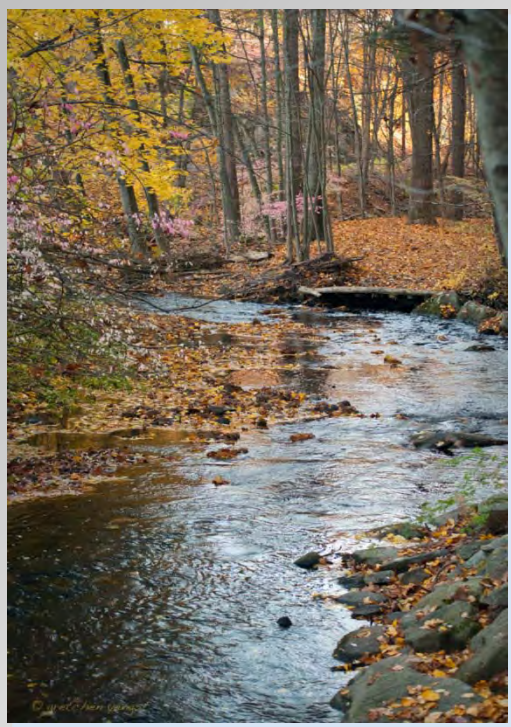
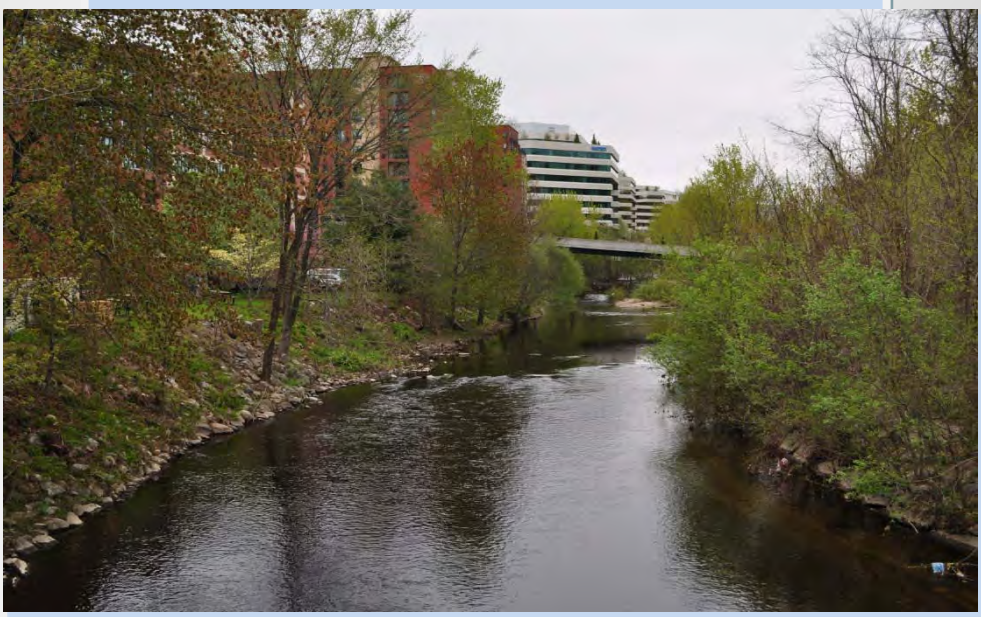


Norwalk River Watershed Based Plan

2011 Update to the 1998 Plan

The Norwalk River Watershed Action Plan

It's Our Watershed – Let's Take Care of It



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Prepared for:
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HDR | HydroQual

SWRPA
South Western Regional Planning Agency

Vision Statement of Norwalk River Watershed Initiative Committee, 1998

"We envision a restored Norwalk River Watershed system:
one that is healthy, dynamic and will remain so for generations to come;
one that offers clean water and functioning wetlands;
one in which a diversity, of freshwater and diadromous fish as well as other wildlife and plants are once again sustained;
one in which the river system is an attractive community resource that enhances quality of life, education, tourism and recreation; and above all one in which growth respects this vision and all people participate in the stewardship of the watershed."

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LIST OF ACRONYMS

AVGWLF	ArcView Generalized Watershed Loading Functions (GWLF) model
BMPs	Best Management Practices
CLEAR	Center for Land Use Education and Research, University of Connecticut
CT	State of Connecticut
CTDEP	Connecticut Department of Environmental Protection (changed to Department of Energy & Environmental Protection (DEEP) July 1, 2011)
CTDOT	Connecticut Department of Transportation
CWA	Clean Water Act
CWP	Center for Watershed Protection
DEEP	Connecticut Department of Energy & Environmental Protection
DO	Dissolved Oxygen
E. coli	*Escherichia Coli*
EMC	Event Mean Concentration
EPA	United States Environmental Protection Agency
FC	Fecal Coliform
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GWLF	Generalized Watershed Loading Functions
HW/RW	Harbor Watch/River Watch
HVCEO	Housatonic Valley Council of Elected Officials
IDDE	Illicit Discharge Detection and Elimination
LIDs	Low Impact Development practices
mg/L	Milligrams per liter
mgd	Million gallons per day
MS4	Municipal Separate Storm Sewer Systems
NEIWPCC	New England Interstate Water Pollution Control Commission
NEMO	Non-point Education for Municipal Officials
NMA	Norwalk Maritime Aquarium
NPS	Non-point Source
NRCS	Natural Resources Conservation Services
NRWA	Norwalk River Watershed Association
NRWI(C)	Norwalk River Watershed Initiative (Committee)
NY	State of New York
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and Maintenance
TMDL	Total Maximum Daily Loads
TN	Total Nitrogen
TP	Total Phosphorus
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UCONN	University of Connecticut
USGS	U.S. Geological Survey
WBP	Watershed Based Plan
WLA	Waste Load Allocation
WPCF	Water Pollution Control Facility
WQS	Water Quality Standards

