominium
1-3 Unit Residential, Medium Density	Three Family
1-3 Unit Residential, Medium-Low Density	Two Family
1-3 Unit Residential, Low Density	One Family
Cluster/Open Space Residential	One-Family
Industrial	Industrial
Multi-Family	Multi-Family
Planned Area Development Including Residential	Mixed Use
Planned Industrial	Industrial
Planned Residential	Multi-Family
Town Center	Mixed Use
Town Scale Commercial	Commercial

Figure 2-21: Developable Land – Tankerhoosen River Watershed

The results of the buildout analysis are summarized in Table 2-20, which compares acreage of existing and future land use in the watershed. The most significant potential land use change is in the residential land use categories, which is predicted to increase by approximately 15% watershed-wide. The area of resource/recreation and undeveloped land is predicted to decrease by approximately 15% watershed-wide, while commercial and industrial land are predicted to increase by approximately 3%.

Table 2-20. Landuse Buildout Analysis Results

Land Use Type	$Acres_{Existing}$	Percent of $Basin_{Existing}$	$Acres_{Future}$	Percent of $Basin_{Future}$	Relative Percent Change
Agriculture	103	1%	89	1%	0
One Family	3160	38%	3415	42%	4%
Two Family	48	<1 %	811	10%	10%
Three Family	2	<1 %	3	<1 %	0
Multi Family	39	<1 %	60	1%	1%
Condominium	165	2%	177	2%	0
Group Quarters	12	<1 %	12	<1 %	0
Commercial	110	1%	206	3%	2%
Retail	88	1%	88	1%	0
Mixed Use	3	<1 %	33	<1 %	0
Industrial	183	2%	270	3%	1%
Government/Non-Profit	102	1%	102	1%	0
School	26	<1 %	26	<1 %	0
Cemetery	22	<1 %	14	<1 %	0
Health/Medical	6	<1 %	6	<1 %	0
Resource/Recreation	2398	29%	1787	22%	-7%
Undeveloped	851	10%	233	3%	-7%
Right-of-way	770	9%	770	9%	0
Water	77	<1 %	77	<1 %	0
Unknown	61	<1 %	46	<1 %	0

Impervious Cover

The watershed buildout analysis was used in conjunction with the existing conditions impervious cover analysis to estimate future impervious cover in the Tankerhoosen River subwatersheds. To complete this analysis, impervious cover was included as a parameter in the pollutant load model described in Section 2.6.

Land use data for both existing and buildout conditions were then entered into the model to determine the change in impervious cover for each subwatershed. The predicted change in impervious cover was then added to the existing impervious cover estimates to estimate future impervious cover.

Table 2-21 presents estimates of existing and future impervious cover by subwatershed. The shaded cells in the table highlight the subwatersheds in which future impervious cover is predicted to approach or exceed either the "sensitive" (10% to 12%) or "impacted" (25%) threshold values as described by the Impervious Cover Model.

Table 2-21. Percent Impervious Cover – Existing and Future Conditions

Subwatershed	Existing Percent Impervious Cover	Future Percent Impervious Cover	Percent Change[1]
Bolton Notch Pond	16.60%	18.90%	2.30%
Clarks Brook	17.20%	20.60%	3.40%
Gages Brook	11.50%	14.20%	2.70%
Gages Brook South Tributary	11.30%	13.50%	2.20%
Lower Tankerhoosen River	15.80%	23.00%	7.20%
Middle Tankerhoosen River	12.90%	15.50%	2.60%
Railroad Brook	1.70%	3.40%	1.70%
Tucker Brook	8.10%	10.30%	2.20%
Upper Tankerhoosen River	4.50%	4.70%	0.20%
Walker Reservoir	19.90%	29.13%	9.20%
Total	**9.87%**	**12.47%**	**2.60%**

1. Percent change = $(IC^{Future} - IC^{Existing}) \times 100$

It is significant to note that, based on this analysis, the overall impervious cover in the Tankerhoosen River watershed is predicted to increase from less than 10% to greater than 12%, which is considered impacted. The largest change in impervious cover is predicted in the Walker Reservoir subwatershed, where imperviousness could increase from approximately 20%, or "impacted," to approximately 29%, or "non-supporting." Additionally, the impervious cover in Gages Brook and the associated Gages Brook South Tributary subwatersheds, both of which are important headwater streams, is predicted to cross the state-wide 12% sensitive threshold value.

Another useful metric was developed by Goetz et al. (2003) for the Chesapeake Bay region, which combines subwatershed impervious cover and tree cover within the 100-foot stream buffer. Each of the subwatersheds within the Tankerhoosen River Basin was analyzed with regard to the combined impervious cover/riparian zone metric, which is summarized in Table 2-22 by Goetz et al. (2003).

Table 2-22. Impervious Cover/Riparian Zone Metric

Stream Health	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer
Excellent	< = 6%	>=65%
Good	6-10%	60-65%
Fair	10-25%	40-60%
Poor	> 25%	<40%

Natural vegetation was determined using the CLEAR land cover data and included the deciduous forest, coniferous forest, forested wetland, and non-forested wetland categories. The Table 2-23 presents the results from the combined impervious cover/riparian zone metric.

Table 2-23. Impervious Cover/Riparian Zone Metric – Existing and Future Conditions

Subwatershed	Existing		Future	
	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer
Bolton Notch Pond	16.6%	40.4%	18.9%	39.8%
Clarks Brook	17.2%	51.9%	20.6%	38.0%
Gages Brook	11.5%	59.5%	14.2%	50.1%
Gages Brook South Tributary	11.3%	69.6%	13.5%	40.2%
Lower Tankerhoosen River	15.8%	42.7%	23.0%	26.0%
Middle Tankerhoosen River	12.9%	49.7%	15.5%	41.8%
Railroad Brook	1.7%	89.4%	3.4%	73.7%
Tucker Brook	8.1%	65.5%	10.3%	49.6%
Upper Tankerhoosen River	4.5%	84.6%	4.7%	76.3%
Walker Reservoir	19.9%	41.2%	29.1%	31.8%

Overall, most of the Tankerhoosen River subwatersheds are currently categorized as "fair" to "good" based on the riparian zone metric published by Goetz et al. (2003), while several of the key headwater streams, including Railroad Brook and the Upper Tankerhoosen River, fall into the highest category. Comparison between the existing and future ratings indicates that four of the ten subwatersheds (Clarks Brook, Gages Brook South Tributary, Lower Tankerhoosen River, and Tucker Brook) are predicted to experience a decline in stream health as a result of future development and, in particular, development within the riparian corridor.

2.9 Pollutant Loading

A pollutant loading model was developed using the land use/land cover data described in Section 2-5. The model was used to compare existing nonpoint source (NPS) pollutant loads from the watershed to projected future pollutant loads that would occur under a watershed buildout scenario. It is important to note that the results of this screening-level analysis are intended for the purposes of comparing existing and future conditions and not to predict future water quality. This section summarizes the methods and results of the analysis, which are presented in greater detail in the *Baseline Watershed Assessment, Tankerhoosen River Watershed*, dated May 28, 2008 (Fuss & O Neill, Inc.).

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), Version 4.0, was used for this analysis. This model was developed for US EPA by Tetra Tech in EPA Region 5 and has since been modified for use in other areas of the country. The model calculates watershed pollutant loads for sediment and nutrients based on land use-related pollutant sources, including urban runoff, septic system failures, stream bank erosion, and agricultural activities. The model also allows simulation of best management practices (BMPs) and Low Impact Development (LID) practices to reduce pollutant loads.

Data obtained as part of the Land Use/Land Cover analysis presented in Section 2.5.2 were used to generate model inputs. Several other model parameters were specified for each pollutant and subwatershed, including:

- Event Mean Concentrations (EMCs), which are literature values for the mean concentration of a pollutant in stormwater runoff for each land use.
- Curve Number (CN), which is a measure of the runoff potential of the land surface and is a function of soil type, cover condition, and slope.

The model was applied to each subwatershed to estimate pollutant loads for each subwatershed under existing land use and future land use scenarios, as described in Section 2-5. The existing and future pollutant loads were compared to assess anticipated changes in loads for each subwatershed. Table 2-24 presents the results of this analysis. Results are shown in terms of increase in pollutant loading rate (the mass of pollutant to be discharged from each acre of land in a watershed) and percent increase in pollutant load (based on the total pollutant discharge from each of the watersheds).

Table 2-24. Projected Pollutant Loading Rate and Load Increases

Watershed	Loading Rate Increase (Load Increase per Acre, mass [lb or ton]/ac-yr)				Load Increase (%) (Total for Each Watershed)			
	N	P	BOD	Sediment	N	P	BOD	Sediment
Bolton Notch Pond (318 ac)	0.66	0.1	2.7	0.012	9.6%	8.0%	10.9%	7.7%
Clarks Brook (647 ac)	0.91	0.13	3.9	0.017	14.1%	12.9%	16.1%	11.7%
Gages Brook (695 ac)	1.29	0.19	5.6	0.027	19.4%	17.0%	21.5%	16.7%
Gages Brook South Trib. (680 ac)	0.73	0.11	3.1	0.014	12.2%	10.2%	14.1%	10.5%
Lower Tankerhoosen R. (306 ac)	1.31	0.1	6.3	0.022	20.0%	8.9%	27.6%	14.7%
Middle Tankerhoosen R. (1570 ac)	0.63	0.07	3.1	0.008	10.6%	7.6%	14.2%	5.8%
Railroad Brook (1203 ac)	0.89	0.06	4.3	0.015	56.8%	20.3%	69.8%	46.4%
Tucker Brook (934 ac)	0.67	0.04	3.3	0.012	14.1%	5.3%	18.0%	9.4%
Upper Tankerhoosen R. (1472 ac)	0.24	0.05	1.1	0.003	9.3%	11.1%	11.2%	6.0%
Walker Reservoir (322 ac)	1.86	0.28	8.6	0.036	25.8%	23.3%	34.6%	21.6%
Total (8149 ac)	0.77	0.09	3.5	0.013	16.0%	11.4%	19.9%	12.0%

Several of the subwatersheds are predicted to experience significantly higher increases in pollutant loads and loading rates under a watershed buildout scenario. These include:

- *Gages Brook*. The existing conditions pollutant load model indicates that this subwatershed is characterized by both relatively high total pollutant loads and pollutant loading rates, with approximately 70% urban land use, the largest amount of industrial land use, and the second-highest commercial land use composition in the entire watershed. The buildout condition of this watershed is projected to result in a 19% increase in urban land use with a corresponding decrease in forest; and the new urban land is likely to consist of new residential and industrial development. As such, relatively large loads and loading rate increases may occur.

- *Lower Tankerhoosen River*. The existing conditions pollutant load model for this subwatershed predicts relatively small loads (since the watershed area is small) and moderate loading rates. Under a buildout scenario, this subwatershed is projected to result in more than a 20% increase in nitrogen and BOD loads. The resulting loading rates for these parameters are projected to be the second highest of the Tankerhoosen River subwatersheds.

- *Railroad Brook*. The projected buildout pollutant loadings in this subwatershed for nitrogen and BOD are anticipated to increase by approximately 57% and 70%, respectively. Significant increases are also anticipated in phosphorus and sediment loads. Currently, the Railroad Brook sub watershed is heavily forested, with comparatively little development. Several large tracts of land within this subwatershed are potentially available for future development, especially in Bolton and South Vernon, which makes this watershed vulnerable to potentially significant pollutant load increases.

- *Walker Reservoir*. The existing conditions pollutant loading model suggests that this subwatershed has some of the highest levels of pollutant loads within the overall Tankerhoosen River watershed. Potential land use changes in this subwatershed include significant areas of new residential and mixed-use development, much of which is located adjacent to Walker Reservoir. These changes are predicted to result in the greatest increases in pollutant loading rates for all of the parameters evaluated.

2.10 Comparative Subwatershed Analysis

A Comparative Subwatershed Analysis was performed for the Tankerhoosen River subwatersheds to identify the subwatersheds with the greatest vulnerability and restoration potential. Subwatershed "metrics" were used to conduct this analysis. Metrics are numeric values that characterize the relative vulnerability and restoration potential of a subwatershed. The metrics used are presented in Table 2-25. The results of this analysis will be used to prioritize field assessment efforts in future phases of this study and to guide plan recommendations.

The analysis involves a screening level evaluation of selected subwatershed metrics that are derived by analyzing available GIS layers and other subwatershed data sources. The basic approach used to conduct the Comparative Subwatershed Analysis consisted of:

1. Delineation of subwatershed boundaries and review of available metric data.
2. Selection and calculation of metrics that best describe subwatershed vulnerability and restoration potential. (The metrics used to rank subwatershed vulnerability were selected separately from the metrics used to rank subwatershed restoration potential.)
3. Developing weighting and scoring rules to assign points to each metric.

4. Computing aggregate scores and developing initial subwatershed rankings.

Subwatersheds with higher aggregate "vulnerability" scores are more sensitive to future development and should be the focus of watershed conservation efforts to maintain existing high-quality resources and conditions. Subwatersheds with higher aggregate "restoration potential" scores are more likely to have been impacted and have greater potential for restoration to improve upon existing conditions. This approach enables watershed planners to allocate limited resources on subwatershed where restoration and conservation efforts have the greatest chances of success.

The following sections describe the metrics used and the rationale for their selection, how the various metrics were calculated, and the results of the evaluation. Available GIS and other data were used to compute the value of each metric.

Table 2-25. Summary of Subwatershed Vulnerability Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Vulnerability Potential When	Metric Points
1. Impervious Cover Change	% increase in impervious cover in subwatershed	**Increase in IC is high**, suggesting greater development potential and stream impacts	Award 1 pt for each 1% increase in impervious cover
2. Impervious Cover Threshold	Comparison of current and future IC relative to ICM threshold	**Predicted IC crosses "impacted" (12%) threshold**, development could result in significant stream impacts	Award 5 pts for each exceedance of the 12% threshold
3. Stream Order	% of subwatershed consisting of 1st or 2nd order streams	**Subwatershed consists of more lower order streams**, vulnerability of headwater streams for habitat and water quality protection	Award 6 pts if 100% of streams are 1st and 2nd order; 4 pts if 50% are 1st and 2nd order; 2 pts if 33% are 1st and 2nd order; 0 pts if 0% are 1st and 2nd order
4. Pollutant Loading	% increase in pollutant loading in subwatershed	**Increase in pollutant loading is high**, suggesting water quality impacts from future development	Award 1 pt for each pollutant loading parameter > 10% and 3 pts for each parameter >20%
5. Industrial/ Commercial Land	% of subwatershed as industrial or commercial land	**Industrial/commercial land is high**, greater potential for water quality impacts from pollutant hot spot	Award 1 pt for each 2% of subwatershed classified as industrial or commercial/retail
6. Forest Cover	% of subwatershed with developable forest cover	**Area of developable forest cover is high**, potential for significant future reductions in forested land	Award 1 pt for each 5% of subwatershed with developable forest cover
7. Stream Corridor Forest Cover	% of stream corridor that is forested	**Corridor forest cover is high**, potential for significant future reductions in forested riparian areas if public ownership of corridor is low	Add 1 pt for each 10% increase in forest cover
8. Public Ownership of Stream Corridor	% of stream corridor that is publicly owned	**Public ownership is low** (see metric 7)	Add 1 pt for each 10% reduction of stream corridor in public ownership
9. Road Crossings	number of road crossings / square mile	**Number of road crossings is high**, greater potential for direct stormwater discharges from roadways	<1 = 0pts; 1 to 5 = 1 pts; 5 to 8 = 3 pts; 9 to 12 = 5 pts; 13-15 = 7pt; >15 = 10 pts
10. Developed	% of subwatershed	**Area served by septic is high**,	Award 1 pt for each 5% of

Table 2-25. Summary of Subwatershed Vulnerability Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Vulnerability Potential When	Metric Points
Areas with Septic	served by septic	indicating potential for pollutant loadings from failing septic systems	subwatershed area served by septic
11. Drinking Water Resources	Acreage of developable land within a public drinking water supply area	**Area of developable land is high**, greater potential for impacts to sensitive surface and groundwater drinking water supplies	Award 3 pts for each subwatershed within an aquifer protection area

2.10.1 Priority Subwatersheds for Conservation

The results of the subwatershed vulnerability analysis are summarized in Table 2-26.

Table 2-26. Results of Subwatershed Vulnerability Analysis

Subwatershed	Impervious Cover Change	Impervious Cover Threshold	Stream Order	Pollutant Loading	Industrial/ Commercial Land	Developable Forest Cover	Stream Corridor Forest Cover	Public Ownership of Stream Corridor	Road Crossings	Developed Areas Served by Septic	Drinking Water Resources	Total
Bolton Notch Pond	2	10	6	1	7	2	3	3	0	5	0	41
Clarks Brook	3	10	6	4	7	2	5	5	1	4	0	47
Gages Brook	3	5	6	6	11	4	6	6	3	5	0	55
Gages Brook South Tributary	2	5	6	4	1	5	6	5	3	5	0	42
Lower Tankerhoosen River	7	10	0	7	2	5	4	5	7	5	0	53
Middle Tankerhoosen River	3	10	2	2	2	2	4	5	3	3	3	38
Railroad Brook	2	0	6	12	0	6	9	0	5	1	0	40
Tucker Brook	2	0	6	2	0	3	5	6	3	2	0	28
Upper Tankerhoosen River	0	0	4	2	0	4	8	3	3	3	0	27
Walker Reservoir	9	10	4	4	2	3	2	5	10	6	0	56

As shown in Table 2-27, the following subwatersheds are considered most vulnerable to future development impacts and should be given highest priority for conservation efforts to maintain existing resource conditions:

- Clarks Brook,
- Gages Brook,
- Gages Brook South Tributary,
- Lower Tankerhoosen River,
- Walker Reservoir.

Table 2-27. Summary of Subwatershed Restoration Potential Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Restoration Potential When	Metric Points
1. Existing Impervious Cover	% impervious cover in subwatershed	**Current impervious cover is low**, suggesting range of possible sites for storage retrofits and stream repairs	<10% = 10 pts; 10 to 15% = 5 pts; >15% = 1 pt
2. Publicly-owned land	% of subwatershed that is publicly owned	**Public land ownership is high**, providing range of potential sites for restoration practices	Award 1 pt for each 2.5% of subwatershed in public ownership
3. Industrial Land	% of subwatershed that is industrial land	**Industrial land is high**, suggesting potential for source controls, discharge prevention, and on-site retrofits	Award 1 pt for each 2% of subwatershed classified as industrial
4. Forest Cover	% forest cover in subwatershed	**Forest cover is low**, suggesting potential for upland and riparian reforestation	<35% = 7pts; 36 to 50% = 5 pts; 50 to 70% = 3 pts; >70% = 1pt
5. Wetland Cover	% of subwatershed that is wetlands	**Wetland cover is high**, suggesting potential for wetland and riparian restoration	Award 1 pt for each 2% of subwatershed area
6.Development Potential	% of developable land in subwatershed	**No more development is expected**; stable conditions increase feasibility of stream repairs and storage retrofits	30 to 35% = 1pts; 25 to 30% = 4 pts; 20 to 25% = 7 pts; 15 to 25% = 10pt
7. Stream Density	stream miles / square mile	**Stream density is high**, suggesting greater feasibility of corridor practices	Award 1 pt for each 10% increase in stream density from watershed average of 1.3 stream miles / square mile
8. Stream Corridor Forest Cover	% of stream corridor that is forested	**Corridor forest cover is low**, suggesting feasibility of riparian reforestation and stream repairs	Add 1 pt for each 10% reduction in forest cover
9. Public Ownership of Corridor	% of stream corridor that is publicly owned	**Public corridor ownership is high**, suggesting greater feasibility of corridor practices	Add 1 pt for each 10% of stream corridor in public ownership
10. Road Crossings	number of road crossings / square mile	**Number of road crossings is high**, suggesting greater potential for stream repairs, culvert modifications	<1 = 0pts; 1 to 5 = 1 pts; 5 to 8 = 3 pts; 9 to 12 = 5 pts; 13-15 = 7pt; >15 = 10 pts
11. Developed Areas with Septic	% of subwatershed that is served by septic	**Area served by septic is high**, suggesting greater potential for septic system upgrades	Award 1 pt for each 5% of subwatershed area served by septic
12. Water Quality Impairments	number of water quality impairments / square mile	**Number of water quality impairments is high**, suggesting regulatory need to focus on WQ improvements	Award 3 pts for each water quality impairment identified

The results of the subwatershed restoration potential analysis are summarized in Table 2-28.

Table 2-28. Results of Subwatershed Restoration Potential Analysis

Subwatershed	Existing Impervious Cover	Publicly-owned Land	Industrial Land	Forest Cover	Wetland Cover	Development Potential	Stream Density	Stream Corridor Forest Cover	Public Ownership of Stream Corridor	Road Crossings	Developed Areas Served by Septic	Water Quality Impairments	Total
Bolton Notch Pond	1	1	1	5	3	10	0	6	6	0	5	0	38
Clarks Brook	1	10	5	7	8	10	0	4	11	1	4	0	60
Gages Brook	5	12	6	5	8	4	10	3	12	3	5	6	79
Gages Brook South Tributary	5	3	0	3	3	1	14	2	9	3	5	9	57
Lower Tankerhoosen River	1	6	1	5	1	1	15	5	11	7	5	6	64
Middle Tankerhoosen River	5	6	1	5	6	10	5	5	10	5	3	0	61
Railroad Brook	10	0	0	1	6	1	9	0	0	5	1	0	34
Tucker Brook	10	10	0	5	6	7	11	4	11	1	2	0	66
Upper Tankerhoosen River	10	3	0	1	7	4	12	1	6	3	3	3	52
Walker Reservoir	1	10	1	7	4	1	0	7	9	10	6	0	55

As shown in Table 2-28, the following subwatersheds should be given highest priority for restoration potential to improve upon existing conditions:

- Clarks Brook,
- Gages Brook,
- Lower Tankerhoosen River,
- Middle Tankerhoosen River,
- Tucker Brook.

Based on the combined results of the subwatershed vulnerability and restoration potential analyses, the following subwatersheds were recommended for detailed assessment and planning:

- Clarks Brook,
- Gages Brook,
- Gages Brook South Tributary,
- Lower Tankerhoosen River,
- Middle Tankerhoosen River,
- Tucker Brook,
- Walker Reservoir.

3 Watershed Field Inventories

Field inventories were performed during summer 2008 to further assess existing watershed conditions and potential sources of pollution. The field inventories are screening level tools for locating potential pollutant sources and environmental problems in a watershed along with possible locations where restoration opportunities and mitigation measures can be implemented. The field inventories included selected stream corridors and upland areas within priority subwatersheds, which were identified from the Comparative Subwatershed Analysis. Field inventories were performed within the priority subwatersheds identified in Section 2.7.1.

This section of the watershed management plan provides a summary of the methods and results of the field inventories. More detailed information on the field inventory methods and findings is available in *Watershed Field Inventories and Land Use Regulatory Review* (Fuss & O Neill, October 2008), a copy of which is provided on CD-ROM as Appendix A of this watershed management plan.