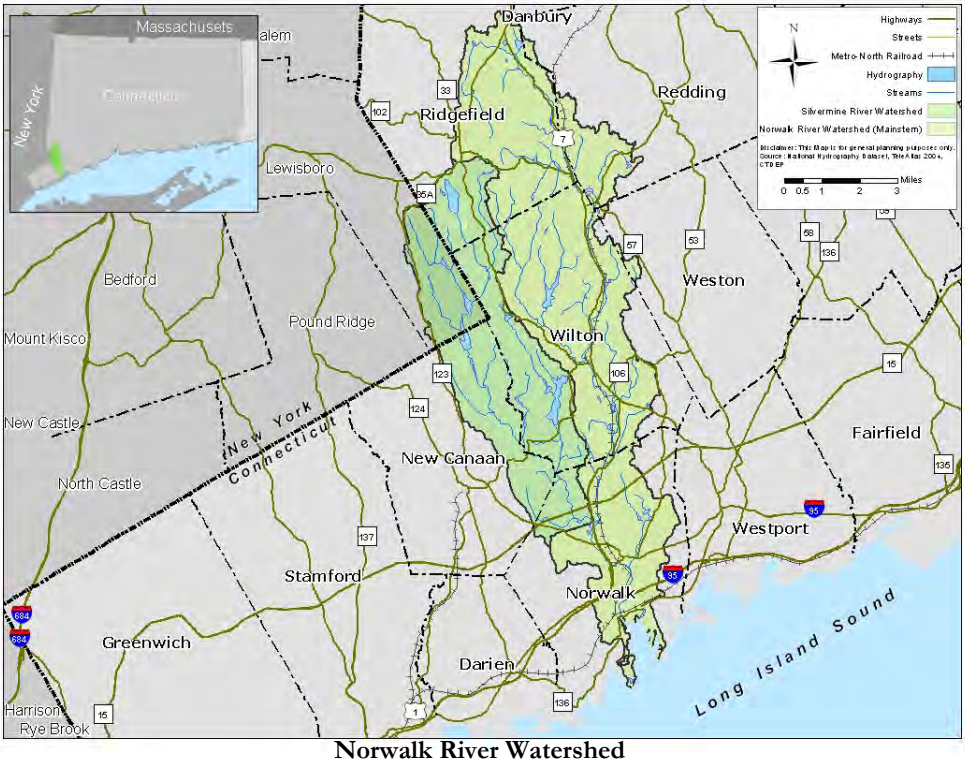
EXECUTIVE SUMMARY

E.1 Norwalk River and Tributaries

The Norwalk River watershed is a regional basin located in the southwestern portion of the State of Connecticut and Westchester County, New York. The Norwalk River Watershed is approximately 64 square miles in size, with two major tributaries: Comstock Brook and the Silvermine River. Similar to other coastal watersheds in Connecticut and New York, this watershed is heavily urbanized in the lower reaches and near the outlet into Norwalk Harbor, while the upper reaches of the watershed exhibit more forested and suburban landscapes.

The watershed extends into six municipalities in Connecticut (New Canaan, Norwalk, Redding, Ridgefield, Weston, and Wilton) and one in New York (Lewisboro). Major concerns in the watershed including flooding, streambank and channel erosion, excessive bacteria loads, nutrient loads to impoundments or the Long Island Sound (LIS), and other pollutant loads. Through an extensive and collaborative effort among watershed stakeholders, the original *Norwalk River Watershed Action Plan* published in 1998 and its update in 2004 have documented degradation in the watershed and the previous monitoring efforts such as streamwalk surveys performed by the Natural Resources Conservation Services (NRCS) in the late 1990s.

The planning efforts described in this Watershed Based Plan (WBP) cover the characterization, analysis and pollutant load calculations performed in the fresh water portion of the Norwalk River watershed, which extends from headwaters in Ridgefield southward towards Wall Street near the top of the Norwalk Harbor.



Norwalk River Watershed

E.2 History of Community Involvement

The Norwalk River watershed has a rich history of watershed planning and represents one of the earliest community-driven, locally-led initiatives in the U.S. to restore and protect watershed resources. The Norwalk River Watershed was identified as an important resource in which water quality improvements could provide benefits to LIS and the community, in the mid-1990s. A committee was formed, as a as a collaborative effort between federal, state, regional and local governments and the public to develop the 1998 *Norwalk River Watershed Action Plan* (the 1998 Action Plan).