The stream corridor assessment procedure used in this study is adapted from the U.S. EPA Rapid Bioassessment (RBA) protocol (EPA, 1999) and the Center for Watershed Protection's Unified Stream Assessment (USA) method (CWP, 2005). Upland areas and activities that may impact stream quality were also assessed using methods adapted from the Center for Watershed Protection's Unified Subwatershed and Site Reconnaissance (USSR) techniques (CWP, 2005). The upland assessments included inventories of selected representative residential neighborhoods, streets and storm drainage systems, and land uses with higher potential pollutant loads (i.e., "hotspot" land uses). Field assessment efforts were targeted on stream segments and upland areas with the greatest potential for direct impacts to the streams. These areas were identified through aerial and land use mapping. To the extent possible, efforts were also focused on publicly-owned land, which typically offers greater opportunities for retrofits and mitigation projects as opposed to privately-owned land.

During the field inventories, crews assessed approximately 8.7 miles of stream corridors, six potential hotspot locations, five representative residential neighborhoods, and a number of streets and storm drainage systems associated with the residential neighborhoods and hotspot land uses. Field inventory nomenclature used throughout this report is summarized in Table 3-1. Copies of completed field assessment forms are provided as attachments to the *Watershed Field Inventories and Land Use Regulatory Review* (Fuss & O Neill, October 2008). Photographs of specific or representative pollutant sources and problem areas are included throughout this document for illustrative purposes. All of the photographs taken during the field inventories are available on CD.

Table 3-1. Field Inventory Nomenclature

Clarks Brook	CB
Lower Tankerhoosen River	LTR
Middle Tankerhoosen River	MTR
Walker Reservoir	WR
Gages Brook	GB
Gages Brook South Tributary	GBST
Tucker Brook	TB

Table 3-1. Field Inventory Nomenclature

Reach Level Assessment	RCH
Channel Modification	CM
Severe Bank Erosion	ER
Impacted Buffer	IB
Stormwater Outfall	OT
Stream Crossing	SC
Trash & Debris	TB
Utilities	UT
Hotspot Investigation	HSI
Neighborhood Site Assessment	NSA
Streets and Storm Drains	SSD

3.1 Summary of Findings

A variety of common issues and problems were identified during the field inventories. Some prevalent issues throughout the watershed are described below.

- Overall in-stream habitat in the assessed reaches was mixed. Some of the assessed reaches have high quality habitat, with riparian cover, good floodplain connection, varied substrate, and significant stream shading. In other segments, in-stream habitat is marginal to poor due to bank erosion, buffer encroachment, trash and debris, lack of shading, and in-stream sedimentation. However, the majority of the stream reaches assessed appear to be either supporting biological communities (fish, frogs, birds, etc.) or sufficient to support such communities. Many potential barriers to fish passage were observed throughout the watershed, including perched culverts, culverts with very shallow flow, and natural and manmade dams. Therefore, the impact of potential fish barriers and the feasibility of fish barrier removal efforts should be investigated further.

Arch-type railroad crossing (SC-02) may prevent fish passage and is suffering from downstream scour evidenced by the large pool shown in the photograph.

- Stream buffer encroachments are prevalent along stream corridors in or near areas of residential and commercial development. Residential lawns and some commercial lawns extend down to the banks of the stream in many areas, particularly in residential back yards. Yard waste such as grass clippings, leaves, and brush and waste materials were also common occurrences in and near these areas where easy access exists to the streams. Education, signage,

Stream segment GB-05B showing limited vegetative buffer and a small footbridge crossing the stream.

stream buffer regulations, and stream cleanups are potential approaches for improving buffer management.

- Residential areas appear to contribute significant quantities of rooftop runoff to the storm drainage system, particularly in medium and high-density residential neighborhoods with smaller yards. Many small outfall pipes were observed from the backyards of residential areas, which are presumably associated with foundation drains, yard drains, or roof downspouts. Opportunities exist to disconnect residential rooftop runoff from the storm drainage system and reduce the quantity of runoff by redirecting the runoff to pervious areas or through the use of rain barrels or rain gardens.

Trash and debris along Reach CB-02.

- Numerous outfalls were observed from virtually all of the land uses encountered during the stream assessments. Many appear to be associated with sources having low potential for water quality impacts (i.e., residential foundation drains), while others were of unknown origin and should be the focus of future investigation. Illicit discharge investigations are recommended in targeted areas and land uses.

- Invasive species (phragmites, cattails, reed canary grass, etc.) were observed in stream corridors in many areas of the watershed. Invasive species management should be incorporated into stream corridor restoration activities.

Stream crossing (SC-01) below I-84 and outfall (OT-03) along reach GBST-02.

- Parking lots associated with apartment complexes, institutional land uses (schools), and commuter lots are potential candidates for stormwater retrofits to reduce site runoff and improve water quality through the use of bioretention, water quality swales, buffer strips/level spreaders, and other small-scale LID approaches.

- The field assessments identified very little evidence of storm drain stenciling or watershed stewardship signage, with the exception of a residential subdivision in the Tucker Brook subwatershed.

- Most of the developed areas surveyed have inadequate stormwater quality controls. Many of the residential developments were constructed prior to the advent of modern stormwater quality regulations and design requirements. Therefore, most of the development observed in the watershed employs traditional curb and gutter storm drainage collection systems with little, if any, stormwater management beyond detention basins for peak flow control. In most cases, the stormwater management controls that were observed at newer developments were not being maintained.

- No Low Impact Development (LID) design practices were observed in the watershed. With the recent shift toward LID site design and stormwater management requirements, as demonstrated by the Town of Tolland's new LID regulations and design manual, the watershed is an ideal candidate to showcase LID practices for both new development and retrofit applications. Local LID demonstration sites are a valuable tool for public education and promoting the widespread use of such practices. Incorporating LID into town projects, including roadway projects, can also serve as a proactive model for private development.

- Stormwater runoff from Interstate 84, other state roads such as Route 30 and 31, and local roads typically receives little or no treatment prior to discharge. Such discharges are a source of sediment and other pollutants to the receiving water bodies. Opportunities exist for stormwater retrofits at roadway stormwater outfalls

- Relatively isolated areas of moderate to severe streambank erosion were observed throughout the assessed portions of the watershed. Most of these areas are located at or downstream of stormwater outfalls in developed areas of the watershed. Access to many of these areas is limited; therefore, potential candidate sites for bank stabilization projects should be evaluated further for overall feasibility.

Stream segment GB-05B showing area of stream bank erosion.

- Very few active construction sites were observed in the watershed. However, a large amount of developable land exists in the watershed, and future construction activity is a major potential source of polluted runoff. Approaches for stronger soil erosion and sedimentation controls include regulating building envelopes, encouraging property owners to minimize clearing for other purposes, and requiring drainage review for activities that disturb less than ½ acre.

- Due to limited project funding, not all stream segments in the priority subwatersheds were assessed, and other subwatersheds (Railroad Brook, Bolton Notch Pond, and Upper Tankerhoosen River) were not assessed as they were determined to be less vulnerable to future development impacts. A schedule should be established for assessing the remaining stream segments and subwatersheds.

3.2 Stream Corridor Assessment

Stream corridors within the Tankerhoosen River watershed were assessed during June 3 through 6, 2008, and on July 2 and 10, 2008. Field crews consisted of staff from Fuss & O Neill, the North Central Conservation District, and volunteers with Friends of the Hockanum River Linear Park of Vernon. Stream corridors were assessed along selected reaches within priority subwatersheds using methods adapted from the U.S. EPA Rapid Bioassessment (RBA) protocol (EPA, 1999) and the Center for Watershed Protection s Unified Stream Assessment (USA) (CWP, 2005).

The stream assessment method used in this study is a continuous stream walk method that identifies and evaluates the following impact conditions for each reach:

- Outfalls (OT), including stormwater and other manmade point discharges;
- Severe Bank Erosion (ER), such as bank sloughing, active widening, and incision;
- Impacted Buffer (IB), which is a narrowing or lack of natural vegetation;
- Utilities in the stream corridor (UT), such as leaking or exposed pipes;
- Trash and Debris (TR), such as drums, yard waste, and other illegal dumping;
- Stream Crossings (SC), which are hard objects, whether natural or artificial, that restrict or constrain the flow of water. These may include bridges, culverts, dams, and falls;
- Channel Modification (CM), where the stream bottom, banks, or direction have been modified;
- Miscellaneous (MI), other impacts or features not otherwise covered; and
- Reach Level Assessment (RCH), the average characteristics of each reach.

The stream assessment method also includes a semi-quantitative scoring system as part of the reach level assessment to evaluate the overall condition of the stream, riparian buffer, and floodplain, based on a consideration of in-stream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation and habitat, and floodplain encroachment.

Collected information was entered into a database and used to quantify the overall condition of stream corridors in the watershed, compare subwatersheds within the watershed to each other, and prioritize areas for restoration, stormwater retrofit, land preservation, and other stewardship opportunities.

Stream reaches were assigned a subwatershed abbreviation followed by a two-digit numerical identifier. Reaches were generally numbered sequentially from downstream to upstream when in series and west to east upstream from confluences. A reach was considered to be a stream segment with relatively consistent geomorphology and surrounding land use, and generally less than one-half mile in length. Features noted at reach junctions (e.g., culvert crossings) were associated with the downstream reach. Impact conditions within each reach were numbered sequentially with an abbreviation followed by a two-digit number. For example, the second stream crossing in a reach would have the identifier SC-02.

Forty-one stream reaches were evaluated in the Tankerhoosen River watershed using this stream assessment protocol. Table 3-2 summarizes the number of impact conditions identified and reach level assessments that were performed within each subwatershed.

Table 3-2. Number of Reach Level Assessments Performed and Impact Conditions Identified

Subwatershed	RCH	CM	ER	IB	OT	SC	TD	UT
Clarks Brook	5	--	2	--	10	8	2	--
Lower Tankerhoosen River	1	--	--	--	1	1	--	--
Middle Tankerhoosen River	5	--	1	--	14	5	7	--
Walker Reservoir	5	--	--	--	6	6	--	--
Gages Brook	12	1	8	5	21	12	3	1
Gages Brook South Trib.	7	1	1	1	3	8	--	--
Tucker Brook	6	--	2	4	9	9	3	--

Reach level assessment scores were assigned by field crews based upon the overall stream, buffer, and floodplain conditions. A subjective determination of eight criteria is assessed on a scale of 0 to 20; 0 relating to poor conditions and 20 being optimal conditions. The total of these scores provides a quantitative index of overall stream health and condition. The maximum possible number of points that would be assigned for a fully optimal stream reach is 160 points.

Streams were assessed relative to a base condition, which for this study, is the highest scoring stream reach in the Tankerhoosen River watershed (153 points). All other assessed stream reaches were assigned a numerical score and categorized relative to the base score of 153 points (Table 3-3). Reaches scoring greater than 90% of the base condition (138 points) are considered "excellent", between 75% and 90% of the base condition are categorized as "good", between 55% and 75% of the base condition are categorized as "fair", between 35% and 55% of the base condition are categorized as "poor", and less than 35% of the base condition are categorized as "very poor". Table 3-4 summarizes stream reach assessment scores and classifications for the assessed stream reaches.

Table 3-3. Stream Reach Classifications

Category	Percentile	Point Threshold
Excellent	90%	≥138
Good	75%	≥115
Fair	55%	≥84
Poor	35%	≥54
Very Poor	<35%	<54

Table 3-4. Stream Reach Assessment Scores and Classifications

Excellent		Good		Fair		Poor		Very Poor	
Reach ID	Score	Reach ID	Score	Reach ID	Score	Reach ID	Score	Reach ID	Score
MTR-08	153	GBST-02	127	GB-09	114	TB-04B	83	GB-05B	53
GB-10	146	GB-02	120	GBST-03	111	MTR-01	82	WR-01	35
GBST-04A	146	GBST-09B	120	LTR-03	111	GB-04	80		
GBST-01	145	TB-02	119	GB-07	105	WR-02	80		
MTR-07	139	GBST-04B	117	CB-03	104	WR-04	76		
CB-04	138	TB-01	116	GB-01	102	GB-03B	72		
		GB-08	115	GB-03A	97	GBST-09A	59		
				MTR-09	94				
				GB-05A	93				
				CB-02	93				
				TB-03	92				
				TB-04A	92				
				WR-03	91				
				GB-06	88				
				MTR-02	87				
				CB-01	85				
				WR-05	84				
Note: TB04C and CB-05 were not scored during the reach level assessment									

As depicted in Figure 3-1, MTR-08 is the highest rated stream reach due to good riparian cover and bed material. WR-03 is considered fair due to the presence of invasive species within the riparian corridor. TB-04B and GB-05B are poor and very poor, respectively, because of poor channel characteristics, outfalls, stream crossings, trash and debris and lack of stream buffer and bank erosion in the case of GB-05B.

Figure 3-1. Examples of Stream Reaches in Various Classification Categories

Additional details regarding the assessed stream reaches are provided in *Watershed Field Inventories and Land Use Regulatory Review* (Fuss & O Neill, October 2008), a copy of which is provided on CD-ROM in Appendix A of this plan.

3.3 Upland Assessments

Fuss and O Neill conducted upland assessments in the Tankerhoosen watershed in July 2008. The field observations assist in identifying pollution prevention and potential restoration opportunities at hotspot land uses and residential neighborhoods in the watershed. Factors that were considered when determining which hotspots and neighborhood areas to prioritize for assessment include:

- Stream condition (assessed during stream corridor inventory),
- Site proximity to the stream,
- Land use type and development density,
- Land ownership,
- Restoration potential.

The assessment framework was adapted from the Unified Subwatershed and Site Reconnaissance (USSR) method developed by the Center for Watershed Protection. USSR is a "windshield survey" evaluation method in which field crews drive and walk through areas of the watershed to quickly identify pollution prevention and restoration opportunities. The three major components to the upland assessments conducted in the Tankerhoosen watershed are: hotspots, residential neighborhoods, and streets and storm drains. Field data forms that were completed during the assessments are provided in *Watershed Field Inventories and Land Use Regulatory Review* (Fuss & O Neill, October 2008).

3.3.1 Hotspot Investigations

Hotspot site investigations were conducted for six representative sites with a high potential to contribute polluted stormwater runoff to the storm drain system and receiving streams. The purpose of the investigation was to qualitatively assess the potential for stormwater pollution from previously identified commercial, industrial, municipal or transport-related sites. The hotspot investigation was limited in scope to representative hotspot facilities in order to evaluate and illustrate common issues. The investigation was not intended to be an exhaustive review of all potential hotspot facilities in the entire watershed nor a detailed inspection or audit of each facility, which are beyond the scope of this study.

The hotspots examined in the field were located within the Lower Tankerhoosen River, Walker Reservoir, Clarks Brook, and Gages Brook subwatersheds. Representative priority hotspots were selected to cover a range of watersheds and land uses, including three industrial sites, one commercial site, one transportation-related site, and one state/municipal site. Sites are identified by the watershed abbreviation, followed by "HSI" and a numeric identifier. Table 3-5 summarizes the selected hotspots that were evaluated. Several of the sites that were investigated are privately owned, and field crews were unable to gain full access to the sites to closely evaluate the storm drainage and other site characteristics.

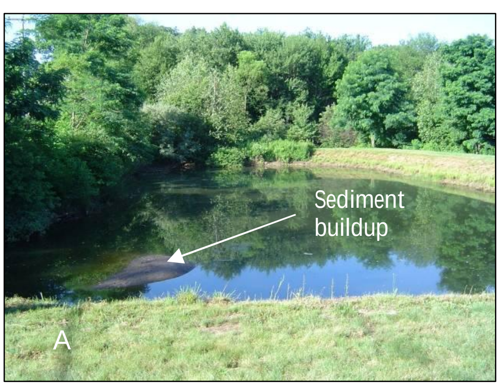
Table 3-5. Hotspot Site Investigation Summary

Site ID (Watershed)	Land Use Category	Description of Site Operations
GB-HSI-01 (Gages Brook)	Industrial	Industrial Park - Gerber Technologies Office Building
GB-HSI-02 (Gages Brook)	Industrial	Dari Farms Ice Cream Distribution Center
WR-HIS-01 (Walker Reservoir)	Transportation	ConnDOT Commuter Lot
CB-HIS-01 (Clarks Brook)	Commercial	Superior Energy - Propane
CB-HIS-02 (Clarks Brook)	Industrial	Sand, gravel, construction storage/processing facility
LTR-HIS-01 (Lower Tankerhoosen River)	State/Municipal	ConnDOT Maintenance and Service Center

Gerber Technologies Office Building

The Gerber Technologies office building is located in the Tolland Industrial on Industrial Park Road West adjacent to Gages Brook. The office building has landscaped areas around the building with shrubs and turf lawn. The site is characterized by a large amount of impervious cover, consisting of building roof areas and parking lots. Approximately 100 vehicles were parked in the employee parking lots at the time of the inspection. Stormwater runoff from the site appears to discharge to the stormwater basin located near the southern limit of the site. The stormwater basin is a wet pond design containing a permanent pool of water and is approximately 70 feet wide by 140 feet long. The basin contained accumulated sediment captured from the site runoff. The basin outfall discharges to Gages Brook via a riprap spillway.

The stormwater basin that receives runoff from the Gerber Technologies facility incorporates many of the recommended elements to meet current stormwater quantity and quality design criteria. However, the basin is also in need of maintenance as demonstrated by the sediment accumulation near the center of the basin and the overgrown woody vegetation at the overflow spillway. Existing stormwater basins such as this one may also be good retrofit candidate to improve treatment effectiveness by incorporating a sediment forebay at the basin inlet, which may also facilitate routine sediment removal.



Stormwater basin at the Gerber Technologies facility on Industrial Park Road West. Sediment has built up near the center of the basin (A) and its overflow spillway is overgrown with vegetation (B).

Dari Farms Ice Cream Distribution Facility

The Dari Farms Ice Cream Distribution Facility has a covered fueling station and landscaped grounds (shown in the foreground).

The Dari Farms distribution facility is also located in the Tolland Industrial Park on Research Way/Gerber Drive near the divide between the Gages Brook and Gages Brook South Tributary subwatersheds. The facility is estimated to be less than 5 years old, as evidenced by the facility's modern pollution prevention site design elements including a covered fueling station, no visible outdoor storage of materials, and well maintained landscaping on the grounds. Possible pollution sources to the storm drainage system are the runoff from the large impervious areas on the site (the roof and parking areas) and potential vehicle fluids from truck fueling activities and employee vehicles. It could not be determined whether stormwater is managed on-site, by the downgradient stormwater basin near the Gerber Technologies facility, or both. The site did not appear to incorporate Low Impact Development (LID) design features such as vegetated swales or parking lot bioretention. New commercial and industrial facilities with significant impervious area, such as this one, are potential candidates for on-site LID and stormwater treatment practices to reduce runoff volume and pollutant loads.

ConnDOT Commuter Parking Lot

The southeastern side of the Interstate 86 Exit 67 commuter parking lot showing the edge of the lot on the left side of the photograph and the wetland corridor on the right side. The center of the photograph shows the easily accessible and open area for a potential stormwater retrofit.

The hotspot investigation included the Connecticut Department of Transportation commuter parking lot at exit 67 of Interstate-84, which is located in the Walker Reservoir subwatershed.

Approximately 150 vehicles were parked at the lot during the site visit, which occurred on a weekday during mid-day. The site is contains significant impervious cover and high-intensity vehicle usage and is therefore a source of automobile-related stormwater pollutants including hydrocarbons, sediment, and metals. The entire parking lot drains to a double catch basin located on the southeastern side of the lot. The catch basin discharges through a short wetland corridor and subsequently to the stream segment located upstream of Reservoir Road and Walker Reservoir East. An easily accessible grass strip exists between the paved lot and the adjacent wetland and stream corridor. This site is a potential stormwater retrofit candidate (bioretention or water quality swale) to encourage infiltration and provide additional treatment for the parking lot runoff.

Superior Energy

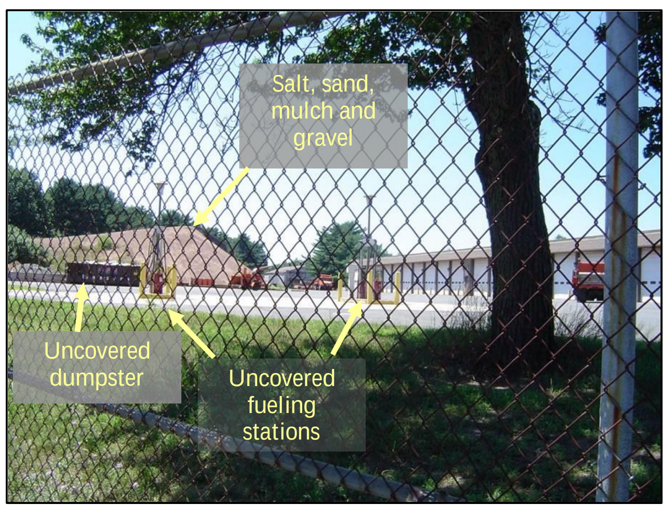
Superior Energy is a propane gas and related equipment distributor located on Hartford Turnpike (Route 30) in Vernon. The site is located within the Clarks Brook subwatershed near the headwaters of Clarks Brook. The property consists of a retail store, a paved parking lot for delivery trucks, and outdoor storage of propane tanks. It is unknown if vehicle maintenance or fueling occurs on-site. The site appears to have been modified in the past through grading/filling based on an inspection of the existing site drainage and discussions with facility personnel. This site should be further investigated to better define potential impacts of the historical filling, current drainage issues, and plans for additional site development.

Sand & Gravel Facility

The facility is located on Clark Road at the western end of Industrial Park Road and near the western limit of the Clarks Brook subwatershed. Facility operations appear to include storage and processing of sand, gravel and other construction materials. The site contains one building, which is assumed to be an office and/or maintenance area. The majority of the site consists of an unpaved yard used for the storage of sand and gravel piles and equipment to process the materials and load transport vehicles. The site contains numerous potential sources of sediment and other pollutants associated with the sand and gravel stockpiles, heavy equipment and vehicles, waste construction materials stored outdoors, and pipes and debris in the yard. Sand and gravel operations such as this should employ stormwater pollution prevention practices and source controls as required by the DEP *General Permit for Stormwater Discharges Associated with Industrial Activity*, in addition to stormwater treatment practices to reduce sediment and hydrocarbon loadings in site stormwater runoff.

DOT Maintenance Service Center

The State of Connecticut operates a Department of Transportation Maintenance Service Center for District #1 located on Campbell Avenue in Vernon, which is located in the Lower Tankerhoosen River subwatershed. The facility has an office building, garages for vehicle storage and maintenance, a small parking lot, outdoor storage of sand, salt, gravel and mulch, and an uncovered outdoor fueling station. Vehicle maintenance activities and outdoor vehicle fueling are potential sources of stormwater pollution, in addition to the outdoor stockpile storage.