The 1998 Action Plan represented a watershed community with a common interest in restoring and protecting the watershed and its resources. The *2004 Supplement to the 1998 Norwalk River Watershed Action Plan* (the 2004 Supplement) highlighted the accomplishments of the 1998 Action Plan and reprioritized watershed goals and recommendations.

The 1998 Action Plan and 2004 Supplement have lead to a number of successfully implemented projects and continued support and collaboration from watershed stakeholders. A successful water quality monitoring program has been established for the Norwalk River led by Harbor Watch/River Watch (HW/RW). In-stream and outfall monitoring have taken place at selected locations for more than 10 years. Regular water quality monitoring has identified and led to the detection and correction of a number of problems, including illicit discharges to stormwater sewers and failing septic systems. A summary of implementation activities has been included in Appendix A.

E.3 Water Quality Concerns

Despite significant accomplishments from watershed stakeholders, sections of the mainstem of the Norwalk River and its tributaries are categorized as impaired. Indicator bacteria levels are the primary pollutant of concern for recreational uses in the river and shellfishing in the Norwalk Harbor. A waterbody is designated as impaired when the water quality standards for the designated or existing water quality classifications are not met (CTDEP, 2008). Impairments for recreational uses due to elevated levels of indicator bacteria are well documented in the watershed (CTDEP 2008). In 2005, the Connecticut Department of Energy & Environmental Protection developed a Total Maximum Daily Load (TMDL) for indicator bacteria for the Norwalk River and various tributaries. Indicator bacteria loads were attributed to a variety of sources, including failed or improperly maintained septic systems, urban stormwater, illicit discharges to storm sewers, hobby farms, wildlife and pet waste. Targeted percent reductions in indicator bacteria pollutant loads identified as part of the TMDL ranged from 3 to 76% depending on the specific impaired segments in the mainstem of Norwalk River or the tributaries (CTDEP, 2005).

In addition to indicator bacteria loads, high levels of nutrients (both phosphorus and nitrogen) have caused water quality concerns in the tributaries and mainstem, as well as in the Long Island Sound (LIS). Localized nutrient inputs such as lawn fertilizers, failing septic systems and illicit discharges contribute to these water quality concerns. Nutrients are the primary causes for eutrophication in reservoirs/lakes/ponds (impoundments) and variations in dissolved oxygen (DO) levels that can impact aquatic life in waterways. Specific impoundment characteristics such as depth, extent of aquatic vegetation, sediments and temperature can also exacerbate water quality degradation. Several

impoundments in the Norwalk River watershed, such as Great Swamp, have been identified to have excessive algal growth (NRCS, 1997).

Segments of the river have also been identified as impaired for fish and other aquatic life support, with the sources identified as "unknown" by DEEP (CTDEP, 2008). Flooding, streambank and channel erosion, restoration of fish passage, habitat protection, and adequate base flow are also concerns in the watershed, and are further discussed in 1998 *Norwalk River Watershed Action Plan* and the *2004 Supplement to the 1998 Norwalk River Watershed Action Plan*.

E.4 Development of a Watershed Based Plan

To garner continued support of watershed planning and conservation efforts the DEEP funded the update and development of this WBP containing the "Nine Elements of Watershed Planning" recommended by the U.S. Environmental Protection Agency (EPA). Funding was provided in part through an EPA Clean Water Act Section 604(b) Water Quality Management Planning Grant. The adoption and approval of the WBP by the DEEP will aid in securing necessary funding to implement recommendations of the plan. The overall goal of this WBP is to identify recommendations that can be implemented on a short to long-term basis, which will improve water quality in the Norwalk River and its tributaries, ultimately leading to segments being removed from the state impaired waters list.

Development of the WBP consisted of the following specific tasks:

i. Baseline Watershed Conditions and Natural Resource Assessment: A baseline assessment of the watershed conditions was performed to characterize the current state of the Norwalk River watershed and its tributaries. Existing data from previous studies and the HW/RW data were reviewed to support this characterization. Delineation of the watershed into smaller sub-watersheds was performed to develop pollutant loads and also to correlate the sub-watersheds and monitoring data to identify areas of the watershed that would need specific management measures for pollution control.

ii. Watershed Management Goals and Objectives: Building on the watershed goals developed previously as part of the 1998 Action Plan, water quality and non-point source runoff management were the focus of this WBP aimed at non-point source pollution reduction. The following objectives were selected to guide the development of short to long-term water quality recommendations:

Goal D: Water Quality

D-1: Eliminate illicit discharges to storm sewers
D-2: Improve solid waste and liquid waste management throughout the watershed
D-3: Reduce the impact of road sand and salt on water quality and stream habitat
D-4: Maintain adequate baseflows in the Norwalk River and its major tributaries
D-5: Eliminate or reduce the anthropogenic impacts to in-stream water quality
D-6: Reduce nitrogen loads from groundwater
D-7: Reduce nitrogen loads from atmospheric deposition
D-8: Continue water quality monitoring, data collection and assessment

Goal E: Non-point Source Runoff Management

E-1: Reduce the cumulative impacts of development and expand efforts to promote and implement low impact development (LID) practices

E-2: Ensure municipal regulations support the implementation of LID practices

E-3: Advocate for a state and local permitting framework that best protects water resources from the impacts of non-point source runoff

E-4: Adopt land use practices that reduce the impacts of non-point source runoff

E-5: Manage bacterial contamination from waterfowl and domestic/hobby animals

Additional recommendations to support "Goal B" on Habitat Restoration, "Goal C" on Land Use, Flood Protection and Open Space and "Goal F" Stewardship and Education where also developed during the planning process to support ongoing watershed initiatives.

iii. Pollutant Loading Assessment: Pollution load assessments were conducted maximize the use of existing pollutant load characterization efforts from previous studies to support the development for this WBP. An ArcView-based Generalized Watershed Loading Functions (AVGWLF) model developed for the Long Island Sound U.S. Environmental Protection Agency was adopted and recalibrated based on recent monitoring data. This model was used to support the quantification of pollutant loads for indicator bacteria, total nitrogen, total phosphorus and total suspended solids.

iv. Watershed Recommendations: A range of potential management measures were developed to achieve the watershed goals and objectives discussed above and also based on loading calculations performed for the individual sub-watersheds. Watershed-wide, site-scale and targeted recommendations were developed and refined based on input from the steering committee.

v. Load Reductions, Implementation Schedule, Interim Milestones and Performance Criteria: For each of the key recommendations, potential reductions in both nutrient and indicator bacteria loads expected on a sub-watershed level were developed. In addition, implementation schedules for all the management measures along with interim milestones and performance criteria were identified in collaboration with the steering committee that could be used to track the progress from implementation of measures developed and presented in this plan.

E.5 Plan Recommendations

This plan recommends both structural and non-structural practices on a watershed-wide basis and at smaller scales to reduce the impacts on non-point source pollution. The watershed-wide perspective highlights the relationship between existing land uses and water quality, so that the controls envisioned at this broader level will bring consistency among various watershed municipalities in achieving an overall pollutant load reduction. Targeted and site scale recommendations focus attention on addressing impairments at selected sites or smaller geographical regions where the controls undertaken will make meaningful reductions in pollutant loads to improve water quality in the Norwalk River watershed and its tributaries. These sites are direct contributors of indicator bacteria and nutrients and will require specific investigation and implementation strategies to achieve the desired water quality goals. Additional targeted recommendations are provided to address concerns around specific sub-watersheds or stream reaches.

Recommendations were assigned an implementation priority based on both technical and financial considerations, overall benefits, as well as the extent of involvement from various watershed stakeholders needed to complete of each recommended plan element. In general, a planning element that could be completed in a few months to one to two year timeframe was designated as a short-term recommendation. Completion in three to four years was considered a mid-term recommendation, and any element that would take over four years was designated as a long-term recommendation. Table ES-1 provides a summary of pollution reductions expected with implementation of recommended management measures identified as part of the WBP. Also shown are the reduction targets set forth by the DEEP as part of the 2005 TMDL for specific segments identified as impaired for not meeting the state standards for indicator bacteria in Connecticut's 303(d) list.

Table ES-1: Summary of Pollution Reductions Achieved to Delist Impaired Segments

Impaired Segment		% Reduction Expected with 100% Implementation	TMDL Target % Reduction
CT7300-02_02	Ridgefield Brook	66%	51%
CT7300-02_01	Ridgefield Brook	66%	51%
CT7300-00_05	Norwalk River	70%	39%
CT7300-00_04	Norwalk River	73%	54%
CT7300-00_03	Norwalk River	74%	5%
CT7300-00_02	Norwalk River	75%	38%
CT7302-00_01	Silvermine River	75%	66%
CT7300-00_01	Norwalk River	76%	76%

A majority of the key management measures recommended below are necessary to achieve the targeted pollution reductions, although some of these measures will need to be achieved 100% on a watershed-wide basis and others to varying degrees depending on specific impaired segments in the Norwalk River or its tributaries.

Illicit Discharge Detection and Elimination (IDDE): With a stringent TMDL goal to reduce bacteria loading by 76% at the lower end of Norwalk River, the recommendation is to achieve 100% elimination of these dry weather sources over a period of 10 years, with an interim target of 50% to be achieved over the next five years.

Management of Septic Systems (SEP): Being another major contributor of bacterial loads at both watershed and site-scales, the recommendation is to achieve 100% in proper inspection, repairs and operation and maintenance of septic systems, so as to completely eliminate such failures over a period of 10 years. An interim target of 50% over the next five years is recommended.

Low Impact Development Adaptation (LID): With the goal of managing stormwater runoff while maintaining or restoring the natural hydrology, the recommendation is to implement LID retrofits as source control mechanisms to reduce stormwater discharge volumes and associated pollutant loads to the Norwalk River and its tributaries.

Land Use Regulations and Smart Growth (LUS): Exploration of the potential benefits is recommended from streamlining of land use regulations within the watershed municipalities and promoting smart growth in certain geographical areas can help in reducing the potential for pollutant loads.

Downspout Disconnection (DOD): A generic recommendation is made to first conduct field scale assessment of downspout connections to sewers and target areas in the watershed with high density of connections that will benefit from disconnection. Outreach and assistance can follow to help home owners with implementation.

Riparian Buffers (RBF): With high levels of targeted reductions in bacteria loads, intact riparian buffers are recommended for 100% of river miles along the low and high intensity developments, over a period of 20 years with an interim target of 50% over the next 10 years.