ConnDOT District #1 Maintenance Service Center, Campbell Avenue

A rolloff dumpster was observed to be overflowing and uncovered at the time of the windshield survey. Municipal and state-operated highway maintenance facilities such as this should employ source controls, pollution prevention, and stormwater treatment practices as necessary in accordance with the DEP *General Permit for Stormwater Discharges Associated with Industrial Activity*.

3.3.2 Neighborhood Source Assessment

Stormwater runoff from existing residential neighborhoods and future residential development in the watershed is an important consideration for this study, since approximately 40 percent of the Tankerhoosen River watershed consists of residential land use and future buildout of the watershed could result in conversion of an additional 10 percent of the watershed to residential land use. Neighborhood source assessments were conducted on July 16, 2008 to evaluate pollution source areas, stewardship behaviors, and residential restoration opportunities within individual residential neighborhoods throughout the watershed. The residential behaviors that contribute to stormwater quality were assessed by considering the following source areas for "average" neighborhoods throughout the subwatershed:

- Yards and Lawns
- Driveways, Sidewalks, and Curbs
- Rooftops
- Common Areas

Neighborhoods were selected for assessment based on their proximity to stream corridors and their overall potential to contribute pollutants to the stream. The selected neighborhoods include a variety of residential types, including low- and high-density single-family residential and multi-family residential (apartments and condos). One field sheet was completed for each neighborhood assessed. The selected neighborhoods are located in the Tucker Brook, Lower Tankerhoosen River, Clarks Brook, Walker Reservoir, and Gages Brook subwatersheds, as summarized in Table 3-6.

Each neighborhood was assigned a score for pollution severity and restoration potential. Pollution severity is a measure of how much nonpoint source pollution a neighborhood is likely generating based on easily observable features such as lawn care practices, drainage patterns, oil stains, etc. Restoration potential is a measure of the feasibility of on-site retrofits or behavior changes based on available space, number of opportunities, presence of a strong homeowners association, and other factors.

Table 3-6. Neighborhood Source Assessments Conducted in the Tankerhoosen River Watershed

Neighborhood/ Subdivision Name	Subwatershed	Residential Type	Pollution Severity	Restoration Potential
Mount Vernon Apartments	Walker Reservoir	Multi-family	Moderate	Moderate
Campbell Avenue	Lower Tankerhoosen River	High-density, single-family	Moderate	Low
Valley View Drive/Andrew Way	Gages Brook	Medium-density, single-family	None	Low
High Manor Mobile Home Park	Clarks Brook	High-density, single-family	Moderate	Moderate
Meadowbrook Drive	Tucker Brook	Medium-density, single-family with open space areas	None	Low

Mount Vernon Apartments

The Mount Vernon apartments are a 33-acre multi-family housing complex situated between Hartford Turnpike (Route 30) and Interstate 84 in the Walker Reservoir subwatershed. The apartments are served by outdoor surface parking lots in front of each building. Site imperviousness is estimated at approximately 50 percent. Runoff downspouts are connected directly to the site stormwater drainage system, and parking areas are served by traditional curb and gutter drainage. The complex is generally well-maintained, with generally clean gutters, catch basins, and parking areas. Some oil staining was observed on the pavement within individual parking stalls

The overall pollution severity is rated as moderate due to the large amount of directly connected impervious area and potential pollutant sources from parking areas. This site is a potential retrofit candidate to reduce stormwater runoff from the site, including disconnecting downspouts from the storm drainage system and redirecting them to pervious grass areas, rain barrels/cisterns, and rain gardens. Multi-family parking lots, such as the parking lots at this complex, may also be good candidates for stormwater retrofits. The following photograph depicts an existing landscaped area adjacent to the parking lot that could potentially function as a bioretention/rain garden.

The Mount Vernon apartment complex buildings showing clean and well-maintained parking areas and landscaping (A) and a landscaped area that has the potential to be used as a rain garden (B).

Campbell Avenue

The Campbell Avenue residential development is a 13-acre neighborhood of single family homes on approximately ¼ acre lots. The neighborhood is located off of Dobson Avenue and is situated between Interstate 84 and the ConnDOT Maintenance Service Center to the north and Dobsonville Pond to the south. The age of the neighborhood is estimated as approximately 50 years. Almost none of the homes have a garage, and nearly all have impervious driveways connected to the street curb and gutter drainage system. No on-site or centralized stormwater management practices were observed, other than curb and gutter drainage. Most of the homes have downspouts that are directed to pervious lawn areas near the house. Landscaping practices were minimal. This type of older, high density single family residential neighborhood has limited potential for stormwater retrofits due to limited land area.

Valley View Drive/Andrew Way

The Valley View Drive/Andrew Way neighborhood is approximately 55 acres in size and located near the headwaters of Gages Brook. The neighborhood is approximately 25 years old and consists of single family homes occupying approximately 1-acre lots. Most of the homes have garages and a high percentage of the lots are covered by lawn (60%) and landscaped areas (20%). The subdivision is served by traditional curb and gutter drainage. No centralized stormwater management measures were observed. Approximately three quarters of the roof downspouts are connected to adjacent pervious areas. Overall, the neighborhood was rated as having low pollution potential and limited potential for stormwater retrofits.

A typical lot in the Valley View Drive/Andrew Way neighborhood.

High Manor Mobile Home Park

High Manor Mobile Home Park is an approximately 28-acre neighborhood located in the Clarks Brook subwatershed, situated between Route 30 and Interstate 84. The park is believed to have been developed in the 1970s. The average lot in the neighborhood has approximately 40 percent impervious cover, including the home and driveway, 40 percent grass cover, and 20 percent landscaped area. Approximately 90 percent of the homes have roof downspouts that discharge to lawns. The streets have traditional curb and gutter drainage, and storm drain inlets were observed to be clean. No centralized stormwater management measures were observed.

A street view of the High Manor Mobile Home Park showing turf lawns with some mature trees on the properties.

Meadowbrook Drive

The Meadowbrook Drive neighborhood is an approximately 100-acre residential neighborhood in the northeast corner of Manchester. The neighborhood is situated in the central portion of the Tucker Brook subwatershed, and Tucker Brook flows partially through and along the north and west sides of the development. The subdivision is estimated as approximately 10 years old, and the average lot size for the single family homes in the subdivision is approximately ½ acre. All of the homes have garages. The driveway, sidewalks and curb areas are clean and dry. A majority of the homes have roof downspouts that discharge to pervious lawn areas. The street storm drains are stenciled. An approximately 1-acre wet stormwater basin near the corner of Yale and Chatham Drives receives runoff from the subdivision storm drainage system. The basin outlet discharges to Tucker Brook. At the time of the inspection the stormwater basin outlet was observed to be overgrown with vegetation, and stream bank erosion was observed at the outfall to the stream. The basin appears to be in need of regular maintenance. Buffer encroachment, stream crossings, residential drain outfalls, and yard waste dumping were common in residential areas along the stream corridors in this subdivision.

Typical conditions in the Meadowbrook Drive neighborhood showing landscaping, lot sizes, and general cleanliness.

3.3.3 Streets and Storm Drain Assessment

Urban streets and storm drains can be a source of stormwater pollutants if not maintained on a regular basis. The condition of the local road and storm drain infrastructure can be assessed to determine if existing maintenance practice could reduce pollutant accumulation. Selected streets and storm drains were assessed during the upland field inventories conducted on July 16, 2008. Most of the streets and storm drains that were assessed are located in or near hotspot or neighborhood source assessment locations. Findings of the street and storm drain assessment are summarized below. Photographs of the storm drains and the street conditions evaluated are provided as Table 3-7.

Table 3-7. Streets and Storm Drain Assessment Photographs

Location	Storm Drains		Streets
Campbell Avenue			
Mount Vernon Apartments			
Valley View Drive/Andrew Way			
High Manor Mobile Home Park			
Gerber Technologies			
Clark Road Industrial Park			[No photo]

Most of the streets were clean, free of sediment and debris, and in good condition. The one exception is Industrial Park Road in the Clark Road Industrial Park where roads were observed to be in poor condition (cracked, broken, and sediment accumulation). Storm drains along Industrial Park Road were also partially obstructed with sediment, leaves, trash, and one of the catch basins had standing water above the elevation of the stream water surface, indicating blockage of the outlet pipe. Many of the inspected catch basins had varying degrees of sediment accumulation and nearly all could benefit from increased clean-out and street sweeping. With the exception of the Meadowbrook Drive subdivision in the Tucker Brook subwatershed, none of the storm drains observed during the field assessments was stenciled.

4 Land Use Regulatory Review

4.1 Introduction

Municipal land use regulations control patterns of new development and redevelopment and can play a significant role in protecting water quality and other natural resources in a watershed. These commonly include local plans of conservation and development, zoning regulations, subdivision regulations, inland wetland regulations, and stormwater regulations, all of which influence the type and density of development that can occur within a watershed. Local land use regulations often vary by town within a watershed, and regulations are periodically revised in response to development pressure, shifts in attitude toward natural resource protection, and political and socioeconomic factors.

A key element in the development of a Watershed Management Plan is to identify potential land use regulatory mechanisms (i.e., new or modified land use regulations) that can be implemented by the watershed towns to strengthen existing land use controls and better protect natural resources within the watershed. Many Connecticut communities are in the process of developing new or modified land use regulations that incorporate Low Impact Development (LID) and related stormwater management approaches to address stormwater quantity and quality objectives. Communities in urbanized areas are also faced with a mandate to meet State and Federal Phase II stormwater permit requirements under the National Pollutant Discharge Elimination System (NPDES) program, as well as addressing local concerns about the damaging effects of increased impervious cover and uncontrolled stormwater runoff from land development and suburban sprawl.

An opportunity exists for the watershed towns to develop revised and/or new regulatory mechanisms to satisfy Phase II stormwater requirements, while also protecting water quality and other natural resources in the Tankerhoosen River watershed consistent with the objectives of this plan.

This section summarizes the following information:

- Existing municipal land use planning entities and regulations for each of the watershed communities based on information obtained from a land use questionnaire conducted by the North Central Conservation District in 2005 as part of the *Hockanum River State of the Watershed Report* (Fuss & O Neill, 2005). The information was updated where necessary to reflect current conditions.

- Existing land use regulations and related planning documents that pertain to stormwater management and natural resource protection issues, as well as potential approaches for developing regulatory mechanisms to incorporate improved stormwater management, including LID concepts and opportunities to reduce impervious cover, into the local land use regulations. The regulatory review was performed for the towns of Tolland and Vernon because they comprise the majority of the land area in the Tankerhoosen River watershed and have the greatest potential for future development. Findings of the regulatory review are described in the report *Watershed Field Inventories and Land Use Regulatory Review* (Fuss & O Neill, October 2008), as well as a technical memorandum dated June 9, 2008 for the Town of Vernon, a copy of which is provided in Appendix B of this watershed management plan.

4.2 Summary of Land Use Planning Entities

The 2005 land use questionnaire provided information from the watershed municipalities on the land use regulations in each town, including information on wetlands and watercourses regulations, zoning regulations, plans of development, open space planning, and stormwater regulations. The following paragraphs summarize information obtained from the questionnaire, which was updated to reflect current conditions as of October 2008.

Local land use regulations are administered by various Town commissions, boards, and agencies. Land use commissions in the Tankerhoosen River watershed communities are summarized in Table 4-1.

Table 4-1. Tankerhoosen River Watershed Land Use Commissions

Town	Land Use Commissions
Manchester	• Planning and Zoning Commission (acts as Inland Wetlands and Watercourses Agency) • Conservation Commission
Vernon	• Planning and Zoning Commission • Inland Wetlands Commission • Conservation Commission • Design Review Advisory Commission • Open Space Task Force • Local Historic Properties Commission
Tolland	• Planning and Zoning Commission • Inland Wetlands and Watercourses Commission • Conservation Commission • Design Advisory Board
Bolton	• Planning and Zoning Commission • Inland Wetlands Commission • Conservation Commission • Open Space Preservation, Acquisition, and Conservation Committee

Source: Hockanum River –State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005; amended in 2008.

Table 4-2 summarizes the current plan of development, subdivision, inland wetlands, zoning, floodplain management, and stormwater regulations for the watershed towns. The table lists the last revision date for the applicable land use regulations.

Table 4-2. Municipal Land Use Regulations

Regulation	Manchester	Vernon	Tolland	Bolton
Plan of Development	2004	2001	1999	1990
Subdivision Regulations	2005	2007	2008	2004
Wetlands Regulations	2007	2006	2007	2006
Zoning Regulations	2008	2009	2008	2005
Floodplain Management	1994	In Zoning Regs.	None	2005
Stormwater Regulations	Connecticut Stormwater Quality Manual	In Zoning Regs.	2008 (LID)	2004

Source: Hockanum River – State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005; amended in 2008.

Inland Wetlands & Watercourses

Regulating activity with the potential to affect wetlands and watercourses is an essential component in preserving or improving the water quality and overall health of the Tankerhoosen River. In Connecticut, the Inland Wetlands and Watercourses Act requires that each municipality establish an Inland Wetlands and Watercourses Agency or Commission and local regulations regulating private and municipal work located in or affecting wetlands or watercourses.

Each of the surveyed watershed towns has an inland wetlands agency, and each town has defined an upland review area, or distance from wetlands and watercourses that is subject to review. Three of the four watershed towns indicated that they have identified wetlands or watercourses that are impaired or that require restoration or require special protection. Table 4-3 summarizes the regulating agencies, upland review areas, and identified wetlands and watercourses of special significance for the surveyed watershed towns.

Table 4-3. Inland Wetlands and Watercourses Regulations

Town	Regulating Agency	Upland Review Area	Wetlands and Watercourses of Special Significance
Manchester	Planning & Zoning Commission	50' wetlands and watercourses	None identified
Vernon	Inland Wetlands & Watercourses Agency	100' wetlands 200' designated watercourses	• Vernal pools on Box Mountain Road • Tankerhoosen River • Hockanum River • Belding Wildlife Management Area
Tolland	Inland Wetlands & Watercourses Commission	50' wetlands 100' watercourses	Preliminary*
Bolton	Inland Wetlands Commission, Conservation Commission	100' wetlands and watercourses	Yes*

Source: Hockanum River – State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005. *Information available from the individual towns; amended in 2008.

Stormwater Management and Soil Erosion and Sediment Control

Development of the landscape with impervious surfaces can alter the hydrology of a watershed and has the potential to adversely affect water quality and aquatic habitat. As a result of development, vegetated and forested land that consists of pervious surfaces is largely replaced by land uses with impervious surfaces. This transformation increases the amount of stormwater runoff from a site, decreases infiltration and groundwater recharge, and alters natural drainage patterns. Natural pollutant removal mechanisms provided by on-site vegetation and soils have less opportunity to remove pollutants from stormwater runoff. During construction, soils are also exposed to rainfall, which increases the potential for erosion and sedimentation. Development can also introduce new sources of pollutants from everyday activities associated with residential, commercial, and industrial land uses.

Stormwater runoff both during construction and following completion of construction for new development and redevelopment projects is regulated at the local and state levels. All of the watershed towns have erosion and sediment control regulations as mandated by the Soil Erosion and Sediment Control Act. Most Connecticut municipalities have adopted regulations requiring that a soil erosion and sediment control plan be submitted with any application for development within the municipality when the disturbed area of such development is more than one-half acre. Projects that disturb greater than 5 acres of land are subject to regulation under the DEP *General Permit for the Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities*. This permit applies to discharges of stormwater and dewatering wastewaters from construction activities including, but not limited to, clearing, grading, and excavation that result in the disturbance of 5 or more acres of total land area on a site. Pursuant to Phase II of the NPDES Stormwater Program, construction activities disturbing between 1 and 5 acres have been delegated by DEP to the municipalities provided that the erosion and sediment control plan is reviewed and receives approval from the town, under the Soil Erosion and Sedimentation Control Act.

Post-construction stormwater quantity and quality are also regulated by the watershed municipalities through municipal planning and zoning and inland wetlands and watercourses regulations. All of the watershed towns are subject to the requirements of the NPDES Phase II stormwater program, which is regulated under the DEP *General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems* (MS4 General Permit). The MS4 General Permit regulates the quality of municipal stormwater discharges and requires the creation of a Stormwater Management Plan that addresses the following six minimum control measures:

1. Public education and outreach on storm water impacts required throughout the entire municipality;
2. Public involvement/participation required throughout the entire municipality;
3. Illicit discharge detection and elimination required throughout the entire municipality including mapping all storm water discharges from a pipe or conduit with a diameter of 15 inches or greater (or equivalent cross-sectional area) owned or operated by the municipality;
4. Construction site storm water runoff control required throughout the entire municipality;

5. Post-construction storm water management in new development and redevelopment; and
6. Pollution prevention/good housekeeping for municipal operations.

The DEP *Connecticut Stormwater Quality Manual* provides guidance on the measures necessary to protect the waters of the State of Connecticut from the adverse impacts of post-construction stormwater runoff. It is intended for use as a planning tool and design guidance document by the regulated and regulatory communities involved in stormwater quality management in Connecticut. The manual provides uniform guidance for developers, engineers, and review agencies on the selection, design, and application of stormwater control measures. All of the watershed towns in the Tankerhoosen River watershed have indicated that they use the stormwater manual in reviewing development proposals for stormwater management issues.

In February 2008, the Town of Tolland amended its zoning and subdivision regulations to require that Low Impact Development (LID) techniques be implemented on all development to protect high quality wetlands, watercourses, open water bodies and other sensitive areas from the impacts of point and nonpoint sources of stormwater due to land development projects. Tolland also developed a companion LID design manual.

Open Space

Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious coverage, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space includes preserved natural areas as well as lightly developed parks and playgrounds.

While approximately 40 percent of the Tankerhoosen River watershed consists of undeveloped land uses, much of this land is not considered open space because it may be privately owned and ultimately developed. Protected open space areas include deeded open space that is privately owned, parcels owned by land trusts, state and federally-owned land, land owned by water companies, and municipal park land. Such land is protected against future development. Each of the watershed towns has prepared an open space plan for their respective communities (Table 4-4).

Table 4-4. Status of Municipal Open Space Plans
in the Tankerhoosen River Watershed

Town	Open Space Plan
Manchester	2004
Vernon	2005
Tolland	2006
Bolton	2004

Source: Hockanum River – State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005; amended in 2008.

In addition to the designation of protected open space through donation, purchase of land by a town, conservation or land trusts, or other private and/or public agencies, towns also require that some land be dedicated as open space with the development of new subdivisions. The subdivision regulations of all of the towns in the Tankerhoosen River watershed require the set aside of a percentage of new subdivisions as open space, and all but Manchester have provisions for fee-in-lieu-of open space. Table 4-5 summarizes responses from the surveyed watershed communities regarding their current open space regulations.

A majority of the surveyed watershed towns also allow "cluster development" and "open space subdivisions" in their subdivision regulations. These are compact forms of development that concentrate density in one portion of the site in exchange for reduced density elsewhere, thereby reducing overall site imperviousness and associated stormwater impacts and potentially avoiding development in sensitive areas of a site.

Table 4-5. Open Space Regulations

Town	Allow Cluster Development	Allow Open Space Subdivisions	Subdivision Open Space	
			Required	Fee in lieu of
Manchester	Yes	No	Yes, 6%	No
Vernon	Yes	No	Yes	Yes
Tolland	Yes	Yes	Yes, 10%	Yes
Bolton	Yes	Yes	Yes	Yes

Source: Hockanum River – State of the Watershed Land Use Questionnaire, North Central Conservation District, 2005; amended in 2008.

4.3 Summary of Existing Regulations

The following policy, regulatory and planning documents were reviewed for the towns of Vernon and Tolland relative to stormwater management and natural resource protection:

- Subdivision Regulations,
- Zoning Regulations,
- Inland Wetland and Watercourses Regulations,
- Plan of Conservation and Development/Open Space Plan.

4.3.1 Town of Vernon

The Town of Vernon has a number of land use regulations that regulate construction and post-construction stormwater runoff from new development and redevelopment activities, and provide for protection of natural resources. The local regulations are particularly strong in terms of erosion and sediment control (as well as consistent between the various regulations), open space protection, and regulating activities that can potentially affect wetlands and watercourses, including requirements for watercourse buffers. However, there are several areas where the regulations and design standards and guidance could be strengthened through amendments or new regulations to clarify and strengthen stormwater management requirements and better promote the use of LID principles.

This section contains preliminary recommendations for the town of Vernon based on the review of the existing land use regulations and planning documents. The recommendations in this section are a summary of the more detailed regulatory review, which is provided in the technical memorandum dated June 9, 2008 (Appendix B).

Town Design Manual

- Develop a Town stormwater and LID design manual. A local manual should reference applicable sections of the DEP Connecticut Stormwater Quality Manual to take advantage of the existing design guidance, but also include more detailed guidance and stronger emphasis on LID practices and include specific stormwater standards tailored to the characteristics and needs of the Town. The Town land use regulations should also reference the local stormwater design manual, thereby serving as a single, unifying guidance document that could be updated without the need for major revisions to the land use regulations.

- Include a section of the design manual that addresses stormwater retrofits for redevelopment and drainage system upgrade and maintenance projects. Stormwater retrofits for residential and commercial redevelopment projects are an important element for the Town's stormwater management strategy given the level of existing development in the Town. Stormwater retrofits also present an opportunity to implement lot-level LID strategies as opposed to larger end-of-pipe controls where land may not be available for stormwater management facilities.

- Incorporate/reference stormwater quantity and conveyance sections of the Connecticut DOT Drainage Manual for consistency with state drainage standards.

Stormwater Management Standards

- Develop and incorporate into the Town stormwater design manual a set of stormwater management standards, which would become regulatory standards referenced by the existing Town land use regulations and/or new stormwater ordinance. Development of stormwater management standards would allow Vernon to establish clearer, specific standards that all projects must meet in order to obtain local land use permits. The stormwater standards could include LID requirements, complement the hydrologic sizing criteria in the *Connecticut Stormwater Quality Manual* and be tailored (using variable minimum performance standards) to protect specific water bodies or sensitive resources in the Town of Vernon. An example set of stormwater management standards is included with the memorandum in Appendix B.

New or Modified Stormwater Regulations

- Develop and implement new or revised stormwater regulations to 1) satisfy Phase II Stormwater Program regulatory requirements, 2) encourage or require LID principles to be implemented for development projects in Vernon, and 3) address other local drainage and natural resource protection issues identified by the Town. Two potential approaches have been identified – 1) a new stand-alone stormwater ordinance, or 2) addition/amendments to the existing Zoning Regulations.

- Form an advisory committee or workgroup consisting of representatives from the various land use commissions and selected Town departments to further evaluate and select the best approach for Vernon, including key decisions regarding:
    - If a new, stand-alone stormwater ordinance is selected, which department or commission will have responsibility for administering the program (i.e., the "Stormwater Authority")?
    - Which projects and activities will the new ordinance apply to (i.e., applicability)?
    - How will applications be received and reviewed?
    - Who will be responsible for inspections and enforcement?
    - Will additional staff be required to handle the increased workload to review and process applications?