Management of Pollution from Waterfowl and Domestic/Hobby Animals (WAT): Connecticut DEP has developed statewide population estimates for Canadian geese and ducks to be 24,000 and 57,000, respectively, during the 2011 breeding season. Population estimates specific to the Norwalk River watershed are unavailable and these estimates include both migratory and non-migratory goose populations. The recommendation is to achieve a targeted 30% reduction in pollutant source reduction from baseline condition for the Norwalk River watershed, targeting the non-migratory goose population.

Urban Greening (UGR): Increased tree canopies and plant coverage will benefit in terms of capturing additional water through evapotranspiration and interception, reductions in thermal pollution and providing secondary environmental benefits, such as increased habitat.

Large-scale BMPs for Urban Stormwater Management (BMP): Structural BMP practices such as bioretention (with bacteria reduction effectiveness of 70%), constructed wetlands (effectiveness of 50%) and wet ponds (effectiveness of 70%) are effective in terms of reducing bacteria loads from contributing urban drainage areas. Among the targeted recommendations are the public and large-private properties that can offer potential for structural BMP implementation. About 50-60% of the urban runoff from the entire watershed will need to be treated with multiple constructed wetlands, wet ponds and bioretention, in order to meet the desired bacterial control targets for various impaired segments.

Streambank Stabilization/Restoration (STR): There is no direct benefit for bacteria load reduction from this recommendation, therefore, the stabilization can be adopted where there are specific stream segments with bank erosion and sedimentation problems.

Transportation Corridors (TRA): The Norwalk watershed is intersected by major transportation elements including parkways, national highways and boulevards/streets. The recommendation is to achieve 100% treatment of highway/roadway runoff over a period of 20 years, with an interim target of 50% over the next 10 years. Highway runoff treatment can be in the form of grass swales, wetponds, constructed wetlands, bioretention cells and buffer strips implemented based on feasibility and cost considerations along the transportation corridor to reduce bacterial and nutrient pollutant loads. In order to support the prioritization process, the subwatersheds with more than 8% (by area) of transportation

corridors have been classified as high density areas for implementation of BMPs to reduce nutrients and indicator bacteria in the near term and then for the remaining areas over the long term.

Public Education and Outreach (EDU): Both lawn care practices and pet waste disposal aspects were considered in the estimation of load reductions from public education and outreach and recommended for implementation. Continued stewardship and educational opportunities are necessary for successful implementation of the WBP.

Annual average pollutant load reductions for TN, TP, TSS, and bacteria (*E. coli*) were estimated for the entire Norwalk watershed. Table ES-2 summarizes the estimated pollutant load reductions for each watershed management measure, on a watershed-wide basis.

E.6 Prioritization

Elimination of dry weather discharges through illicit discharge detection and removal, moderate control of waterfowl and the proper operation and maintenance of septic systems emerged as the most cost-effective ways to significantly reduce bacteria loads in the Norwalk River and its tributaries. Riparian buffers can also provide load reductions with moderate investments. Large-scale urban stormwater management measures can provide significant reductions; however, the associated costs are the highest in comparison to other management measures. In spite of their large costs, if specific or dedicated funding mechanisms can be pursued for projects such as wetland restoration or creation in public lands, such projects can become viable opportunities for reduction in water quality impairments. Transportation corridors also offer opportunities for large-scale treatment that provide measurable benefits. However these projects can be costly and may require collaboration among local, state and federal agencies for funding.

Distributed LIDs do require significant financial investments and extensive coordination among stakeholders to provide watershed-wide benefits. These source control practices can reduce runoff through infiltration, increase baseflow in the streams and reduce bank/channel erosion due to reduced peak flows during rainy periods. These practices can be implemented as small or large-scale projects and can also be pursued selectively based on the funding mechanisms available.

Practices such as urban greening and streambank restoration may provide limited benefits for bacteria control. However, those can be promising for controlling of other pollutants such as TSS and nutrients, reduction of thermal pollution and will provide additional habitat in the watershed.

A focused list of recommendations are included in Table 6-1, with a full list of recommendations in Appendix B. Information regarding targets/performance metrics for specific watershed management measures provided are also provide in Table 6-1 and Appendix B.

Table ES-2: Estimated Pollutant Load Reductions on a Watershed-wide Basis

Watershed Management Recommendation	TN	TP	TSS	*E. coli*	Percentages			
	(lb/yr)	(lb/yr)	(lb/yr)	(billion/yr)	N	P	TSS	*E. coli*
Existing	**266,193**	**33,669**	**13,973**	**1,552,146**	100%	100%	100%	100%
Illicit Discharge Detection & Elimination (IDDE)	5,324	673	-	491,573	2%	2%	-	32%
Management of Septic Systems (SEP)	96,437	19,855	-	231,781	36%	59%	-	15%
LID Adaptation (LID)	124	23	2	7,898	0%	0%	0%	1%
Land Use and Smart Growth (LUS)	-	-	-	-	-	-	-	-
Downspout Disconnection (DOD)	-	-	-	-	-	-	-	-
Riparian Buffers (RBF)	3,646	147	85	64,519	1%	0%	1%	4.2%
Management of Waterfowl & Animal Wastes (WAT)	11,392	1,441	-	66,426	4%	4%	-	4.3%
Urban Greening (UGR)	-	-	-	-	-	-	-	-
Large-scale BMPs for Urban Stormwater Mgmt (BMP)	8,369	916	88	296,923	3%	3%	1%	19%
Streambank stabilization/ Restoration (STR)	44	51	1,155	-	0%	0%	8%	-
Transportation Corridors (TRA)	2,315	309	16	5,354	1%	1%	0%	0%
Education & Outreach (EDU)	5,877	388	-	21,296	2%	1%	-	1%
Load Reduction Achieved	**33,528**	**23,803**	**1,346**	**1,185,770**	**50%**	**71%**	**10%**	**76%**
Remainder Pollutant Loads to Norwalk Waterways	**132,665**	**9,866**	**12,628**	**366,375**	**50%**	**29%**	**90%**	**24%**

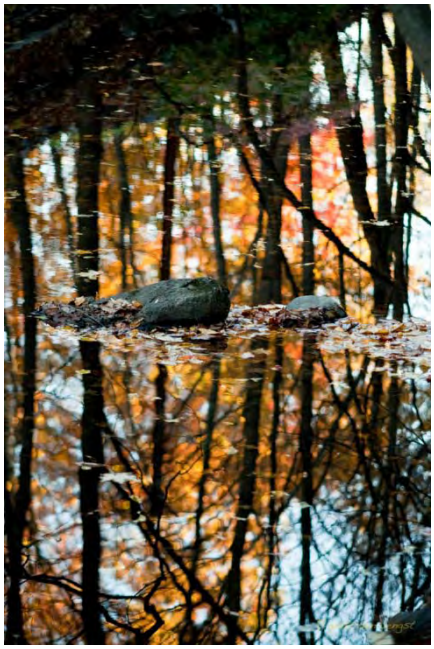
NOTE: TN – Total Nitrogen, TP – Total Phosphorus, TSS – Total Suspended Solids and *E. coli* – Escherichia Coli

1. INTRODUCTION

1.1 Need for a Watershed Based Plan

Watershed management and the methods utilized to reduce water quality impairments have continued to evolve in the 21st century, and require innovation, collaboration and local leadership. Significant progress has been made to address point sources of pollution, mainly through the National Pollution Discharge Elimination System (NPDES) program. The NPDES permitting programs strictly regulate and require advanced levels of treatment for municipal sanitary and industrial wastewater. Some urban stormwater is also regulated through the Municipal Separate Storm Sewer System (MS4) permit, which serves to establish pollution control programs (USEPA, 2002; 2010).

Despite great progress in controlling point sources, water quality problems remain. At a national level, stormwater from urban, sub-urban and non-urban land areas have been identified as major contributors to water quality impairment (NRC, 2008). These non-point sources include runoff from roads, parking lots, and lawns; leachate from septic systems; animal waste from wildlife, pets and hobby farms; and atmospheric deposition of pollutants. Non-point sources are defined as diffuse sources with multiple entry pathways into the receiving waters. Discharges from non-point sources are generally controlled through voluntary programs administered at the state and local level. Although urban stormwater conveyed through a storm sewer is regulated as a point source and permitted through the MS4 program. Stormwater runoff flowing directly form watershed lands, urban, sub-urban or rural, into a waterway is considered a non-point source. Various funding sources dedicated to non-point sources exist to help fund projects, including the 319 program.



Source: Gretchen Yengst - Loving Focus Photograph

The Norwalk River watershed (the watershed) is a regional basin predominately located in the southwestern portion of the State of Connecticut and is approximately 64 square miles in size. Comstock Brook and the Silvermine River are the major tributaries to Norwalk River (Figure 1-1). The watershed comprises approximately 40,000 acres of drainage area, extending into six municipalities in Connecticut: New Canaan, Norwalk, Redding, Ridgefield, Weston, and Wilton; and Lewisboro, New York. Similar to other coastal watersheds in Connecticut and New York, the Norwalk River is heavily urbanized in the lower reaches and near the outlet through Norwalk Harbor into the Long Island Sound (LIS), with pockets of suburban development along the Silvermine River. The upper reaches of the watershed tend to be characteristic of a more suburban landscape; however typical urban stormwater issues are still common. Historic development, economic and recreational opportunities and the proximity/accessibility of New York City are attributed to these development patterns seen throughout the LIS region.

This watershed based plan (WBP) covers the characterization, analysis and pollutant load calculations performed in the fresh water portion of the Norwalk River watershed, which extends from headwaters in Ridgefield southward to the top of the Norwalk Harbor.