4.3.2 Town of Tolland

Zoning and Subdivision Regulations

The Town of Tolland amended its zoning and subdivision regulations to:

1. Incorporate Low Impact Development (LID) principles. The Town also developed a companion LID Design Manual that provides recommendations for site design, road design, and stormwater management.
2. Create a natural Resource and Wildlife Protection Overlay Zone around sensitive habitat areas and steep slopes throughout the town.
3. Adopt density-based zoning to replace the minimum lot size requirements.

Tolland is one of the first towns in Connecticut to adopt comprehensive LID regulations. The regulations are a good model for the other watershed communities to require the use of LID practices. The regulations are currently in the early stages of implementation. The Town should continue to monitor the effectiveness of the LID regulations as development projects subject to the new regulations are designed, reviewed, and constructed.

Inland Wetlands and Watercourses Regulations

The Inland Wetlands and Watercourses regulations were amended in 2007, and are in accordance with the Connecticut General Statues. The regulations define an Upland Review Area extending a minimum 50 feet from the edge of a wetlands and/or watercourse and a extending a minimum of one hundred 100 feet from any watercourse, including intermittent watercourses. The width of the Upland Review Area may be doubled in cases where the slopes bordering the wetland and/or watercourse are in excess of 15%, the presence of highly erodible soils, or unique and/or easily damaged wetland ecosystems exist.

Permit application requirements include documentation that proposed stormwater quality management systems, at a minimum, conform to the DEP *Connecticut Stormwater Quality Manual*, as amended. The Inland Wetlands and Watercourses Regulations should be revised to require that projects also meet the design requirements contained in the Tolland LID Design Manual, for consistency with the zoning and subdivision regulations and to promote the use of LID.

The town should also consider incorporating more explicit watercourse buffer recommendations, including minimum buffer widths, similar to the watercourse buffer provisions in the Town of Vernon Inland Wetlands and Watercourses Regulations. Pending passage of enabling legislation by the Connecticut state legislature, the Town should also adopt riparian buffer protection regulations that would establish requirements for a contiguous buffer strip on either side of selected watercourses such that they remain in a natural, undisturbed state.

Plan of Conservation and Development

The Tolland Planning & Zoning Commission is in the process of updating the 1999 Plan of Conservation & Development (POCD) in accordance with the Connecticut General Statutes which requires the plan to be updated every ten years. The plan will establish a common vision for the future of the community and determine policies that will help attain that vision. The plan will address a range of themes, including natural resources, open space, utility infrastructure, and community development.

The Town's planning consultant has prepared draft recommendations related to conservation issues as part of the POCD update process. The recommendations address surface and groundwater quality, important habitat areas, drainage issues, green infrastructure, and open space protection. Some of the key recommendations for natural resource protection that also apply within the Tankerhoosen River watershed include (Planimetrics, 2008):

- Future development should occur in a manner and in locations that are environmentally sustainable.
- Impacts from existing development should be minimized through education, incentives, and town leadership.

Open Space and Conservation Plan

The 2006 Tolland Open Space and Conservation Plan inventoried natural resources throughout the town, including wetlands, rivers and streams, lakes and ponds, vernal pools, water supply watersheds, forest resources, and wildlife resources. In addition to the Open Space and Conservation Plan, the town has also completed or is implementing the following open space preservation activities (Planimetrics, 2008):

- Establishing an Open Space Acquisition Fund.
- Setting up a structured process for open space procurement and management.
- Promoting the use of open space, with trail maps and programmed activities.
- Tapping into a volunteer group for maintenance (Tolland Conservation Corps).

5 Watershed Goals and Objectives

This section presents the overall management goals for the watershed, specific objectives and indicators to measure progress in achieving the objectives, and recommended management strategies. The goals, objectives, and management strategies presented in this section were developed in conjunction with the Technical Advisory Committee based upon the results of the watershed inventory and evaluation phases of the project.

5.1 Watershed Management Goals

The watershed management goals for the Tankerhoosen River watershed are summarized below. The first two goals listed below reflect the overall goals for managing the Tankerhoosen River, while the latter two reflect protection/preservation and restoration goals, respectively.

- Develop an affordable and effective watershed management plan that can be implemented by the watershed municipalities, residents, and other stakeholders.
- Maintain and enhance water quality and ecological health in and along the Tankerhoosen River and its tributaries, which is essential to the economic well-being, environmental and public health, recreational opportunities, and quality of life for the residents, local governments, and visitors of the Tankerhoosen River watershed.
- Protect the upper region of the Tankerhoosen River watershed, including high-quality headwater streams that sustain significant natural resources such as the Belding Wild Trout Management Area, from existing pollutant sources and future threats related to new development and redevelopment.
- Restore and enhance the water quality and ecological health of impacted portions of the Tankerhoosen River and its tributaries to support designated uses for fish and wildlife habitat and recreational use.

5.2 Watershed Management Objectives and Strategies

Specific objectives and recommended management strategies to achieve the watershed management goals are described below. Additional details of the recommended management strategies, including implementation priority, schedule, costs, funding sources, and implementation responsibilities, are presented in Section 6 of this plan.

Objective 1. Establish a sustainable coalition of partners to take a leadership role in implementing the Tankerhoosen River Watershed Management Plan, and encourage inter-municipal coordination in managing water quality and habitat issues in the watershed through this coalition.

Management Strategies

- Maintain the existing Technical Advisory Committee but shift its responsibilities from planning to implementation.
- Include representatives from each of the watershed municipalities (Vernon, Tolland, Manchester, and Bolton), the Connecticut Department of Environmental Protection, and possibly new members to fill in missing expertise.
- This group would form the core of a watershed partnership or coalition specifically for implementing the Tankerhoosen River Watershed Management Plan. The coalition would take the lead on implementing specific action items identified in the watershed plan, including:
    - Identify funding opportunities for grants or other financial assistance,
    - Periodically review and update action items in the plan (at least every 5 years),
    - Develop annual work plans (i.e., specific "to-do" lists),
    - Host annual public meetings to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps.
- Encourage adoption of the watershed plan by the watershed municipalities.
- Identify funding sources and prepare and submit grant applications for projects identified in the watershed plan.

Objective 2. Enhance in-stream and riparian habitat along the river and its tributaries to sustain a diversity of aquatic life.

Management Strategies

- Conduct a fish passage assessment to refine the understanding of fish passage barriers throughout the watershed and opportunities for restoring fish passage and aquatic habitat for various parts of the river system.
- Revise local storm drainage design standards and regulations such that new or modified stream crossings are designed consistent with the Connecticut DEP Stream Crossing Guidelines (February 26, 2008).
- Investigate the feasibility of dam removal, including the implications of release of contaminated sediments behind the dams. Consider the impacts of dams beyond barriers to anadromous fish passage and fragmentation of resident fish populations. Dams affect water quality and particularly coldwater habitat. Accompany dam removal feasibility studies with assessments of fish passage at culverts upstream and downstream of the dams.
- Implement priority stream bank stabilization projects identified during the watershed field inventories.

Objective 3. Protect existing and restore degraded vegetative and riparian buffers.

Management Strategies

- Implement priority buffer reforestation and invasive species management projects identified during the watershed field inventories.
- Pending passage of enabling legislation by the Connecticut state legislature, adopt riparian buffer protection regulations that would establish a contiguous buffer strip on either side of the river such that it remains in a natural, undisturbed state.
- Tolland should consider incorporating more explicit watercourse buffer protection, including minimum buffer widths, similar to the watercourse buffer recommendations in the Town of Vernon Inland Wetlands and Watercourses Regulations.
    - Vernon should adopt LID regulations, which include site design credits or other similar incentives for developers to restore or establish vegetative buffers as part of site development.
    - Partner with the Connecticut Department of Transportation on state roadway projects in the watershed to request Transportation Equity Enhancement funding available for habitat/ecological restoration projects under SAFTEA-LU).
    - Educate developers, town staff, and the public.

Objective 4. Improve water quality by identifying and eliminating illicit discharges and encouraging stream cleanups.

Management Strategies

- Follow-up with recommended discharge investigations (by the responsible municipality) identified during the watershed field inventories.
- Ensure that illicit discharge detection and elimination (IDDE) efforts of the watershed municipalities (required by the MS4 General Permit) include their respective areas of the Tankerhoosen River watershed.
- Ensure that the watershed municipalities implement IDDE programs as required by the MS4 General Permit, including an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the regulated municipal separate storm sewer system and an IDDE Plan to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.
- Implement priority stream cleanup projects identified during the watershed field inventories.
- Educate town staff and the public.

Objective 5. Build awareness of land stewardship and management practices and reduce nonpoint source impacts in residential areas.

Management Strategies

- Increase watershed stewardship signage (watershed, stream, stormwater pollution prevention, and storm drain markings).
- Encourage disconnection of rooftop runoff from the storm drainage system to reduce the quantity of runoff by redirecting the runoff to pervious areas or through the use of rain barrels or rain gardens.
- Tailor education efforts to the types of pollution producing behaviors observed in residential neighborhoods throughout the watershed (buffer encroachments, yard waste, piped discharges, septic system maintenance for unsewered areas, etc.).
- Encourage the creation of backyard habitat in residential areas that abut the Tankerhoosen River and its tributaries and recognize efforts of the public.

Objective 6. Advance local government and community business awareness of the Tankerhoosen River through pollution prevention education and watershed restoration outreach activities.

Management Strategies

- The watershed municipalities should review the current compliance of their municipal facilities in the watershed with pollution prevention best management practices and applicable regulatory programs. "Good housekeeping" at municipal facilities should serve as demonstration sites for comparable private operations. Recognize examples of good practices and hold them up as models.
- The watershed municipalities should improve implementation of municipal stormwater management programs during the second term of the MS4 General Permit.
- Create a general brochure and presentation to inform businesses about pollution prevention. Conduct compliance assistance outreach (e.g., visits, group training, and/or printed materials) for specific types of businesses in the watershed (e.g., light industry, offices, commercial retail centers, restaurants).
    - Create educational displays in highly visible, strategic locations throughout the watershed to highlight water quality and habitat amenities, and to reinforce the watershed protection efforts in the watershed.
    - Increase watershed stewardship signage (watershed, stream, stormwater pollution prevention, and storm drain markings).

Objective 7. Implement an ongoing water quality and biological monitoring program to assess the effectiveness of implementation efforts and build upon the existing water quality database to guide future decision making.

Management Strategies

- Establish a long-term water quality and biological monitoring program building upon previous baseline monitoring and ongoing DEP and volunteer monitoring efforts.
- Conduct a field monitoring study of the effectiveness of new LID practices (pervious pavement, rain gardens, etc.) in the watershed. The study could be used as a demonstration project to highlight a "local, real-world" example of LID stormwater design.

Objective 8. Manage, maintain, and promote existing open space and continue to acquire open space that meets resource protection and recreational goals within the watershed.

Management Strategies

- Continue efforts to acquire unprotected open space, with priority given to the headwater subwatersheds (Gages Brook, Gages Brook South Tributary, Walker Reservoir, Upper Tankerhoosen River, Railroad Brook, and Bolton Notch Pond), riparian areas, and contiguous unfragmented parcels of open space.
- Implement existing municipal Open Space Plans and update the plans at least once every 5 years. Endorse the remaining priority open space in the watershed as high priority open space conservation areas in the municipal Open Space Plans and Plans of Conservation and Development.
- Seek alternative funding sources and approaches for open space acquisition such as state grants, limited market rate development on a parcel to help fund the acquisition of the remainder of the parcel as open space, transferring development rights from sensitive locations to locations better suited for development.
- Create watershed-wide trail maps and promote the use of existing open space by publicizing trail maps and events on open space parcels.
- Develop an invasive species management plan for the watershed, including prevention and education efforts to preempt arrivals, early detection and citizen monitoring efforts, rapid response measures for successful eradication, and when a species cannot be eradicated, continued control efforts that are necessary to minimize ecological and economic impacts.

Objective 9. Mitigate the negative impacts of stormwater runoff on hydrology and water quality through the use of Low Impact Development, sustainable design, and other state-of-the-art stormwater management practices.

Management Strategies (Regulatory)

- All municipalities in the watershed are subject to the NPDES Phase II requirements, including adoption of a local regulatory mechanism to control construction and post-construction runoff from new development and redevelopment projects.
- Tolland is one of the first towns in Connecticut to adopt comprehensive LID regulations. The regulations are a good model for the other watershed communities to require the use of LID practices. The regulations are currently in the early stages of implementation. The Town of Tolland should continue to monitor the effectiveness of the LID regulations as development projects subject to the new regulations are designed, reviewed, and constructed.
- The Tolland Inland Wetlands and Watercourses Regulations should be revised to require that projects also meet the design requirements contained in the Tolland LID Design Manual, for consistency with the zoning and subdivision regulations.
- Vernon should develop and implement new or revised stormwater/LID regulations to 1) satisfy Phase II Stormwater Program regulatory requirements, 2) encourage or require LID principles to be implemented for development projects, and 3) address other local drainage and natural resource protection issues identified by the Town.
    - Two potential approaches have been identified – 1) a new stand-alone stormwater ordinance, or 2) addition/amendments to the existing Zoning Regulations.
    - Vernon should form an advisory committee or workgroup consisting of representatives from the various land use commissions and selected Town departments to further evaluate and select the best approach for Vernon.
    - Vernon should develop a Town stormwater and LID design manual, incorporating a set of stormwater management standards, which would become regulatory standards referenced by the existing Town land use regulations and/or new stormwater regulations.
- Other amendments to the Vernon Subdivision, Zoning, and Inland Wetlands regulations are recommended to achieve reductions in impervious cover and to promote the use of LID practices (see Vernon Land Use Regulatory Review recommendations, Appendix B).
- Manchester and Bolton should also consider adopting LID design guidance and regulations or similar regulatory mechanism that satisfies the NPDES Phase II requirements and promotes or requires the use of LID design practices.
- All of the watershed communities should consider updating their zoning regulations to require a zoning permit/drainage review for land clearing activities less than ½ acre and minimize land clearing by regulating building envelope or through the use of an LID credit system.

Management Strategies (Structural)

- Install priority stormwater retrofits (municipal, state, and private outfalls and/or sites) for water quality improvements based on watershed field inventory recommendations.
- Watershed towns should incorporate LID into town projects, including roadway work using emerging LID/Green Roads principles. The Town of Tolland should take a leadership role by incorporating LID into a high-profile demonstration project at a publicly-owned facility. The site should be regularly monitored and actively used for educational purposes.
- Education for developers, town staff, and the public.

Objective 10. Conduct additional assessment in non-priority subwatersheds.

Management Strategies

- Not all of the Tankerhoosen River subwatersheds and/or stream reaches were assessed during the development of this watershed management plan. Therefore, the remaining subwatersheds (Railroad Brook, Bolton Notch Pond, and the Upper Tankerhoosen River) and stream reaches should be assessed over the next two years to identify additional site-specific issues and restoration projects.

6 Watershed Management Recommendations

This section of the plan describes specific recommendations to meet the watershed management goals and objectives outlined in Section 5. The recommendations include watershed-wide recommendations that can be implemented throughout the Tankerhoosen River watershed, targeted recommendations that are tailored to issues within specific subwatersheds or areas, and site-specific recommendations to address issues at selected sites that were identified during the watershed field inventories.

The recommendations presented in this section are classified according to their implementation priority. Recommendations can be viewed as short-term, mid-term, and long-term, as summarized below:

- *Short-Term Recommendations* are initial actions to be accomplished within the first one to two years of plan implementation. These actions establish the framework for implementing subsequent plan recommendations. Such actions include development of local regulations and stormwater design guidance, discharge investigations, education program planning, and field inventories within previously unassessed subwatersheds. Small demonstration restoration projects could be completed during this phase, however construction of larger retrofit practices and stream restoration projects requiring extensive design, engineering, and permitting should be planned for later implementation.

- *Mid-Term Recommendations* involve continued programmatic and operational measures, delivery of educational and outreach materials, and construction of one or two larger retrofit and/or stream restoration projects over the next two to four years. Progress on land conservation, LID implementation, and discharge investigation follow-up activities should be completed during this period, as well as project monitoring and tracking.

- *Long-Term Recommendations* consist of continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed management plan. Long-term recommendations are intended to be completed during the next 5- to 10-year timeframe and beyond.

Table 6-1 summarizes the management recommendations for the Tankerhoosen River watershed based upon the management objectives identified in the previous section. The recommendations are organized by implementation priority (short-, mid-, and long-term), scale and location (watershed, targeted, or site-specific), and the groups who are responsible for implementing the recommendations. The remainder of this section presents detailed plan recommendations, including implementation priority, schedule, anticipated benefits, potential costs, funding sources, implementation responsibilities, and an evaluation framework to measure the progress and of plan implementation.

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Table 6-1. Watershed Management Plan Recommendations Summary

Key Actions	Priority	Scale/Location	Who Should be Involved (L = lead, A = assist)													
			Watershed Towns	Friends of HRLP	Watershed Coalition	Landowners	NCCD	HRWA	Belding WMA	ConnDOT	CTDEP	NRCS	USEPA	Citizens/Volunteers
Objective 1. Build a Foundation for Implementing the Plan																
Form sustainable partnership or coalition	S	W	A	L			A	A	A		A			
Adopt watershed management plan	S	W	L		A									
Identify potential funding sources and submit grant applications	S	W	L		L	A	A	A	A	A	A	A		
Objective 2. Enhance In-Stream and Riparian Habitat																
Conduct fish passage assessments	S	T	A		L		A	A						
Revise local stream crossing & stormwater design standards	S	W	L											
Belding Pond Dam removal feasibility evaluation	S	T			A						A	L		
Conduct aquatic invasive species study	S	S	A		L									
Priority stream restoration projects	M/L	S	A		L							A		
Objective 3. Protect/Restore Riparian Buffers																
Priority riparian buffer restoration projects	M/L	S	A		L	A			A			A		
Adopt stream buffer regulations, pending enabling legislation	M	W	L											
Revise riparian buffer recommendations (Tolland)	S	W	L											
Incorporate invasive species management measures	M	T			L			A	A		A			
Objective 4. Identify and Eliminate Illicit Discharges																
Targeted illicit discharge investigations	S	T	L		A		A							
Implement municipal IDDE programs	M	W	L											
Priority stream cleanup efforts	S	S			L			A						A
Develop education/outreach materials	S	W			L		A				A			
Deliver education/outreach to the public	M	W	L				A							
Objective 5. Residential Management Practices																
Increase watershed stewardship signage in residential areas	M	W	L		A		A	A						A
Encourage disconnection of rooftop runoff	M	W	L		A		A							
Develop education/outreach materials	S	W			L		A							
Deliver education/outreach to the public	M	W	L				A							
Objective 6. Municipal and Business Management Practices																
Review municipal facility compliance	S	W	L											
Improve municipal stormwater management programs	S/M	W	L											
Implement street sweeping and catch basin cleaning	M	W	L							L				

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Table 6-1. Watershed Management Plan Recommendations Summary

Key Actions	Priority	Scale/Location	Who Should be Involved (L = lead, A = assist): Watershed Towns	Friends of HRLP	Watershed Coalition	Landowners	NCCD	HRWA	Belding WMA	ConnDOT	CTDEP	NRCS	USEPA	Citizens/Volunteers
Develop education/outreach materials	S	W			L		A							
Deliver education/outreach to the public	M	W	L				A							
Increase watershed stewardship signage in commercial areas	M	W	L		A		A	A						A
Objective 7. Implement Water Quality Monitoring Program														
Develop and implement long-term monitoring program	S	W			L		A	A			A			A
Field monitoring study of LID effectiveness	M	W	A		L		A							
Objective 8. Protect Open Space														
Priority land acquisitions	S/M	T	L		A	A			A		A			
Continue to implement municipal open space plans	S	T	L											
Seek alternative funding sources for open space acquisition	S/M	T	L		A									
Promote use of open space through trail maps and events	S/M	T			L			A	A					
Develop and implement invasive species management plan	M	T			L			A			A			A
Objective 9. Promote LID and Sustainable Site Design														
Monitor effectiveness of LID regulations (Tolland)	S/M	W	L											
Revise Inland Wetland regulations for consistency (Tolland)	S	W	L											
Develop and implement new stormwater/LID regulations (Vernon)	S	W	L											
Form advisory committee	S	W	L											
Develop Town stormwater/LID manual and/or guidance	S	W	L											
Update existing zoning, subdivision, wetlands regulations	S	W	L											
Priority stormwater retrofits	M/L	S	A		L		A			A				
Incorporate LID into Town projects	M	W	L											
LID demonstration projects (green roads, public works, schools)	S	S	L		A		A							
Develop education/outreach materials	S	W			L		A				A			
Deliver education/outreach to the public	M	W	L				A							
Objective 10. Assess Additional Subwatersheds														
Perform stream and upland assessments	S	T			L		A	A	A					A

Priority Abbreviations: S = short-term, M = mid-term, L = long-term Scale/Location Abbreviations: W = watershed-wide, T = targeted, S = site-specific
HRLP – Hockanum River Linear Park, NCCD – North Central Conservation District, HRWA – Hockanum River Watershed Association, ConnDOT – Connecticut Department of Transportation, CTDEP – Connecticut Department of Environmental Protection, NRCS – Natural Resource Conservation Service, USGS – United States Geological Survey, USEPA – U.S. Environmental Protection Agency, Belding WMA – Belding Wildlife Management Area

6.1 Watershed-Wide Recommendations

Watershed-wide recommendations are those recommendations that can be implemented throughout the Tankerhoosen River watershed. These basic measures can be implemented in each of the watershed towns, are applicable in most areas of the watershed, and are intended to address nonpoint source pollution through municipal land use regulations, public education and outreach, open space protection, and watershed monitoring. The benefits of these measures are primarily long-term, cumulative benefits resulting from source control, pollution prevention, and improved stormwater management for new development and redevelopment projects.

6.1.1 Build a Foundation for Implementing the Plan

During the planning process, the Technical Advisory Committee provided direction and local knowledge of the watershed in guiding the watershed assessments, determining priorities, and developing the management plan. As the focus of the planning process moves towards implementation, the Technical Advisory Committee, under the leadership of the Friends of the Hockanum River Linear Park, should transition to a watershed partnership or coalition specifically for implementing the Tankerhoosen River Watershed Management Plan. Recommended actions include:

- Maintain the existing Technical Advisory Committee but shift its responsibilities from planning to implementation.
- Include representatives from each of the watershed municipalities (Vernon, Tolland, Manchester, and Bolton), the Connecticut Department of Environmental Protection, and possibly new members to fill in missing expertise.
- Periodically review and update action items in the plan (at least every 5 years).
- Develop annual work plans (i.e., specific "to-do" lists).
- Host annual public meetings to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps.
- Encourage adoption of the watershed plan by the watershed municipalities. As a group, the watershed partnership or coalition should encourage formal adoption of the watershed plan by the watershed towns and develop basic guidelines and procedures for long-term membership.
- Review and prioritize potential funding sources that have been preliminarily identified in this plan (see Section 6.5.3), and prepare and submit grant applications for projects identified in the watershed plan.