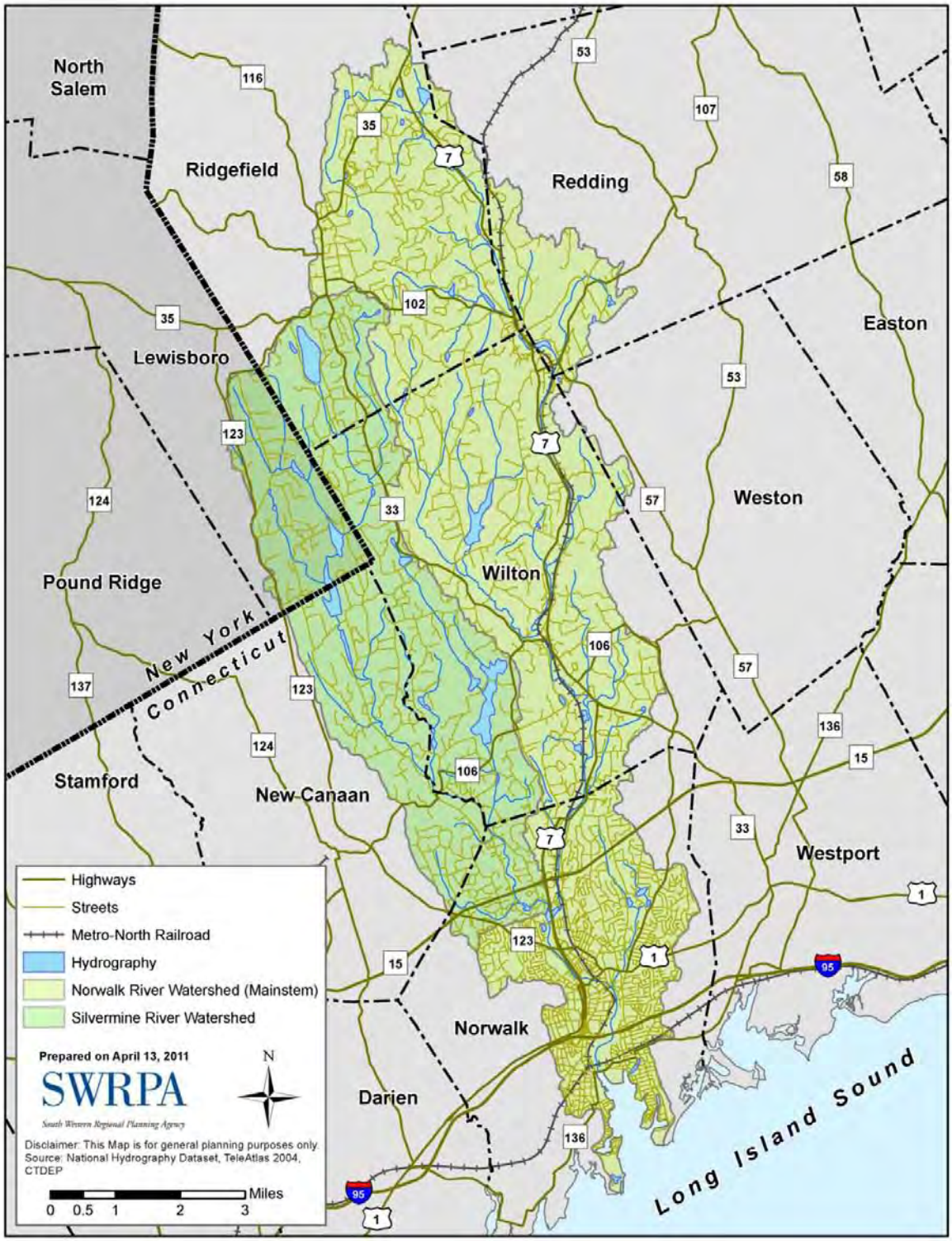


Figure 1-1. The Norwalk River Watershed

1.1.1 History of Planning Efforts in the Norwalk River Watershed

In the mid-1990s, the USDA-Natural Resources Conservation Service (NRCS), United States Environmental Protection Agency (EPA) through its Long Island Sound Office (EPA-LISO), and the Connecticut Department of Energy & Environmental Protection (DEEP) recognized the importance of a comprehensive watershed management approach to protect and restore the State's surface and ground waters, and the LIS. The Norwalk River Watershed was identified as an important resource in which water quality improvements could provide benefits to LIS and the community. As a result, the Norwalk River Watershed Initiative Committee (NRWIC) was created in early 1997 to develop a methodical framework for watershed management, as a collaborative effort between federal, state, regional and local governments and the public. Early planning focused on a "Streamwalk Assessment," which added considerably to the existing knowledge regarding the physical condition of the watershed's stream corridors. An 18-month formal planning process was undertaken by NRWIC, which resulted in the development of the 1998 Norwalk River Watershed Action Plan (the 1998 Action Plan).

This represents one of the earliest community-driven, locally-led initiatives in the U.S. to restore and protect the watershed resources. The people who live, work and recreate in the watershed are most likely to understand the problems affecting it, have the greatest stake in its health, and have the greatest incentive to affect the changes necessary to restore and protect resources. This approach assumes that the watershed is a logical, geographically defined unit, in which a wide range of environmental issues can be analyzed and assessed in a comprehensive fashion, taking into account the interactions and cumulative impacts of various pollution sources and resource impairments. The 1998 Action Plan represents a watershed community with a common interest in restoring and protecting the watershed and its resources (NRWIC, 1998). In June 2003 the NRWIC began the process to review progress in implementing the recommendations from the 1998 Action Plan. The 2004 Supplement to 1998 Action Plan (the 2004 Supplement) highlighted the accomplishments of the NRWIC and reprioritized watershed goals and recommendations for the next five years (NRWIC, 2004).