6.1.2 Municipal Regulations and Design Guidance

The regulatory review described in Section 4 of this plan identifies areas for improvements in local land use regulations and municipal stormwater design guidance to strengthen stormwater management and resource protection throughout the watershed. More detailed recommendations that were identified for the Town of Vernon are described in the technical memorandum provided in Appendix B. Many of the detailed concepts and recommendations that are described in the Vernon land use regulatory review memorandum are also applicable to the other watershed towns.

Town of Tolland

1. *LID/Stormwater Regulations*

- Tolland is one of the first towns in Connecticut to adopt comprehensive LID regulations. The regulations are a good model for the other watershed communities to require the use of LID practices. The regulations are currently in the early stages of implementation. The Town of Tolland should continue to monitor the effectiveness of the LID regulations as development projects subject to the new regulations are designed, reviewed, and constructed.

2. *Inland Wetlands and Watercourses Regulations*

- The Tolland Inland Wetlands and Watercourses Regulations should be revised to require that projects also meet the design requirements contained in the Tolland LID Design Manual, for consistency with the zoning and subdivision regulations and to further promote the use of LID. Permit application requirements include documentation that proposed stormwater quality management systems, at a minimum, conform to the DEP Connecticut Stormwater Quality Manual, as amended.

- The town should also consider incorporating more explicit watercourse buffer recommendations, including minimum buffer widths, similar to the watercourse buffer provisions in the Town of Vernon Inland Wetlands and Watercourses Regulations. Pending passage of enabling legislation by the Connecticut state legislature, the Town should also adopt riparian buffer protection regulations that would establish requirements for a contiguous buffer strip on either side of selected watercourses such that they remain in a natural, undisturbed state.

Town of Vernon

1. *Town Design Manual*

- Vernon should develop a Town stormwater and LID design manual. A local manual should reference applicable sections of the DEP Connecticut Stormwater Quality Manual to take advantage of the existing design guidance, but also include more detailed guidance and stronger emphasis on LID practices and include specific stormwater standards tailored to the characteristics and needs of the Town. The Town land use regulations should also reference the local stormwater design manual, thereby serving as a single, unifying guidance document that could be updated without the need for major revisions to the land use regulations.

- The design manual should include a section that addresses stormwater retrofits for redevelopment and drainage system upgrade and maintenance projects. Stormwater retrofits for residential and commercial redevelopment projects are an important element for the Town's stormwater management strategy given the level of existing development in the Town. Stormwater retrofits also present an opportunity to implement lot-level LID strategies as opposed to larger end-of-pipe controls where land may not be available for stormwater management.

- The design manual should incorporate or reference stormwater quantity and conveyance sections of the Connecticut DOT Drainage Manual for consistency with state drainage standards.

2. *Stormwater Management Standards*

- The Town should develop and incorporate into the design manual a set of stormwater management standards, which would become regulatory standards referenced by the existing Town land use regulations and/or new stormwater ordinance. Development of stormwater management standards would allow Vernon to establish clearer, specific standards that all projects must meet in order to obtain local land use permits. The stormwater standards could include LID requirements, complement the hydrologic sizing criteria in the DEP *Connecticut Stormwater Quality Manual* and be tailored (using variable minimum performance standards) to protect specific water bodies or sensitive resources in the Town of Vernon. An example set of stormwater management standards is included in the memorandum in Appendix B.

3. *New or Modified Stormwater Regulations*

- The Town of Vernon should develop and implement new or revised stormwater regulations to 1) satisfy Phase II Stormwater Program regulatory requirements, 2) encourage or require LID principles to be implemented for development projects in Vernon, and 3) address other local drainage and natural resource protection issues identified by the Town. Two potential approaches have been identified – 1) a new stand-alone stormwater ordinance, or 2) addition or amendments to the existing Zoning Regulations. Both approaches are discussed in Appendix B.

- The Town should form an advisory committee or workgroup consisting of representatives from the various land use commissions and selected Town departments to further evaluate and select the best approach for Vernon, including key decisions regarding:

- If a new, stand-alone stormwater ordinance is selected, which department or commission will have responsibility for administering the program (i.e., the "Stormwater Authority")?
- Which projects and activities will the new ordinance apply to (i.e., applicability)?
- How will applications be received and reviewed?
- Who will be responsible for inspections and enforcement?
- Will additional staff be required to handle the increased workload to review and process applications?

4. Subdivision Regulations

- Amend Section 6.4 to reference the Connecticut Guidelines for Soil Erosion and Sediment Control, as amended, as opposed to the outdated reference to the 1976 version of the Erosion and Sediment Control Handbook.

- Section 6.5.1.1 (Street Grading and Improvement): Consider eliminating the curbing requirement for roads with grades less than 5% to encourage the use of vegetated swales and similar LID practices.

- Section 6.6.6 (Cul-de-sacs): Consider smaller cul-de-sac radius of (30 to 40 feet), or alternative designs such as hammerheads, to reduce impervious cover, such that the design allows for continuous turning movement of the largest fire fighting vehicle used by the Town of Vernon. Also consider encouraging the use of LID bioretention/rain gardens in cul-de-sac islands for stormwater management.

- Section 6.7.1 (Design Standards, Road Width): Consider pavement widths of between 24 and 28 feet, if such a reduction will not negatively impact public safety or emergency response. Refer to Table 4-3 in the Connecticut Stormwater Quality Manual for potential variation in residential roadway widths based on terrain and development density.

- Section 6.7.2 (Design Standards, Curbs): Consider eliminating the curbing requirement for roads with grades less than 5% to encourage the use of vegetated swales and similar LID practices.

- Section 6.9 (Drainage and Storm Sewers): Modify these sections to reference stormwater management standards and LID principles contained in a stand-alone stormwater ordinance or new section of the Zoning Regulations, and/or the Town stormwater design manual.

- Section 6.9.3 (Drainage Design): Amend this section to allow the use of roadside vegetated swales designed in accordance with the Town stormwater design manual.

- Section 6.12.1 (Sidewalks): Consider requiring sidewalks on only one side of the street and reduce sidewalk width to 3 or 4 feet. Grade sidewalks to the front yard rather than to the street. Consider using alternative materials such as pavers, stone dust, or pervious concrete.

- Section 6.14 (Certified Erosion and Sediment Control Plan): Amend the single family exemption such that the exemption only applies to single family dwellings that do not disturb 1 or more acres of land, which is consistent with the Phase II Stormwater Program regulatory requirement.

5. *Zoning Regulations*

- Section 3.4 (General Provisions): If the Town develops a local stormwater design manual, change the reference to the Connecticut Stormwater Quality Manual to the Town manual.

- Sections 4.1 through 4.25 (Use Districts, Setbacks and Lot Dimensions): Review current setbacks and lot dimensions for potential to relax side yard setbacks and allow narrower frontages to reduce road length and site imperviousness, and to relax front setback requirements to reduce driveway length and lot imperviousness.

- Section 12 (Off-street Parking and Loading): Review existing parking ratios to see if lower ratios are warranted and feasible. The required parking ratio for a particular land use should be enforced as both a maximum and minimum to limit excess parking space construction and impervious cover. Consider allowing the Commission to approve parking lots with more spaces than the allowed maximum provided all of the spaces above the maximum number are composed of a pervious surface, and where adequate stormwater management is provided. Also consider parking spaces held in reserve for phased developments, thereby avoiding the situation where unnecessary parking is not constructed if future phases of development do not occur.

  Clarify Section 12 of the regulations to encourage the use of shared parking. Where shared parking is used, the Zoning Regulations should require a corresponding reduction in parking spaces.

  Consider adding language to Section 12 that references specific stormwater management and landscape design standards in the Town stormwater manual and/or the Connecticut Stormwater Quality Manual.

- Section 18 (Activities Requiring a Certified Erosion and Sediment Control Plan): Amend the single family exemption such that the exemption only applies to single family dwellings that do not disturb 1 or more acres of land, which is consistent with the Phase II Stormwater Program regulatory requirement.

6. Inland Wetlands and Watercourses Regulations

- Section 4.5 (Evaluation of Proposed Activities): Add language referencing the stormwater management standards and LID principles contained in the Town stormwater manual and/or the Connecticut Stormwater Quality Manual.

- Pending passage of enabling legislation by the Connecticut state legislature, the Town should also adopt riparian buffer protection regulations that would establish requirements (as opposed to recommendations) for a contiguous buffer strip on either side of selected watercourses such that they remain in a natural, undisturbed state.

Other Watershed Towns

- Manchester and Bolton should also consider adopting LID design guidance and regulations or similar regulatory mechanism that satisfies the NPDES Phase II requirements and promotes or requires the use of LID design practices.

- All of the watershed communities should consider updating their zoning regulations to require a zoning permit/drainage review for land clearing activities less than ½ acre and minimize land clearing by regulating building envelope or through the use of an LID credit system.

6.1.3 Illicit Discharge Detection and Elimination

Municipal Illicit Discharge Programs

Illicit discharges are non-stormwater flows that discharge into the stormwater drainage system or directly into surface waters. Failing septic systems, wastewater connections to the storm drain system, and illegal dumping are among the types of illicit discharges that can occur in residential and commercial areas. Depending on the source, an illicit discharge may contain a variety of pollutants that can impact both human health and the aquatic environment. A number of potential illicit discharges were identified throughout the watershed during the stream inventories. Identifying and eliminating these discharges is an important means of pollution source control for the watershed.

All of the watershed towns are subject to the requirements of the NPDES Phase II stormwater program, which is regulated under the DEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 General Permit). The MS4 General Permit regulates the quality of discharges from municipal storm drainage systems. The program requires the towns to implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the municipal storm drainage system, as well as sanctions to ensure compliance. This includes developing an Illicit Discharge Detection and Elimination (IDDE) Plan to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.

The MS4 General Permit is anticipated to be reissued in 2009, which represents an opportunity for the watershed towns to review their compliance status relative to the MS4 General Permit requirements, including the illicit discharge detection and elimination component.

The following recommendations apply to each of the watershed towns:

- Review the compliance status of the municipal stormwater management programs relative to each of the minimum measures addressed in the existing and proposed MS4 General Permit. Modify the stormwater management plans as necessary.
- Ensure that illicit discharge detection and elimination efforts of the watershed municipalities include their respective areas of the Tankerhoosen River watershed.
- Conduct follow-up illicit discharge investigations at priority outfall locations identified during the watershed inventories (see Site-Specific Recommendations).
- Develop and implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the regulated municipal separate storm sewer system and an IDDE Plan to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.

6.1.4 Residential Practices

Watershed Stewardship Signage

Stewardship signage can be an effective way of educating the public on the importance of preserving natural resources and common ways in which they may be impacting these resources. The general public is often unaware of the cumulative effects of their every-day activities. Signage can play an important role in making the connection between every-day activities and their sometimes harmful results.

Routine residential practices that can affect water quality and the natural environment include improper disposal of trash, pet waste, yard waste, and hazardous wastes; excessive use of fertilizers and pesticides; depositing fluids and materials in storm drains; and improper management of riparian areas. Educational signage can take the form of kiosks in public areas, storm drain markers or stencils, anti-dumping signs, proper pet waste management signs, and roadside/stream side signage (examples include "adopt a stream/roadway" programs).

The watershed field inventories identified very little evidence of storm drain stenciling or watershed stewardship signage. Stormwater and pollution prevention signage is generally lacking in most residential areas of the watershed. The watershed towns, together with other local stakeholders and volunteers, should consider additional storm drain marking in residential neighborhoods, heavy pedestrian areas served by storm sewers, and municipal facilities (schools, town offices, parks, libraries, etc.).

Rooftop Disconnection

Rain barrel used to capture and re-use rooftop runoff (Source: CWP, 2007).

Residential areas appear to contribute significant quantities of rooftop runoff to the storm drainage system, particularly in medium and high-density residential neighborhoods with smaller yards. Many small outfall pipes were observed from the backyards of residential areas, which are presumably associated with foundation drains, yard drains, or roof downspouts. Opportunities exist to disconnect residential rooftop runoff from the storm drainage system or surface waters directly, and reduce the quantity of runoff by redirecting the runoff to pervious areas or through the use of rain barrels or rain gardens.

Runoff from commercial rooftops can be directed to bioretention planting beds (Source: CWP, 2007).

Rooftop disconnection (also referred to as "downspout or roof leader disconnection") is a cost-effective on-site option for reducing the volume and cost of stormwater that requires public management. Runoff from residential rooftops is collected by eaves troughs, which are installed along the edge of the roofline. Water collected in the eaves trough is conveyed to ground level by one or more downspouts. Downspouts may then connect directly into the storm sewer system or discharge to driveways, which in turn convey the water to the street and storm drainage system.

Rooftop disconnection has a number of economic and environmental benefits to the municipality and the homeowner. The major benefits include:

- Reduces volumes of flows conveyed and resulting loads to watercourses,
- Reduces the volume of flow to the municipal storm drainage system,
- Increases infiltration and groundwater recharge,
- Provides options to "recycle" rainwater.

Rooftop disconnection is ideal in neighborhoods where roof leaders are directly connected to the storm drainage system and in medium density residential areas with lot sizes in the 0.25 to 1.0 acre range (CWP, 2007). However, most residential areas that contribute rooftop runoff to the storm drainage system are potential retrofit candidates for some form of rooftop disconnection.

A variety of alternatives are available for residential and non-residential rooftop disconnections, ranging from simple disconnections to more complex delivery systems. Residential rooftop disconnection options include (Figure 6-1):

- Simple disconnection,
- Rain barrels and rain gardens,
- French drain or dry wells.

Non-residential rooftop disconnection options include (Figure 6-1):

- Simple disconnection,
- Rain gardens,
- Stormwater planters and cisterns,
- Green rooftops.

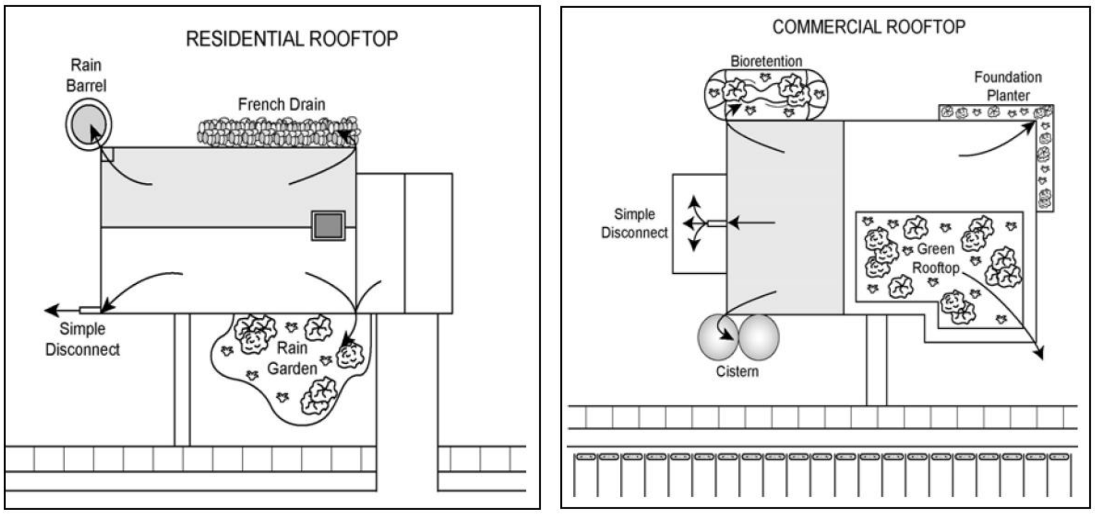


Figure 6-1. Residential and Commercial Rooftop Disconnection Retrofit Strategies (Source: CWP, 2007)

The Town of Vernon should incorporate rooftop disconnections for new development and redevelopment projects in the recommended stormwater/LID regulatory mechanism and design manual. The manual should require the use of rooftop disconnection and other LID techniques or provide incentives for their use such as an LID credit system. The manual should also include specific criteria regarding the suitability and design of various rooftop disconnection practices.

Individual rooftop retrofits target a small area, requiring the participation of many homeowners and businesses to make a measurable difference across a subwatershed. As a result, a coordinated effort is required for widespread participation in such a program, which typically includes a combination of targeted education, technical assistance, and financial subsidies to homeowners or the business community. Examples of effective local rooftop disconnection programs are presented in *Urban Stormwater Retrofit Practices* (CWP, 2007) http://www.cwp.org/Resource_Library/Center_Docs/USRM/ELC_USRM3.pdf.

6.1.5 Municipal and Business Practices

The municipal/state facilities and businesses that were observed during the field inventories exhibited examples of both good pollution prevention practices and opportunities for improvement. The watershed municipalities and ConnDOT should review the current compliance of their respective facilities (public works/maintenance facilities, parks, schools, public safety facilities, etc.) in the watershed with pollution prevention best management practices and applicable regulatory requirements. "Good housekeeping" at municipal facilities should serve as demonstration sites for comparable private operations, many of which are also subject to stormwater pollution prevention and other similar state and federal regulatory programs (oil pollution prevention, hazardous waste, air emissions). Examples of good practices should be recognized and modeled. The proposed watershed coalition should provide guidance (e.g., visits, group training, and/or printed materials) and develop incentives to encourage local businesses to adopt these model practices. Light industry, offices, commercial retail centers, and restaurants in the watershed should be the focus of these efforts.

With the pending reissuance of the DEP MS4 General Permit, the watershed towns have an opportunity to re-evaluate and improve upon the effectiveness of their municipal stormwater management programs during the second term of the MS4 General Permit. This includes the municipal good housekeeping minimum measure contained in the General Permit. The towns should modify their stormwater management plans to include audits of pollution prevention and good housekeeping practices at their respective municipal facilities, as well as re-evaluate their municipal street sweeping, catch basin cleaning, and drainage system maintenance efforts. At a minimum, all streets in the watershed should be swept at least twice per year, with more frequent sweeping of targeted areas, as necessary and as equipment and funding allow. Vacuum-assisted sweeping has been shown to be more effective than conventional mechanical broom sweeping for removing finer particulates.

Educational signage should also be considered in commercial business areas along the major transportation corridors in the watershed, including Interstate 84, Route 30, Route 31, and other heavily-traveled local roads that cross the Tankerhoosen River and its major tributaries. Increased educational signage explaining the linkage between recreational centers in the watershed and the Tankerhoosen River is also recommended within Walker Reservoir East, the Belding Wildlife Management Area, Valley Falls Park, Bolton Notch Pond, Freja Park, the Rails-to-Trails, and Phoenix Mill Park.

6.1.6 Education and Outreach

Nearly all source control and pollution prevention measures rely on some form of public education to change public behavior. In some cases, education efforts must be targeted at municipal officials and public works employees (e.g., stormwater ordinances, roadway deicing application, storm drainage system maintenance). The general public, including residents, business owners and operators, plays an important role in almost all of the source control and pollution prevention measures described in this plan.

Often, the public is not aware of the critical role they have in protecting water resources. Public education is an important part of an overall pollution prevention and source control program because it raises awareness of both personal responsibilities and the responsibilities of others relative to environmental protection and teaches people what individual actions they can take to prevent pollution. This increased understanding has the additional benefit of fostering support for watershed management efforts.

Public education programs can consist of a variety of elements including:

- Educational displays, pamphlets, booklets, and utility stuffers;
- Use of the media (newspapers, television, radio);
- Promotional giveaways (hats, t-shirts, bumper stickers, etc.);
- Stormwater educational materials;
- Classroom education.

The choice of outreach materials depends on the resources available and the target audience. A public education and outreach program should be designed to offer a broad discussion of stormwater and water quality issues. For maximum effectiveness, the program should target selected geographic areas or subwatersheds, audiences, and potential sources of pollution. A variety of general educational materials on stormwater and pollution prevention are available from state and federal government agencies, as well as education and industry groups.

The NPDES Phase II stormwater permitting program has generated a plethora of educational materials regarding water quality and nonpoint source pollution. A collection of educational materials is maintained by the U.S. EPA and is accessible to the public via the U.S. EPA's Nonpoint Source Outreach Toolbox (http://www.epa.gov/nps/toolbox/) and NPDES Stormwater Program page (http://cfpub.epa.gov/npdes/home.cfm?program_id=6). The materials target various audiences including the residences, commercial businesses, and industry. Additional materials can be found at www.asist.net/stormwebs.htm and www.stormwatereducation.com/index_flash.html.

Through implementation of their municipal stormwater programs, the watershed towns should ensure that their public participation and outreach programs focus on target audiences and areas within the Tankerhoosen River watershed. The following target audiences are recommended for watershed public education and outreach programs:

- Homeowners and renters,
- Public school system,
- Builders and residential contractors,
- Residential and commercial lawn care and landscaping professionals,
- Commercial and retail businesses.

Public education and outreach programs should target one or more of the following activities and sources of pollution:

- Illicit discharges,
- Residential downspout disconnection (rain barrels, dry wells, etc.),
- Lawn care practices,
- Yard waste disposal,
- Backyard riparian buffer practices,
- Low Impact Development for homeowners and contractors,
- Septic system maintenance,
- Construction erosion and sediment control,
- Pet waste management.

Educational displays should also be considered for highly visible, strategic locations throughout the watershed to highlight water quality and habitat amenities, and to reinforce the watershed protection efforts. Potential locations include stormwater and LID retrofit demonstration projects at schools, public parking lots, commuter parking lots, and recreational areas (see Site-Specific Recommendations).

6.1.7 Water Quality Monitoring Program

Long-Term Monitoring Program

Continued chemical and biological monitoring within the Tankerhoosen River watershed is recommended to refine the understanding of water quality impacts from potential point and non-point pollution sources in the watershed, to continue developing a water quality database for the watershed to guide environmental decision-making, and to measure the progress toward meeting water quality goals in the watershed. Additional funding sources should be sought to finance future monitoring efforts.

Recommended modifications to the Tankerhoosen river watershed water quality monitoring program for future monitoring events include:

- Chemical monitoring is recommended along Gages Brook immediately downstream of the industrial park to further evaluate potential dry weather impacts and possible illicit connections/discharges from facilities in the industrial park. The Town of Tolland should designate the industrial park as a focus area for its municipal stormwater management program, including outfall monitoring and illicit discharge detection and elimination efforts.

- Chemical monitoring is recommended along tributaries of the lower Tankerhoosen River (Tucker Brook and Tunnel Brook) that have not been previously monitored to provide information on pollutant contributions from developed areas within the lower Tankerhoosen River watershed.

LID Retrofit Demonstration Monitoring

Water quality monitoring (runoff volumes and pollutant concentrations) is recommended in conjunction with the potential LID retrofit demonstration projects that are described in the Targeted and Site-Specific Recommendations sections of this plan. Monitoring of the retrofit site(s) is recommended before and after the installation of the retrofit. Such a monitoring program could help quantify the benefits of innovative LID techniques within the Tankerhoosen River watershed, but would require a significant funding source for a comprehensive and statistically-valid "before and after" study design.

6.2 Targeted Recommendations

Targeted recommendations are tailored to address issues within specific subwatersheds or areas, rather than watershed-wide. Targeted recommendations also include actions to address common types of problems that were identified at representative locations throughout the watershed, but where additional studies or evaluations are required to develop site-specific recommendations. Targeted recommendations can have both short- and long-term benefits. Appendix C contains a series of subwatershed maps that depict targeted stream corridor recommendations.

6.2.1 Priority Parcels for Open Space Protection

As described earlier in this plan, conservation of open space is critical in protecting and preserving the health of a watershed by limiting development and impervious coverage, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Each of the watershed towns continues to implement open space plans for their respective communities.

There are several common ways that undeveloped land can be preserved and protected as open space. These include outright purchase (fee simple), conservation easements, purchase of development rights, and land donations. Regardless of the mechanism, critical to the success of protecting open space land is having a source of funding that can be readily accessed when windows of opportunity to acquire significant parcels arise.

The open space plans of the watershed towns identify priority parcels for preservation and protection. A key goal of the Town of Vernon's Open Space Plan (Revised October 12, 2005) is to protect the Tankerhoosen River watershed and associated wildlife habitat by creating contiguous greenways within the watershed. Preservation of key parcels in the watershed will help to offset the long-term, cumulative impacts of non-point source pollution. The plan's objective is to expand the large contiguous greenway formed by Valley Falls Park, the Belding Wildlife Management Area, Bolton Lakes, and State of Connecticut preserved land in order to protect the Tankerhoosen River and its tributaries from non-point source pollution, link important wildlife habitats, enhance biodiversity, and create extensive opportunities for outdoor recreation. The open space plans of the other watershed towns also identify protection of key natural resources and water quality, including the Tankerhoosen River and its watershed, as an important goal.

The watershed towns, working closely with other stakeholders including local land owners, should:

- Continue to implement their municipal Open Space Plans and update the plans at least once every 5 years. Endorse the remaining priority open space in the watershed as high priority open space conservation areas in the municipal Open Space Plans and Plans of Conservation and Development.
- Continue to pursue funding sources and alternative approaches for open space acquisition such as state grants, limited market rate development on a parcel to help fund the acquisition of the remainder of the parcel as open space, and transferring development rights from sensitive locations to locations better suited for development.
- Create watershed-wide trail maps and promote the use of existing open space by publicizing trail maps and events on open space parcels.

Priority should be given to larger properties that meet one or more of the following general criteria:

- Are contiguous with and would extend current greenways and riparian areas along headwater (1st or 2nd order) streams and other water bodies,
- Provide linkages between existing open space areas and linkages to existing trails,
- Provide important scenic, historic, cultural, or natural resource value,
- Protect groundwater and surface water supply sources,
- Protect other critical environmental resources.

Figure 6-2 identifies priority parcels throughout the watershed that should be targeted for open space protection. Several of these parcels, which are among Vernon's highest priority for open space protection, are also described below.

Tancanhoosen LLC Property

This collection of parcels comprises approximately 470 acres of land and is situated in the headwaters of the Tankerhoosen River watershed, between Walker Reservoir and the Belding Wildlife Management Area. The site is located near the Exit 67 interchange of Interstate 84 and has experienced significant development pressure. The parcel encompasses over 1.5 miles of the Tankerhoosen River that harbors a significant wild trout area. The site is characterized mostly by forested upland, and some steeply-sloped forested wetlands along the Tankerhoosen. A forested swamp and marsh area also exists on the site near Walker Reservoir. Preservation of this property would serve to offset continuing non-point source pollution pressures on the Tankerhoosen; contribute significantly to the wildlife corridor (greenway) expansion; and provide recreational value and diverse habitats including wetland aquatic habitats, stream habitats, and upland forest habitats.

Figure 6-2. Priority Parcels for Open Space Protection

The DEP has been actively pursuing purchase of this property, although funding has been delayed due to recent state budget cuts. The property remains a high priority for acquisition by the DEP, which is a key open space recommendation of this watershed management plan.

Talcottville Gorge Property

This area, known as Talcottville Gorge, is a largely forested, scenic area bisected by the Tankerhoosen River, generally situated between Talcottville Pond and Dobsonville Pond in the lower Tankerhoosen River watershed. The site encompasses a geologically significant gorge with steeply sloped rock outcroppings, a dam and falls, a small pond; and remains of early 19th century textile mills. The acreage also encompasses parcels on either side of Elm Hill Road, which are comprised of some wetlands and steep slopes and forested land and also bound the Rails to Trails. The nearby village area is designated a local historic district. Due to its diverse natural resource, cultural, and recreational value, this property ranks as the highest priority in the Town of Vernon's Open Space Plan.

6.2.2 Invasive Plant Species Management

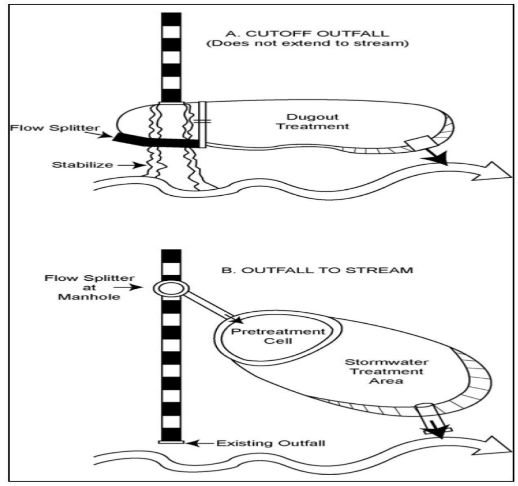
Invasive terrestrial plant species (phragmites, cattails, reed canary grass, etc.) were observed in stream corridors in many areas of the watershed during the field inventories. Management measures for control of invasive plant species should be incorporated into site-specific stream restoration activities. An invasive plant species management plan should be developed for targeted areas or subwatersheds, including the Walker Reservoir, Tucker Brook, and Gages Brook South Tributary subwatersheds. The plan could identify prevention and education efforts to preempt arrivals, early detection and citizen monitoring efforts, response measures for successful eradication, and when a species cannot be eradicated, continued control efforts that are necessary to minimize ecological and economic impacts. Information on invasive plant species planning and management can be obtained from:

- U.S. Fish and Wildlife Service: (http://www.fws.gov/invasives/staffTrainingModule/planning/introduction.html),
- The Connecticut Department of Environmental Protection,
- The Nature Conservancy (TNC),
- Connecticut Invasive Plant Working Group (CIPWG).

6.2.3 Targeted Stormwater Outfall Retrofits

Stormwater runoff from many of the state and local roads in the watershed typically receives little or no treatment prior to discharge. Such discharges are a source of sediment and other pollutants to the receiving water bodies. Opportunities exist for stormwater retrofits at roadway stormwater outfalls, particularly at or near roadway stream crossings.

This type of retrofit creates new treatment adjacent to the stream corridor near the terminus of an existing storm drain outfall. Outfall retrofits are designed off-line by splitting flow from the existing storm drain pipe (or ditch) and diverting it to a stormwater treatment area formed by an existing depression, excavation or constructed berm. A flow splitter allows larger storms to remain in the existing pipe (or ditch) and bypass the retrofit. Typical stormwater treatment options at outfall retrofits can include stormwater basins, constructed wetlands (Figure 6-3), and bioretention.



A common strategy for outfall retrofits in the stream corridor (Source: CWP, 2007).

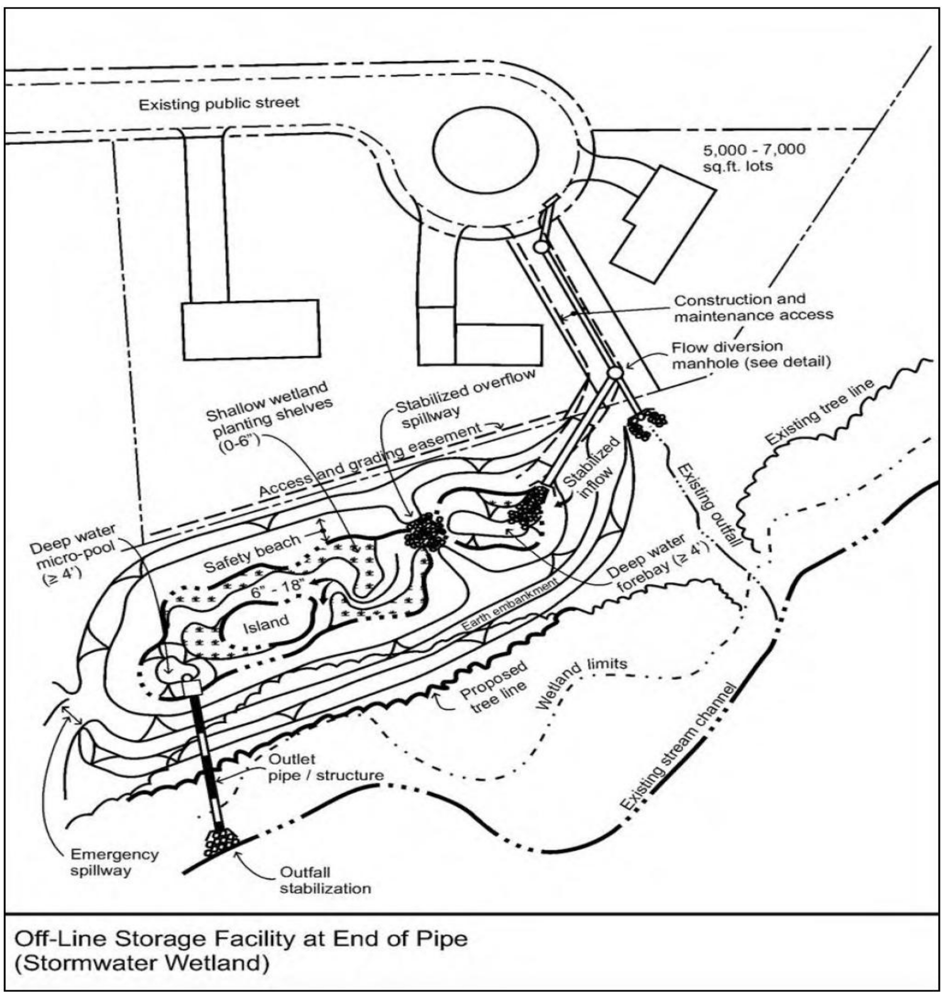


Figure 6-3. Example Constructed Wetland Outfall Retrofit (Source: CWP, 2007)

Table 6-2 lists potential outfall retrofit opportunities that were identified during the watershed field inventories, as well as outfalls where illicit discharge investigations and stabilization measures are recommended (see maps in Appendix C). The feasibility of retrofits at these outfalls should be further evaluated based on consideration of site-specific factors including hydraulic head, available space, soil conditions, and easements.

Table 6-2. Priority Outfall Retrofit Sites

Watershed	Stream Reach	ID	Recommendation			Location
			Stormwater Retrofit	Investigate Illicit Discharge	Stabilize or Repair Outfall	
Clarks Brook	CB-04	OT-01		ü		Downstream of Rockledge Road
Gages Brook	GB-03A	OT-01			ü	Outfall of sedimentation basin on Gerber Drive
	GB-04	OT-01	ü			Adjacent to Industrial Park Road West
	GB-04	OT-02		ü		250 ft south of Industrial Park Road East
	GB-04	OT-03	ü		ü	100 ft south of Industrial Park Road East
	GB-04	OT-04B		ü		Adjacent to Industrial Park Road East
	GB-05B	OT-01			ü	Outfall of detention pond CNC Software
	GB-09	OT-01	ü	ü		Along road adjacent to Industrial Park Road East
	GB-09	OT-02			ü	Along road adjacent to Industrial Park Road East
Gages Brook South Tributary	GBST-02	OT-01	ü		ü	I-84 Drainage at 0.6 miles east of Exit 67
	GBST-02	OT-02			ü	I-84 Drainage 1,000 ft east of OT-01
Lower Tankerhoosen River	LTR-03	OT-01		ü		I-84 runoff from detention pond near Exit 65
Middle Tankerhoosen River	MTR-09	OT-10		ü		South of Warren Street

Table 6-2. Priority Outfall Retrofit Sites

Watershed	Stream Reach	ID	Recommendation: Stormwater Retrofit	Recommendation: Investigate Illicit Discharge	Recommendation: Stabilize or Repair Outfall	Location
Tucker Brook	TB-04B	OT-01	ü		ü	End of Yale Drive, outfall from detention pond
	TB-04C	OT-02		ü		North of Chatham Drive 500 ft east of OT-01
	TB-04C	OT-04		ü	ü	North of Chatham Drive 350 ft east of OT-02
Walker Reservoir	WR-05	OT-01		ü		At Mile Hill Road

6.2.4 Watershed Fish Passage Assessments

Upper Tankerhoosen

The upper portion of the Tankerhoosen River and Railroad Brook support a variety of fish species. This portion of the watershed also includes the Belding Wild Trout Management Area, which has some of the highest-quality, self-sustaining native trout populations in the state. A number of existing or potential barriers to fish passage were identified during the stream inventories (Appendix C). However, the Upper Tankerhoosen River and Railroad Brook subwatersheds were not assessed during the field inventories as they were determined to be less vulnerable to future development impacts.

A field inventory is recommended along the upper portions of the Tankerhoosen River to identify potential barriers to fish passage such as culverts, dams, and other obstructions. The Tankerhoosen River is a cold water stream starting only a short distance below Walker Reservoir. The proposed removal of Belding Pond Dam approximately 1 mile downstream of Walker Reservoir (see Section 6.3.4) could potentially provide for additional passage of resident fish populations upstream to Walker Reservoir and tributaries of the Upper Tankerhoosen River, including Rickenback Brook and Barrows Brook.

Lower Tankerhoosen

The three run-of-river impoundments on the Lower Tankerhoosen River restrict fish passage within this portion of the river. Nevertheless, resident populations of brown trout, bass, and other fish species have been documented in the Lower Tankerhoosen. Although there are no diadromous fish (herring, shad) passage plans for these dams, there has been an effort in recent years to provide American eel passage at inland dams when there is a need and an opportunity.

The Lower Tankerhoosen River should be further evaluated for the presence of American eel and other resident fish populations that could potentially benefit from fish passage at these three dams. If justified, the DEP Inland Fisheries Division should request that any repairs to the dams include provisions for fish passage for resident fish populations.

6.2.5 Targeted Illicit Discharge Investigations

Numerous outfalls were observed from virtually all of the land uses encountered during the stream assessments. Many appear to be associated with sources having low potential for water quality impacts (i.e., residential foundation drains), while others were of unknown origin and should be the focus of future investigation. Priority outfalls that were identified for follow-up illicit discharge investigations are depicted on the subwatershed maps in Appendix C and summarized in Table 6-2.

Methods for identifying illicit discharges can vary widely in the level of effort and cost required for implementation. The following field-based methods are typically used to identify illicit discharges:

- *Testing of Dry Weather Discharges:* Flows from stormwater outfalls during dry weather may indicate an illicit discharge. A combination of visual inspection and chemical analysis of dry weather discharges can aid in identifying potential discharge sources.
- *Visual Inspection:* Examination of piping connections by either physical examination or closed-circuit camera can be used to identify possible illicit connections.
- *Review of Piping Schematics:* Examination of architectural plans and plumbing details can reveal potential sites of improper connections.
- *Smoke Testing:* Injection of a non-toxic vapor (smoke) into the facility plumbing system and following its path of travel can be used to locate connections.
- *Dye Testing:* In this method, appropriate colored dyes are added into the drain water of suspect piping. Appearance of the dyed water in the storm drainage system indicates an illicit discharge. As mentioned in the discussion of septic system discharges, testing for optical brighteners can provide an indication of the presence of domestic wastewater flows.
- *Infrared, Aerial, and Thermal Photography:* Use of aerial, infrared, and thermal photography to locate patterns of stream temperature, land surface moisture, and vegetative growth are emerging techniques to identify potential illicit discharges to stormwater systems.

Other sources of information on performing illicit discharge investigations include:

- New England Interstate Water Pollution Control Commission: http://www.neiwpcc.org/neiwpcc_docs/iddmanual.pdf
- Center for Watershed Protection: http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/idde.htm

The watershed towns are required to develop illicit discharge detection and elimination programs under the NPDES Stormwater Phase II program. The Towns should perform follow-up investigations of the potential illicit discharges that were identified in this watershed study as part of their ongoing municipal stormwater permit program.

6.2.6 Additional Subwatershed Field Assessments

Due to limited project funding, not all stream segments in the priority subwatersheds were assessed, and other subwatersheds were not assessed as they were determined to be less vulnerable to future development impacts. The remaining subwatersheds and stream reaches (Table 6-3) should be assessed over the next two years, pending the availability of funding, to identify additional site-specific issues and potential watershed restoration opportunities.

Table 6-3. Additional Subwatersheds and Stream Reaches to be Assessed

Subwatershed	Stream Reach	Proposed Schedule
Lower Tankerhoosen River	All except LTR-03	Summer/Fall 2009
Middle Tankerhoosen River	MTR-03, MTR-04, MTR-05, MTR-06, MTR-10, MTR-11, MTR-12	Summer/Fall 2009
Gages Brook South Tributary	GBST-06, GBST-07, GBST-08	Summer/Fall 2009
Tucker Brook	TB-05, TB-06, TB-07, TB-08, TB-09, TB-10, TB-11, TB-12	Summer/Fall 2009
Railroad Brook	All reaches	Summer/Fall 2010
Bolton Notch Pond	All reaches	Summer/Fall 2010
Upper Tankerhoosen River	All reaches	Summer/Fall 2010

6.3 Site-Specific Recommendations

Site-specific recommendations are tailored to address issues at selected sites that were identified during the watershed field inventories. These recommendations also provide examples of the types of projects that could be implemented at similar sites throughout the watershed. Site-specific recommendations can have both short- and long-term benefits.

6.3.1 Stormwater Retrofit Opportunities

Stormwater retrofits are structural practices installed in upland areas to capture and treat stormwater runoff before it is delivered to the storm drainage system, and ultimately, the Tankerhoosen River or its tributaries. A total of 10 retrofit sites were identified based on the field inventories and review of previous studies and reports. The majority of the stormwater retrofit opportunities are on publicly-owned land. This list is not intended to be all-inclusive, as only several representative subwatersheds and target areas were included in the field inventories. Rather, the retrofit sites identified in this section should be considered representative of the types of retrofit opportunities that exist throughout the watershed.

The stormwater retrofit options identified in this section generally focus on Low Impact Development techniques such as bioretention practices, porous pavement, water quality swales, stormwater basins, and constructed wetlands. They also include traditional practices such as sediment forebays and deep sump catch basins. Conceptual designs and typical details for the proposed retrofit concepts are provided in Appendix D. While the retrofit concepts presented in this section require additional site-specific evaluation to verify their ultimate feasibility, they illustrate how stormwater retrofits can be applied at these and similar sites throughout the watershed and provide the basis for future implementation projects.

Northeast School

- The paved driveway and parking area at the Northeast School provides an opportunity for a highly visible parking lot retrofit. Retrofits at schools provide an ideal learning opportunity for children and the community. Similar retrofits could be implemented at other schools throughout the watershed.
- *Bioretention on existing traffic island and parking lot median.* These retrofits could be implemented in the Northeast School parking lot by excavating a depression in the existing landscaped areas and planting with plants that tolerate wet conditions. Existing curbing separating the parking area from the traffic islands could also be removed and replaced with curb stops, allowing stormwater to flow into the bioretention areas while protecting the areas from vehicular traffic. Adjacent paved walkways could be replaced with porous pavers for additional infiltration. Existing driveway catch basins could be replaced with outlet structures for the bioretention areas. If soils are not suitable for stormwater infiltration, an underdrain could be installed below the bioretention areas, which would then serve as stormwater filtration devices primarily to treat the water quality volume.
- *Install a new stormwater basin*. As an alternative to the bioretention concept, a new stormwater basin could be located near the corner of Route 30 and the school driveway adjacent to the athletic field to treat runoff from the driveway and parking lot. A new outlet structure could connect to the existing storm drainage system.

Mount Vernon Apartments

- *Install a new stormwater basin in the lawn area along the apartment complex driveway*. The new basin would receive stormwater from the apartment complex's existing drainage system via a diversion manhole that could be constructed to divert low to moderate flows into the stormwater basin for treatment, but high flows would bypass the basin. Existing catch basins could also be replaced with deep sump, hooded catch basins to remove coarse sediment and floatable material.

Fire Station (Route 30)

- *Replace the existing stormwater leakoff with a constructed stormwater basin and swale.* A small constructed stormwater basin and vegetated swale is recommended to treat runoff from the fire station parking lot. The basin would be located along the south side of the parking lot/access road. Removal of a portion of the paved area may be necessary to allow room for the basin. The basin would discharge to the existing natural wetland via a short vegetated swale. The swale would be located on the outlet side of the wetland. Other types of stormwater treatment measures may not be feasible for this location since groundwater is likely to be shallow due to its close proximity to natural wetlands.

Vernon Historical Society (Route 30)

- *Construct a new vegetated swale and pocket wetland*. A new vegetated swale could be constructed along the south side of the parking lot. This swale would convey runoff to the west along the edge of the parking lot. On the southwestern corner of the property's upland area, a pocket wetland could be constructed adjacent to Myrtle's Garden, an existing landscaped area. The pocket wetland would provide partial treatment of stormwater flows and could be used as a demonstration project. The pocket wetland would discharge to existing natural wetlands via a short vegetated swale.
- The retrofits for the Vernon Historical Society and Fire Station sites are examples of the types of retrofits that could be applied at other municipal parking lots throughout the watershed.

ConnDOT Commuter Lot (Route 6/44 and I-384 Interchange)

- *Construct a new vegetated swale and stormwater basin along the east side of the commuter lot*. The commuter lot located at the I-384 and Route6/44 interchange near Bolton Notch Pond is elevated significantly, providing a low area on the south and east sides of the lot. This topography creates two areas that offer potential opportunities for stormwater basins. The low area on the east side of the lot is a more feasible location for a new stormwater basin since buried utilities may be present to the south, and existing surface drainage from the commuter lot enters the low area south of the lot. Surface drainage from the parking lot would be conveyed and treated by creating a new water quality swale. The swale would convey runoff to a new sediment forebay and stormwater basin, which would discharge to an existing ditch and culvert.

ConnDOT Commuter Lot (I-84, Exit 67)

- *Install a long, narrow stormwater basin along the east side of the commuter lot to capture and treat flows from the parking area*. An existing catch basin inlet can be eliminated and a short swale provided to convey flow into the basin. The basin would then convey flows north to maximize retention time since the majority of runoff would enter the wetland at its southern end. Curbing along the adjacent edge of the parking lot could be eliminated and replaced with curb stops, and the area between the basin and the parking lot replaced with a vegetated filter strip if overland flow to the wetland could be facilitated at other low points.
- Similar stormwater retrofits could potentially be implemented at other state, municipal, and commercial parking lots throughout the watershed.

Gerber Technologies Office Building

- *Retrofit an existing stormwater basin with a riprap berm to form a sediment forebay*. The existing stormwater basin that receives runoff from the Gerber Technologies facility incorporates many of the recommended elements to meet current stormwater quantity and quality design criteria. However, the basin is also in need of maintenance as demonstrated by the sediment accumulation near the center of the basin and the overgrown woody vegetation at the overflow spillway. Existing stormwater basins such as this one may also be good retrofit candidate to improve treatment effectiveness by incorporating a sediment forebay at the basin inlet, which may also facilitate routine sediment removal. A sediment forebay would restrict coarse pollutants to a smaller area in the basin, improving treatment of the stormwater that the basin currently receives and facilitating easier maintenance.
- *Maintain the existing riprap outfall, or replace if necessary*. The existing riprap channel leading from this basin to Gages Brook is becoming blocked with shrubs and trees which may restrict its function during a large precipitation event. Additionally, water was observed flowing through the channel rather than over it. The trees and vegetation should be cleared from this channel and the stumps removed. The existing riprap should then be removed, and either replaced with properly bedded riprap, perhaps of a smaller average diameter stone if appropriate, or replaced with a grass swale to facilitate mowing if discharge velocities allow.

Lake Street School

- *Convert existing island in turn-around in front of school into demonstration bioretention/rain garden*. The traffic island in front of the school is a potentially ideal candidate for conversion to a stormwater bioretention area to treat runoff from the school parking lot. The existing island receives surface runoff from the paved turnaround and parking lot areas, but conveys the runoff via a paved low-flow channel through the island to a downgradient headwall and piped drainage system. The island could be converted to a planted bioretention area, incorporating either an exfiltration design if soils allow or an underdrain discharge to the existing storm drainage system for stormwater filtration. The existing walkway and culvert could be replaced with a small pedestrian bridge to. The existing headwall and culvert could be replaced with an outlet structure to convey higher flows.
- This potential retrofit is an excellent opportunity for a bioretention demonstration project.

Tankerhoosen Lake and Tankerhoosen River Road Crossings

- *Construct sediment forebay at inlet of Tankerhoosen Lake and associated treatment retrofits at selected road crossings.* In a 2004 watershed study of Tankerhoosen Lake, Baystate Environmental Consultants recommended the creation of a sediment trap/forebay at the inlet of Tankerhoosen Lake, installation of deep sump catch basins at key locations, maintenance of cross-culverts and drainage structures, and grass swales and vegetated filter strips. None of the BEC recommendations has been implemented to date.

6.3.2 Riparian Buffer Restoration Opportunities

A mature riparian buffer (Source: Delaware Riverkeeper Network).

Riparian buffers are naturally vegetated areas adjacent to waterways, including streams, ponds, and wetlands. This natural vegetation protects the land adjoining a waterway by preserving the floodplain, keeping native soils intact, and maintaining the streamside land and streambanks. Vegetative buffers help encourage infiltration of rainfall and runoff, and provide absorption for high stream flows, which helps reduce flooding and drought. The vegetative community of riparian buffers provides habitat for many species of plants and animals, many of them dependent on riparian habitat features for survival and many of them threatened or endangered species. The buffer area provides a living cushion between upland land use and water, protecting water quality, the hydrologic regime of the waterway and stream structure. The naturally vegetated buffer filters out pollutants, captures sediment, regulates stream water temperature and processes many contaminants through vegetative uptake. Riparian buffers should be kept intact or restored wherever possible (Delaware Riverkeeper Network, undated).

Stream buffer encroachments are prevalent throughout the Tankerhoosen River watershed along stream corridors in or near areas of residential and commercial development. Residential lawns and some commercial lawns extend down to the banks of the stream in many areas, particularly in residential back yards. Yard waste such as grass clippings, leaves, and brush and waste materials were also common occurrences in and near these areas where easy access exists to the streams. Historical mill development along the banks of the Tankerhoosen and its tributaries has also resulted in the loss of riparian forest cover and encroachment of the built environment upon the river.

Table 6-4 lists stream reaches with impacted riparian buffers and potential buffer restoration candidates that were identified during the watershed field inventories (see maps in Appendix C). In general, riparian buffers are more effective along smaller, headwater streams. Potential riparian buffer restoration approaches for these areas include:

- Installation of new riparian buffers,
- Widening existing riparian buffers,
- Invasive species removal/management,
- Tree planting/reforestation.

The feasibility of riparian buffer restoration at these sites should be further evaluated based on consideration of site-specific factors including site access, available land area, land ownership, soil conditions, appropriate buffer width, and native plant species.

Table 6-4. Priority Riparian Buffer Restoration Sites

Watershed	Stream Reach	ID	Location
Gages Brook	GB-03B	IB-01	Along Gerber Drive
	GB-06	IB-01	At footbridge south of Valley View Drive
	GB-07	IB-01	100 feet downstream of Andrew Way
	GB-08	IB-01	50 feet upstream of Andrew Way
	GB-10	IB-01	Begins at house on downstream end of reach to 1,500 feet upstream
Gages Brook South Tributary	GBST-04B	IB-01	Rear of house along Leohr Road
Lower Tankerhoosen River	--	Not Assessed	400-ft length of Tankerhoosen River adjacent to Talcottville Mill
Tucker Brook	TB-01	IB-01	At confluent with Lower Tankerhoosen River
	TB-03	IB-01	50 feet downstream of IB-02
	TB-03	IB-02	400 feet downstream of IB-03
	TB-03	IB-03	250 feet northwest of Vernon Street
	TB-04C	IB-01	Behind houses at end of Yale Drive
	TB-04C	IB-02	Behind houses along Chatham Drive

Talcottville Mill Riparian Damage

In the fall of 2008, extensive removal of trees and vegetated buffer occurred along an approximately 400-foot segment of the Lower Tankerhoosen River. The vegetation removal, and subsequent installation of stone bank stabilization along both sides of the Tankerhoosen River, was associated with redevelopment activities at the Talcottville Mill property. The work was performed without prior approval from the Town of Vernon, the DEP, or the U.S. Army Corps of Engineers. The Town continues to coordinate with the state and federal resource agencies to determine an appropriate course of action to repair the riparian damage.

Corrective actions to restore the lost streambank vegetation and riparian habitat should balance the goal of full restoration with potential disturbance and further water quality impacts associated with complete removal of the existing stone. A dual approach that utilizes the existing stone bank stabilization and introduces new vegetative plantings may be prudent. The feasibility of such an approach should be further evaluated. Subsequent site redevelopment should also incorporate riparian buffer restoration measures (trees and vegetative plantings) into the master plan for the site.

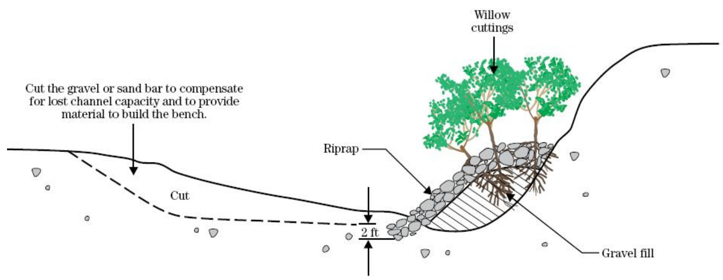
6.3.3 Stream Restoration Opportunities

Relatively isolated areas of moderate to severe streambank erosion were observed throughout the assessed portions of the watershed. Most of these areas are located at or downstream of stormwater outfalls in developed areas of the watershed. Table 6-5 lists stream reaches with

Streambank erosion along Gages Brook.

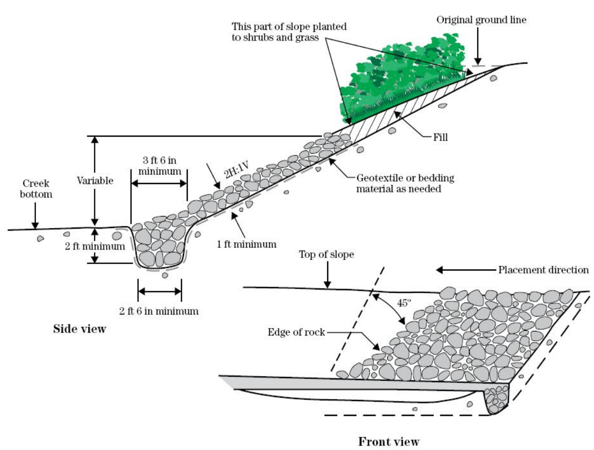
moderate to severe bank erosion that were identified during the watershed field inventories (see maps in Appendix C). These reaches are potential streambank restoration candidates. Streambank restoration requires use of a system of treatment techniques that work together to stabilize slopes, reduce erosion, and improve aquatic habitat. Although every site is different and requires detailed design of restoration components that work together, typical restoration techniques include:

- *Slope Stabilization Techniques.* Of primary concern is preventing an unstable slope from additional failure. It is likely that the slope of an eroded bank is close to the limit of its stability, such that additional loading or saturation of the soil could cause a slide. The slope must first be stabilized before techniques to prevent additional erosion can be implemented. If adequate room is available surrounding the stream, it may be possible to flatten the slope to ensure stability. If site constraints prevent flattening the slope, such as a road, structure, or utilities lying just inland from the bank, it may be necessary to provide structural support for the slope, or buttress the slope while providing adequate flow capacity by widening the channel by a corresponding amount along the inside of the bend. In combination with earthwork, slope stabilization should also include a combination of plantings and toe protection techniques to prevent future destabilization.



Typical slope stabilization where flattering the slope is not allowable (Source: NEH-654).

- *Toe Protection Techniques.* The toe of the streambank, or the portion of the bank where the slope transitions into the relatively flat stream channel bottom, is subject to constant erosive forces of flowing water, especially along the outside bank of bends. Protecting the toe is critical to ensure that upper portions of the bank are not further undermined. A variety of techniques have developed for toe protection, including constructing cribs made from logs, gabions (baskets filled with stone), woody debris anchored in place, and placed or dumped riprap protection. Bioengineering



Typical toe protection for erosion and scour resistance (Source: NEH-654).

techniques are usually not adequate on this part of the slope since the selected treatment technique must be designed to resist the shear stress and energy of the flowing water during high flow conditions, continue deep enough below the stream bottom to resist scour, and not be susceptible to ice damage.

- *Bioengineering Techniques.* Although hard armoring and engineered slope stability systems can be used effectively to restore an area of degraded bank, these techniques often lack habitat and riparian ecological value that natural conditions provide. In addition, engineered techniques are not "self-healing," in that, when damaged, they may fail and allow the degradation of the bank to resume. Bioengineering techniques can be used to avoid these consequences. Streambank bioengineering includes the use of living plant material to supplement or replace engineered systems. Typically, grasses, forbes, shrubs, and trees are used to hold soil in place, resist erosion of high flow events, provide habitat value, and grow into a natural system that could work in place of engineered systems when those systems eventually fail. Native shrub and tree species that root well from cuttings, such as willow and dogwood, can be planted along the bank, projecting into the stream, or through a riprap layer using a variety of techniques to meet site needs. Native grasses and forbes can be planted in areas subject to ice damage or where trees and shrubs are not preferred.

Bioengineering techniques used for slope stabilization and redirection (Source: NEH-654).

- *Grade Control Techniques.* Downcutting of a stream can present a significant problem since it may disconnect a stream from its wetland. Treatment techniques are available that create artificial hard points along a downcutting reach. These points set the bottom elevation of the stream channel, limiting its downward movement along the treated reach.

- *Riparian Buffer Improvement.* An important step in preventing degradation of the river corridor is to improve the width and quality of the existing riparian buffer, or providing a buffer where encroachment has removed it. The riparian buffer provides an important protection and ecological system that supports and complements the riverine system.

Access to many of the potential streambank restoration sites is limited; therefore, potential candidate sites for bank stabilization projects should be evaluated further for overall feasibility including land ownership, erosion severity, upstream and downstream conditions, infrastructure constraints, and construction access to the stream.

Table 6-5. Priority Stream Restoration Sites

Watershed	Stream Reach	ID	Location
Gages Brook	GB-01	ER-01	250 feet upstream of confluence with Gages South Tributary
	GB-01	ER-02	250 feet upstream of confluence with Gages South Tributary
	GB-03A	ER-01	Along entire reach
	GB-05B	ER-01	Downstream side of Old Post Road
	GB-06	ER-01	450 ft upstream of Old Post Road
	GB-06	ER-02	900 ft upstream of Old Post Road
	GB-06	ER-03	1,100 ft upstream of Old Post Road
	GB-06	ER-04	1,200 ft upstream of Old Post Road
Gages Brook South Tributary	GBST-09B	ER-01	700 ft downstream of Tolland Farms Road
Middle Tankerhoosen River	MTR-09	ER-01	Adjacent to Warren Avenue
Tucker Brook	TB-01	ER-01	100 ft upstream of confluence with Lower Tankerhoosen River
	TB-03	ER-01	400 ft downstream of Phoenix Street, adjacent to utility Right-of-Way
Clarks Brook	CB-02	ER-01	Adjacent to baseball field on Bolton Road
	CB-03	ER-01	Rear of Industrial Park Road building complex

6.3.4 Dams and Impoundments

In addition to the recommended fish passage barrier assessments along the upper and lower portions of the Tankerhoosen River (see Section 6.2.4), additional site-specific actions are recommended for several of the dams and impoundments in the watershed.

Walker Reservoir Dam

An engineering evaluation of Walker Reservoir Dam was performed in 1998 by Karl Acimovic, P.E. on behalf of the Vernon Parks and Recreation Department. The dam was determined to be in poor to fair overall condition, requiring significant modifications and improvements to prevent overtopping of the embankment adjacent to the spillway and subsequent erosion of the crest of the dam. The dam should be re-evaluated to verify what modifications, if any, were implemented in response to the 1998 study findings and to assess current conditions.

Walker Reservoir feeds the headwaters of the Tankerhoosen River and is believed to function as "sink" for pollutants carried from upstream areas including Gages Brook. Walker Reservoir is suspected to play a key role in protecting the high quality of the upper portions of the Tankerhoosen River, in addition to the spring water inputs that also feed the upper reaches of the Tankerhoosen. The relationship between the water quality of Walker Reservoir and the Tankerhoosen River is unclear given the limited available monitoring data. Additional study of the water quality of Walker Reservoir and its potential impact on the Tankerhoosen River is recommended in order to understand this relationship and develop management recommendations for Walker Reservoir that are also protective of the Tankerhoosen River.

Valley Falls Pond Dam

An engineering evaluation of Valley Falls Pond Dam was performed in 1997 by Karl Acimovic, P.E. on behalf of the Vernon Parks and Recreation Department. The dam was also determined to be in poor to fair condition due to the poor structural condition of the downstream earth embankment, seepage from the downstream toe of embankment, and poor condition of the secondary spillway and inadequate spillway capacity. A number of recommendations were made including tree removal, increasing the spillway capacity, a new intake/outlet structure, embankment reconstruction and toe drain installation, and reconstruction of the primary spillway. The dam should be re-evaluated to verify what modifications, if any, were implemented in response to the 1997 study findings and to assess current conditions.

Belding Pond Dam

The Natural Resources Conservation Service (NRCS) is evaluating the feasibility of removing the Belding Pond Dam, which is located along the Tankerhoosen River upstream of the Belding Wildlife Management Area. As described previously, removal of the dam could potentially provide for additional passage of resident fish populations upstream to Walker Reservoir and tributaries of the Upper Tankerhoosen River, including Rickenback Brook and Barrows Brook. The feasibility evaluation should consider a range of factors including potential impacts of removal on stream geomorphology, habitat, recreation, economics, and management of legacy sediment accumulated behind the dam.

6.3.5 Aquatic Invasive Species Study

In 2008, the Vernon Conservation Commission verified the presence of the aquatic invasive species, variable leaf milfoil, in Valley Falls Pond, which is located along Railroad Brook before the confluence with the Tankerhoosen River in the Belding WMA. Variable leaf milfoil is one of the two most common invasive milfoil species found in Connecticut, the other being Eurasian milfoil.

Variable leaf milfoil is native to the southern U.S. It first arrived in Connecticut in 1936, and has become a nuisance in many Connecticut lakes, especially in the southeast part of the state. Like Eurasian milfoil, variable leaf milfoil produces long stems that rise to the water's surface, where they spread, producing dense mats of vegetation. Control of this species can be difficult. According to "Nuisance Aquatic Vegetation Management," a guidebook published by DEP (undated), milfoil should generally not be cut to control it, since each piece can grow into another plant. The guidebook states that the most effective chemical controls are systemic herbicides applied at low dosages, which would require a DEP permit. A physical removal method, referred to as "suction harvesting", is being used to remove variable leaf milfoil from Crystal Lake in Ellington and Stafford Springs, Connecticut.

Fanwort, another aquatic invasive plant species that can form large colonies in quiet water bodies, was recently noted in Walker Reservoir by Aquatics Research. Fanwort can grow aggressively and clog drainage canals, ponds, lakes, reservoirs, and slow-moving freshwater streams. It represents a threat to Walker Reservoir and other water bodies throughout the watershed.

An aquatic plant survey and feasibility study is recommended to evaluate the extent and distribution of variable leaf milfoil in Valley Falls Pond, evaluate a range of potential control alternatives, and to identify a preferred control strategy, including costs and potential funding sources. An aquatic plant study of Walker Reservoir is also recommended, including a plant survey for fanwort and other aquatic plants that could threaten the health of the reservoir and other water bodies in the watershed.

More information on aquatic invasive plants is available from:

- Connecticut Invasive Plants council is available at: http://nbii-nin.ciesin.columbia.edu/ipane/ctcouncil/CT_invasive.htm.
- Connecticut Agricultural Experiment Station at: http://www.ct.gov/caes/
- Connecticut Department of Environmental Protection at http://www.ct.gov/dep/cwp/view. asp?a=2702&q=323494&depNav_GID=1641
- The Connecticut Aquatic Nuisance Species Management Plan: http://www.ctiwr.uconn.edu/ProjANS/SubmittedMaterial2005/Material200601/ANS%20Plan%20Final%20Draft121905.pdf.
- The National Invasive Species Information Center: http://www.invasivespeciesinfo.gov/aquatics/watermilfoil.shtml.

6.3.6 Priority Stream Cleanups

The watershed field inventories identified isolated areas of trash and debris dumping along most of the assessed streams. Stream clean-ups and trash removal are often cosmetic and temporary. However, they are an effective tool for involving and educating the public about stream degradation. In addition, some trash and debris accumulation may present risks to infrastructure and increased flooding, such as when outfalls and culverts become clogged with trash.

Table 6-6 lists stream reaches where significant trash and debris were observed (see maps in Appendix C). These sites are recommended candidates for targeted stream cleanups.

Table 6-6. Priority Stream Cleanup Sites

Watershed	Stream Reach	ID	Location	Material
Gages Brook	GB-01	TR-01	Near bridge downstream of detention pond	Sticks, brush wood fencing
	GB-02	TR-01	300 ft upstream of detention pond, adjacent to agricultural field	Tires and automotive debris
	GB-08	TR-01	350 ft downstream of Mountain Springs Road	Tire, bathtub, and two 55-gal drums
Middle Tankerhoosen River	MTR-01	TR-01	650 ft upstream of TR-02	55-gal drum (unknown material, may be toxic)
	MTR-01	TR-02	North of residence on Frederick Road	Debris piled from removal of beaver dam
	MTR-01	TR-03	South of residence on Susan Road	Approx. 16 closed 5-gal buckets
	MTR-09	TR-01	Rear of residences on Tunnel View Terrace	Yard waste and tennis balls
	MTR-09	TR-02	Rear of residences on Tunnel View Terrace	Yard waste (small amount)
	MTR-09	TR-03	Rear of residences on Warren Avenue	Yard waste (small amount)
	MTR-09	TR-04	400 ft downstream of Tunnel Road	Leaves, logs, tires stumps
Tucker Brook	TB-04B	TR-01	End of Yale Drive, outfall from detention pond	Grass and brush clippings
	TB-04C	TR-01	Behind houses along Chatham Drive	Yard waste
	TB-04C	TR-02	Behind houses along Chatham Drive	Pieces of tree approx 1 ft diameter; 2-10ft long
Clarks Brook	CB-02	TR-01	50 ft upstream of Industrial Park Road stream crossing	6 tires; automotive waste; appliance; 55-gallon drum
	CB-03	TR-01	Rear of Industrial Park Road building complex	Automotive waste

6.4 Estimated Costs and Load Reductions

6.4.1 Estimated Costs

Planning level costs were estimated for the targeted and site-specific recommendations in this plan, where sufficiently detailed information was available. The cost estimates assist watershed stakeholders to evaluate the financial resources and funding sources that may be required to implement the plan.

Table 6-7 summarizes typical ranges of planning level unit costs for the targeted recommendations, and some of the site-specific recommendations, that are identified in this plan. Additional information is required to develop more detailed cost estimates for these recommendations.

Table 6-7. Typical Unit Costs for Management Plan Recommendations

Recommendation	Planning Level Cost ($)	Source
Invasive Species Management Plan	$15,000 to 30,000	Professional engineering experience
Targeted Stormwater Outfall Retrofits (design and construction; 2009 $ per cubic ft of runoff treated) Bioretention Stormwater Ponds/Basins Water Quality Swales	 $10.00 to 25.00 $4.00 to 13.00 $11.00 to 31.00	Center for Watershed Protection, Urban Stormwater Retrofit Practices (2007)
Watershed Fish Passage Assessment Upper Tankerhoosen Lower Tankerhoosen	 $10,000 to 15,000 $5,000 to 10,000	
Illicit Discharge Investigation	Costs vary significantly depending on investigation methods and findings	Center for Watershed Protection, IDDE Manual (2004), NEIWPCC IDDE Manual (2003)
Additional Subwatershed Field Assessments	$10,000 to 15,000 (varies depending on the use of volunteers)	Center for Watershed Protection, Unified Stream Assessment (2005)
Riparian Buffer Restoration ($ per acre) Grass/herbaceous buffer Tree and shrub planting	 $450 to 850 $2,000 to 3,000	NRCS, Coginchaug River Watershed Based Plan (2008)
Streambank Restoration (good access, $ per 100 linear feet)) Bank stabilization Channel rehabilitation	 $1,300 to 9,600 $1,100 to 3,700	NOAA Stream Restoration Cost Estimates (2000)
Evaluation of Dams & Impoundments Walker Reservoir Dam Evaluation Walker Reservoir Water Quality Study Valley Falls Pond Dam Evaluation Belding Pond Dam Removal Feasibility Evaluation	 $5,000 to 10,000 $20,000 to 30,000 $5,000 to 10,000 $30,000 to 40,000	Professional engineering experience
Aquatic Invasive Species Study and Invasives Control (Valley Falls Pond and Walker Reservoir)	Cost varies depending on removal method (mechanical harvesting, herbicide application, etc.)	
Stream Cleanups	Highly dependent on the amount of donated supplies and services	

More detailed planning level costs were estimated for the site-specific stormwater retrofits described in Section 6.3.1. These estimates are based upon unit costs derived from published sources and the conceptual designs presented in Appendix D of this plan. Capital (construction, design, permitting, and contingency) and operation and maintenance costs were included in the estimates, and a total annualized cost is presented in 2009 dollars based on the anticipated design life of each retrofit. Table 6-8 summarizes planning level cost estimates for the site-specific stormwater retrofits. A more detailed cost estimate table is included in Appendix E.

Table 6-8. Planning Level Cost Estimates for Site-Specific Stormwater Retrofits

Recommendation	Construction Cost (2009)	Design, Permitting, Contingency		Total Cost	Lifespan (yrs)	Annual Cost Over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
		% Construction	Cost						
Tankerhoosen Lake									
Sediment Forebay	$93,700	32%	$30,000	$123,700	30	$6,310	6%	$380	$6,690
Deep Sump CBs, piping, and swale	$24,300	32%	$7,800	$32,100	50	$1,250	15%	$190	$1,440
Northeast School									
Bioretention Area 1	$42,100	32%	$13,500	$55,600	15	$4,660	8%	$370	$5,030
Bioretention Area 2	$31,100	32%	$10,000	$41,100	15	$3,440	8%	$280	$3,720
SW Basin	$18,100	32%	$5,800	$23,900	30	$1,220	6%	$70	$1,290
Mount Vernon Apartments									
SW Basin	$42,600	32%	$13,600	$56,200	30	$2,870	6%	$170	$3,040
Deep Sump CBs	$18,800	32%	$6,000	$24,800	50	$960	20%	$190	$1,150
Fire Station (Route 30)									
SW Basin	$21,600	32%	$6,900	$28,500	30	$1,450	6%	$90	$1,540
Vegetated Swale	$900	32%	$300	$1,200	10	$140	7%	$10	$150
Vernon Historical Society (Route 30)									
Pocket Wetland	$5,500	32%	$1,800	$7,300	10	$860	6%	$50	$910
Vegetated swale	$9,600	32%	$3,100	$12,700	10	$1,490	6%	$90	$1,580
ConnDOT Commuter Lot (Route 6/44 and I-384 Interchange)									
Vegetated swale	$7,700	32%	$2,500	$10,200	29	$530	7%	$40	$570
SW Basin	$51,700	32%	$16,500	$68,200	30	$3,480	6%	$210	3,690
ConnDOT Commuter Lot (I-84, Exit 67)									
SW Basin	$38,500	32%	$12,300	$50,800	30	$2,590	6%	$160	$2,750
Vegetated Swale	$1,500	32%	$500	$2,000	10	$230	7%	$20	$250
Gerber Technologies Office Building									
Sediment Forebay	$2,000	32%	$600	$2,600	30	$130	30%	$40	$170
Discharge Channel	$9,000	32%	$2,900	$11,900	30	$610	10%	$60	$670
Lake Street School									
Bioretention	$71,300	32%	$22,800	$94,100	15	$7,880	8%	$630	$8,510

6.4.2 Load Reductions

Pollutant load reductions were estimated for the following watershed management plan recommendations using the STEPL pollutant loading model described in the *Baseline Watershed Assessment* report (Fuss & O Neill, May 28, 2008):

1. Implementation of LID treatment practices (bioretention, filter or buffer strips adjacent to impervious areas, and infiltration swales to treat runoff from impervious surfaces) for all future development and redevelopment activity in the watershed, assuming adoption of a local LID stormwater regulatory mechanism and design standards by the Town of Vernon and the other watershed towns that currently do not have such requirements,

2. Implementation of stormwater retrofits in existing developed areas (commercial, industrial, institutional and roadway land uses) to treat runoff from a percentage of each subwatershed, which would be dictated by subwatershed feasibility factors and site-specific conditions.

Pollutant load reductions for total suspended solids (TSS), phosphorus (P), nitrogen (N), and biochemical oxygen demand (BOD) for the above scenarios were estimated for 1) existing conditions, 2) future buildout of the watershed without the proposed controls, and 3) future buildout with the proposed controls.

Table 6-9 summarizes anticipated sediment loads and anticipated load reductions resulting from the implementation of LID treatment practices for all future development and redevelopment projects in the watershed. Sediment load reductions resulting from the use of LID practices varies by subwatershed, but is generally between 4 and 10 percent. The anticipated load reductions for nutrients and BOD are of a similar magnitude (Table 6-10).

Table 6-9. Anticipated Effectiveness of LID in Reducing Sediment Loads

Subwatershed	Existing Conditions (tons/yr)	Future Buildout Without LID Controls (tons/yr)	Future Buildout With LID Controls (tons/yr)	Load Reduction Due to LID Controls (%)
Bolton Notch Pond	48.8	53.3	51.4	3.5%
Clarks Brook	88.2	100.4	92.1	8.1%
Gages Brook	92.3	112.8	102.6	9.0%
Gages Brook South Trib.	82.7	93.3	88.7	4.8%
Lower Tankerhoosen River	45.0	52.9	47.9	8.9%
Middle Tankerhoosen River	199.0	220.2	203.5	7.3%
Railroad Brook	32.0	52.7	37.5	28.2%
Tucker Brook	86.1	98.4	89.0	9.1%
Upper Tankerhoosen River	73.2	80.2	76.7	4.2%
Walker Reservoir	52.6	65.6	58.0	11.1%

Table 6-10. Anticipated Effectiveness of LID in Reducing Nutrient and BOD Loads

Subwatershed	Future Buildout With LID Controls (tons/yr)			Load Reduction Due to LID Controls (%)		
	N	P	BOD	N	P	BOD
Bolton Notch Pond	1.1	0.18	4.1	2.0%	2.7%	2.1%
Clarks Brook	2.1	0.30	8.1	4.6%	6.4%	5.1%
Gages Brook	2.5	0.38	10.0	4.8%	7.4%	4.9%
Gages Brook South Tributary	2.0	0.31	7.5	2.7%	3.9%	2.9%
Lower Tankerhoosen River	1.1	0.16	4.0	5.8%	5.9%	7.2%
Middle Tankerhoosen River	4.7	0.66	18.0	4.4%	5.8%	5.2%
Railroad Brook	1.1	0.12	4.9	16.2%	20.5%	16.8%
Tucker Brook	2.2	0.28	8.8	5.6%	6.2%	6.4%
Upper Tankerhoosen River	1.8	0.26	7.1	2.6%	4.3%	2.9%
Walker Reservoir	1.3	0.20	4.8	6.5%	9.5%	7.8%

Note that sediment loads (Table 6-9) under the future buildout scenario, even with the implementation of LID controls alone, are slightly higher than existing sediment loads in all of the subwatersheds. This result suggests that other source controls/pollution prevention, stormwater retrofits, and watershed restoration practices are necessary to maintain existing pollutant loads or to achieve net reductions in pollutant loads under a future buildout scenario.

The pollutant loading model was then used to estimate the effectiveness of implementing stormwater retrofits in existing developed areas (commercial, industrial, institutional and roadway land uses) to treat runoff from a portion of each subwatershed. Ideally, the entire area watershed could be retrofitted to achieve maximum pollutant load reductions. In practice, stormwater retrofits can be difficult to implement in an urbanized watershed due to a variety of physical constraints and other factors. Therefore, stormwater retrofits are typically limited to treating runoff from some percentage of the total developed area in a subwatershed.

The pollutant loading model was then used to estimate the anticipated pollutant load reductions, compared to existing conditions, for stormwater retrofits applied to between 5 and 30 percent of the developed area (commercial, industrial, institutional and roadway land uses) in each subwatershed. Table 6-11 summarizes the results of this evaluation for sediment, which indicate that even modest applications of watershed-wide stormwater retrofits (20 to 30 percent of the area retrofitted), can result in significant pollutant load reductions (10 to 20 percent sediment load reductions).

Table 6-11. Anticipated Effectiveness of Stormwater Retrofits as a Function of Watershed Treatment Area

Subwatershed	Sediment Load (tons/yr)				
	Existing Conditions	With Retrofits (5% of Watershed Area)	With Retrofits (10% of Watershed Area)	With Retrofits (20% of Watershed Area)	With Retrofits (30% of Watershed Area)
Bolton Notch Pond	48.8	47.2	45.5	42.2	38.9
Clarks Brook	88.2	85.9	83.5	78.9	74.2
Gages Brook	92.3	89.8	87.2	82.1	77.0
Gages Brook South Trib.	82.7	80.4	78.2	73.7	69.2

Table 6-11. Anticipated Effectiveness of Stormwater Retrofits as a Function of Watershed Treatment Area

Subwatershed	Sediment Load (tons/yr)				
	Existing Conditions	With Retrofits (5% of Watershed Area)	With Retrofits (10% of Watershed Area)	With Retrofits (20% of Watershed Area)	With Retrofits (30% of Watershed Area)
Lower Tankerhoosen R.	45.0	43.5	42.0	39.1	36.2
Middle Tankerhoosen R.	199.0	193.9	188.8	178.6	168.5
Railroad Brook	32.0	31.6	31.3	30.6	29.8
Tucker Brook	86.1	84.3	82.5	78.9	75.3
Upper Tankerhoosen R.	73.2	71.7	70.2	67.1	64.1
Walker Reservoir	52.6	50.9	49.2	45.8	42.4

Finally, the potential effectiveness of 1) new LID controls for future development and redevelopment activity in the watershed and 2) stormwater retrofits at existing developed land uses were evaluated collectively to determine the minimum treatment area required for stormwater retrofits in each subwatershed to maintain existing pollutant loads under future buildout conditions. This approach provides a target stormwater retrofit treatment area (which varies by pollutant) for each subwatershed to meet the overall goal of "no net increase in watershed pollutant loads". Table 6-12 lists these minimum retrofit area targets.

Additional retrofits, source controls/pollution prevention, and other watershed restoration practices described in this plan could be implemented to achieve net reductions in future pollutant loads or to maintain existing loads if the target stormwater retrofit treatment areas are not feasible.

Table 6-12. Minimum Retrofit Area (Percent of Subwatershed) Necessary to Maintain Existing Pollutant Loads

Subwatershed	Nitrogen	Phosphorus	Sediment
Bolton Notch Pond	25%	15%	10%
Clarks Brook	35%	15%	10%
Gages Brook	50%	40%	25%
Gages Brook South Tributary	50%	25%	15%
Lower Tankerhoosen River	40%	15%	15%
Middle Tankerhoosen River	30%	15%	5%
Railroad Brook*	--	--	--
Tucker Brook	50%	15%	10%
Upper Tankerhoosen River	50%	50%	15%
Walker Reservoir	50%	35%	20%
** No commercial, industrial, institutional land use and only 17 acres of transportation land use in this subwatershed.*			

6.5 Plan Implementation

6.5.1 Schedule and Milestones

Table 6-13 is a proposed implementation schedule, including actions/milestones, anticipated timeline, products, and evaluation criteria. This table should be revised as necessary to reflect future changes to the watershed plan and implementation activities.

Table 6-13. Proposed Implementation Schedule

Actions	Lead Entity	Timeline	Products	Evaluation Criteria
Objective 1. Build a Foundation for Implementing the Plan				
Form coalition	Friends of HRLP	1-2 yrs	Funding sources and grant applications	Grant applications submitted
Adopt plan	Towns			
Identify potential funding sources	Coalition			
Submit grant applications	Coalition/Towns			
Objective 2. Enhance In-Stream and Riparian Habitat				
Conduct fish passage assessments	Coalition	1-2 yrs	Assessment findings	
Revise local stream crossing & stormwater design standards	Towns	1-2 yrs	Revised standards	
Belding Pond Dam removal feasibility evaluation	NRCS, DEP	1-2 yrs	Evaluation findings	
Conduct aquatic invasive species study	Coalition, Towns	1-2 yrs	Study findings	
Priority stream restoration projects	Coalition, Towns	2-10 yrs	Completed projects	Photos, # sites, WQ monitoring
Objective 3. Protect/Restore Riparian Buffers				
Priority riparian buffer restoration projects	Coalition	2-10 yrs	Completed projects	Photos, # sites, WQ monitoring
Adopt stream buffer regulations, pending enabling legislation	Towns	2-4 yrs	Adopted regulations	
Revise riparian buffer recommendations (Tolland)	Towns	1-2 yrs	Revised recommend.	
Objective 4. Identify and Eliminate Illicit Discharges				
Targeted illicit discharge investigations	Towns	1-2 yrs	Investigation findings	# discharges removed
Implement municipal IDDE programs	Towns	2-4 yrs		
Priority stream cleanup efforts	Coalition	1-2 yrs	Trash removed	# cleanups
Develop education/outreach materials	Coalition, Towns	1-2 yrs	Educational materials	Number of participants & feedback
Deliver education/outreach to the public	Coalition, Towns	2-4 yrs		
Objective 5. Residential Management Practices				
Increase watershed stewardship signage in residential areas	Towns	2-4 yrs	New signage	# signs
Encourage disconnection of rooftop runoff	Towns	2-4 yrs	Rain barrels, disconnections	# participants
Develop education/outreach materials	Coalition, Towns	1-2 yrs	Educational materials	Number of participants & feedback
Deliver education/outreach to the public	Coalition, Towns	2-4 yrs		
Objective 6. Municipal and Business Management Practices				
Review municipal facility compliance	Towns	1-2 yrs	Review findings	Improved BMPs

Table 6-13. Proposed Implementation Schedule

Actions	Lead Entity	Timeline	Products	Evaluation Criteria
Improve municipal stormwater management programs	Towns	1-4 yrs	Revised SWMPs	
Implement street sweeping and catch basin cleaning	Towns, DOT	2-4 yrs	Sweeping and CB cleaning	Frequency
Develop education/outreach materials	Coalition, Towns	1-2 yrs	Educational materials	Number of participants & feedback
Deliver education/outreach to the public	Coalition, Towns	2-4 yrs		
Increase watershed stewardship signage in commercial areas	Towns	2-4 yrs	New signage	# signs
Objective 7. Implement Water Quality Monitoring Program				
Develop and implement long-term monitoring program	Coalition	1-2 yrs	Monitoring data, report	Review results with agencies
LID demonstration monitoring	Coalition	2-4 yrs		
Objective 8. Protect Open Space				
Priority land acquisitions	Towns	1-4 yrs	Protected land	#sites/ acres protected
Continue to implement municipal open space plans	Towns	1-4 yrs		
Seek alternative funding sources for open space acquisition	Towns	1-4 yrs		
Promote use of open space through trail maps and events	Coalition	1-2 yrs	New maps and events sponsored	# events
Develop and implement invasive species management plan	Coalition	2-4 yrs	Management plan	
Objective 9. Promote LID and Sustainable Site Design				
Monitor effectiveness of LID regulations (Tolland)	Town	1-4 yrs	LID measures installed	Photos, WQ monitoring, 3rd party reviews
Revise Inland Wetland regulations for consistency (Tolland)	Town	1-2 yrs	Revised regulations	
Develop and implement new stormwater/LID regulations (Vernon)	Town	1-2 yrs	New SW/LID regulations, revised existing regulations	
Form advisory committee				
Develop Town stormwater/LID manual and/or guidance				
Update existing zoning, subdivision, wetlands regulations				
Priority stormwater retrofits	Coalition	2-10 yrs	Completed projects	Photos, # sites, WQ monitoring
Incorporate LID into Town projects	Town	2-4 yrs	LID measures installed	Photos, WQ monitoring
LID demonstration projects (green roads, public works, schools)	Town	1-2 yrs		
Develop education/outreach materials	Coalition, Towns	1-2 yrs	Educational materials	Number of participants & feedback
Deliver education/outreach to the public	Coalition, Towns	2-4 yrs		
Objective 10. Assess Additional Subwatersheds				
Perform stream and upland assessments	Coalition	1-2 yrs	Inventory findings	# projects identified

6.5.2 Funding Sources

A variety of local, state, and federal sources are potentially available to provide funding for the implementation of this watershed management plan, in addition to potential funds contributed by local grassroots organizations and concerned citizens. Table 6-14 is a list of potential funding sources that has been developed by DEP and NRCS, and further refined through this planning process. The funding entities and grant programs listed in the table is not intended to be an exhaustive list; the table can be used as a starting point to seek funding opportunities for implementation of the recommendations in this watershed plan. The information presented in this watershed management plan and the supporting study documentation will support future grant proposals by demonstrating a comprehensive, scientifically-based approach for addressing identified concerns consistent with EPA's recommended watershed-based approach. The table of potential funding sources is intended to be a living document that should be updated periodically to reflect the availability of funding or changes to the funding cycle, and to include other funding entities or grant programs.

Table 6-14. Potential Funding Sources

Funding Source	Maximum Dollar Amount	Minimum Dollar Amount	Required Match	Applications Open	Deadline
DEP Watershed Funding Website					
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1 Index of many potential funding sources for funding watershed-based planning projects.					
DEP CT Landowner Incentive Program	Up to $25,000	At least 25%			
http://www.ct.gov/dep/cwp/view.asp?a=2723&q=325734&depNav_GID=1655					
DEP Long Island Sound License Plate Program	$25,000			January	March
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635					
DEP Open Space and Watershed Land Acquisition				March	June
860-424-3016 david.stygar@ct.gov http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641					
DEP Recreation and Natural Heritage Trust Program					
http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641					
Eastman Kodak / Nat'l Geographic American Greenways Awards optional Program	$2500	$300	Optional	April	June
jwhite@conservationfund.org, Jen White					
EPA Healthy Communities Grant Program	$35,000	$5,000	Optional, up to 5%	March	May
617-918-1698 Padula.Jennifer@epa.gov					
Northeast Utilities Environmental Community Grant Program	$250	$1,000			April 15
http://www.nu.com/environmental/grant.asp Cash incentives for non-profit organizations					

Table 6-14. Potential Funding Sources

Funding Source	Maximum Dollar Amount	Minimum Dollar Amount	Required Match	Applications Open	Deadline
EPA Targeted Watershed Grants Program			25% of total project costs (non-federal)		
http://www.epa.gov/twg/ Requires Governor nomination.					
DEP CWA Section 319 NPS			40% of total project costs (non-federal)		October 15
Nonpoint Source Management http://www.ct.gov/dep/nps 20-25 projects targeting both priority watersheds and statewide issues.					
DEP Section 6217 Coastal NPS			N/A		
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323554&depNav_GID=1709 Section 6217 of the CZARA of 1990 requires the State of Connecticut to implement specific management measures to control NPS pollution in coastal waters. Management measures are economically achievable measures that reflect the best available technology for reducing nonpoint source pollution.					
DEP Hazard Mitigation Grant Program			75% Federal / 25% Local		
http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325654&depNav_GID=1654 Provides financial assistance to state and local governments for projects that reduce or eliminate the long-term risk to human life and property from the effects from natural hazards.					
American Rivers - NOAA Community-Based Restoration Program Partnership					
http://www.amrivers.org/feature/restorationgrants.htm These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.					
FishAmerica Foundation Conservation Grants	Average $7,500				
703-519-9691 x247 fishamerica@asafishing.org					
Municipal Flood & Erosion Control Board	1/3 project cost	2/3 project cost			
NFWF Long Island Sound Futures Fund Small Grants	$6,000	$1,000	Optional (non-federal)	December	March
NFWF Long Island Sound Futures Fund Large Grants	$150,000	$10,000	Optional (non-federal)	December	March
631-289-0150 Lynn Dwyer Lynn.Dwyer@nfwf.org					
NRCS Conservation Reserve Program					
Jan Dybdahl, (860) 871-4018 http://www.ct.nrcs.usda.gov					
NRCS Wildlife Habitat Incentives Program (WHIP)	$50,000/year	$1,000	25%		
Jan Dybdahl, (860) 871-4018 http://www.ct.nrcs.usda.gov For creation, enhancement, maintenance of wildlife habitat; for privately owned lands.					
NRCS Environmental Quality Incentives Program (EQIP)	$50,000/year		25-50%		
Jan Dybdahl, (860) 871-4018 http://www.ct.nrcs.usda.gov For implementation of conservation measures on agricultural lands.					
NRCS Healthy Forests Reserve Program					
For restoring and enhancing forest ecosystems http://www.nrcs.usda.gov/programs/HFRP/ProgInfo/Index.htm					
NRCS Wetlands Reserve Program					

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Table 6-14. Potential Funding Sources

Funding Source	Maximum Dollar Amount	Minimum Dollar Amount	Required Match	Applications Open	Deadline
Nels Barrett, (860) 871-4015 http://www.ct.nrcs.usda.gov For protection, restoration and enhancement of wetlands					
USFS Watershed and Clean Water Action and Forestry Innovation Grants					
http://www.na.fs.fed.us/watershed/gp_innovation.shtm This effort between USDA FS-Northeastern Area and State Foresters to implement a challenge grant program to promote watershed health through support of state and local restoration and protection efforts.					
Corporate Wetlands Restoration Partnership (CWRP)	Typically $20,000	Typically $5,000	3 to 1	April and August	
http://www.ctcwrp.org/9/ Can also apply for in-kind services, e.g. surveying, etc.					
DEP 319 NPS Watershed Assistance Small Grant			40% of total project costs (non-federal)		
860-361-9349 rivers@riversalliance.org					
Trout Unlimited Embrace A Stream	$5,000				
USFWS National Coastal Wetlands Conservation Grant Program	$1 million		50%		
Ken Burton 703-358-2229 Only states can apply.					
YSI Foundation	$60,000		Optional	March	April
937-767-7241 x406 Susan Miller Susan Miller smiller@ysi.com					
Other Financial Opportunities					
Private Foundation Grants and Awards					
http://www.rivernetwork.org Private foundations are potential sources of funding to support watershed management activities. Many private foundations post grant guidelines on websites. Two online resources for researching sources of potential funding are provided in the contact information.					
Congressional Appropriation - Direct Federal Funding					
Congressman Larson, Courtney, DeLauro, Shays, Murphy					
State Appropriations - Direct State Funding					
http://www.cga.ct.gov/					
Membership Drives					
Membership drives can provide a stable source of income to support watershed management programs.					
Donations					
Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of ways.					
User Fees, Taxes, and Assessments					
Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.					
Rates and Charges					
Alabama law authorizes some public utilities to collect rates and charges for the services they provide.					
Stormwater Utility Districts					
A stormwater utility district is a legal construction that allows municipalities to designated management districts where storm sewers are maintained in order to the quality of local waters. Once the district is established, the municipality may assess a fee to all property owners.					
Impact Fees					
Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.					

Table 6-14. Potential Funding Sources

Funding Source	Maximum Dollar Amount	Minimum Dollar Amount	Required Match	Applications Open	Deadline
Special Assessments					
Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.					
Sales Tax/Local Option Sales Tax					
Local governments, both cities and counties, have the authority to add additional taxes. Local governments can use tax revenues to provide funding for a variety of projects and activities.					
Property Tax					
These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.					
Excise Taxes					
These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.					
Bonds and Loans					
Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects.					
Investment Income					
Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.					
Emerging Opportunities For Program Support Water Quality Trading					
Trading allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.					
Mitigation and Conservation Banking					
Mitigation and Conservation banks are created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the "bankers" get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.					

Source: Coginchaug River Watershed Based Plan, NRCS, July 2008.

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Appendix A

Baseline Watershed Assessment
Watershed Field Inventories and Land Use Regulatory Review
(CD-ROM)

FUSS & O'NEILL

Appendix B

Vernon Regulatory Review Memorandum

Appendix C

Targeted Stream Corridor Recommendations

Appendix D

Stormwater Retrofit Concept Designs

Appendix E

Site-Specific Stormwater Retrofit Cost Estimates