As a result of documented impairments in the Norwalk River, in 2005, the DEEP developed a Total Maximum Daily Load (TMDL) for indicator bacteria for the Norwalk River and various tributaries. The state indicator bacteria criteria are based on the protection of recreational uses such as swimming, kayaking, wading, water skiing, fishing, boating, and aesthetics. Indicator bacteria loads were attributed to a variety of sources, including failed or improperly maintained septic systems, urban stormwater, illicit discharges to storm sewers, hobby farms, wildlife and pets. A TMDL is the mechanism established by the EPA to set pollution control targets for the various contributing pollution sources (both point and non-point), accounting for the assimilative capacity of receiving waters and the anticipated growth and developments in a watershed.

Hypoxic conditions seen in the western end of the LIS and high levels of nutrient inputs from tributaries and ground water led the DEEP and New York State Department of Environmental Conservation (NYSDEC) to develop a TMDL to control Total Nitrogen (TN) inputs into the LIS from both point and non-point sources (NYSDEC and CTDEP, 2000). As documented in Mullaney et al. (2002), significant amounts of nitrogen reaches the LIS through groundwater sources. Nutrients infiltrating into the groundwater reappears in streams as base loads and Mullaney (2006) estimates the groundwater residence times can range from two to more than 50 years. Long

residence times essentially move nutrients through the watershed slowly and present a long-term source of pollution loads into the LIS even when controlled from other sources with appropriate management practices.

Controlling pollution from septic systems through inspection and maintenance and removing illicit discharges to stormwater drainage systems can result in a significant reduction in pollutant loads. However, the reduction in non-point sources such as lawn fertilizers and pet/wildlife/waterfowl waste management require innovation actions for control. Developmental pressure is another major concern. With little undeveloped land in the watershed, local boards and commissions continue to see applications and requests to redevelop residential properties with larger homes or subdivisions, with increased density.

The 1998 Action Plan and 2004 Supplement have led to a number of successfully implemented projects and continued support and collaboration from watershed stakeholders. A long term water quality monitoring program has been established for the Norwalk River led by Harbor Watch/River Watch (HW/RW). In-stream and outfall monitoring has taken place at selected locations for more than 10 years and has led to the detection and correction of a number of problems, including illicit discharges to stormwater sewers and failing septic systems. A summary of implementation activities has been included in Appendix A.

1.1.2 The 2011 update to the Norwalk River Watershed Action Plan

The 2008 State of Connecticut Integrated Water Quality Report (CTDEP, 2008) designated several segments of the main stem of Norwalk River and various tributaries as impaired (further discussed in Section 3 on Watershed Characterization). Segments were considered impaired if they were unable to support designated uses. Portions of the watershed were identified as impaired for aquatic life support, recreational uses and fish consumption.

A WBP was identified as a suitable companion to the 1998 Action Plan. The development of a WBP would serve to reassess the 2004 supplement and enhance the recommended actions through the inclusion of measurable goals, milestones, evaluation criteria and identification of potential funding strategies in order to accelerate the implementation of pollution control programs. To garner continued support of watershed planning and conservation efforts the DEEP provided funding the development of a WBP containing the "Nine Elements of Watershed Planning" recommended by the EPA, through a U.S. EPA Clean Water Act Section 604(b) Water Quality Management Planning Grant. The adoption and approval of the WBP by the DEEP will help focus implementation efforts to reduce water quality impairments and aid in securing necessary funding to implement recommendations of the plan. The 2011 update to the Norwalk River Watershed Action plan will serve as a tool to reduce the impacts of the non-point source contamination and guide conservation efforts throughout the watershed.

1.2 Plan Development Process and Public Involvement

The overall goal of this WBP is to identify recommendations that can be implemented on a short to long-term basis, which will maintain and enhance water quality in the Norwalk River and its tributaries and help to eliminate water quality impairments. Key considerations for the WBP include the maintenance of water quality in upper portions of the river and restoration of waterways downstream to be able to satisfy the appropriate regulatory requirements (Clean Water Act and/ or Safe Drinking Water Act). This plan will enable implementation projects identified in the plan for consideration in the State's Section 319 process.

The DEEP and EPA provide guidance (CTDEP, 2010; EPA, 2008a) for development of WBPs following the "Nine Elements of Watershed Planning." The nine elements set forth for by the EPA include (EPA, 2008a):

- **Impairment:** An identification of the causes and sources of pollution, that will need to be controlled to achieve the load reductions estimated to fix the impairment, and to achieve any other watershed goals identified in the WBP;
- **Load Reduction:** An estimate of the load reductions expected for the management measures described. Spreadsheets and land cover mapping are typically employed in these models to estimate load reductions;
- **Management Measures:** A description of the non-point source (NPS) management measures that will need to be implemented to achieve the estimated load reductions;
- **Technical and Financial Assistance:** An estimate of the amounts of technical and financial assistance needed, and/or the sources and authorities that will be relied on, to implement this plan;
- **Public Information and Education:** An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented;
- **Schedule:** An expedited schedule for implementing NPS management measures identified;
- **Milestones:** A description of interim, measurable milestones for determining whether NPS management measures or other controls are being implemented;
- **Performance:** Criteria to determine whether loading reductions are being achieved over time, and if progress is being made towards attaining water quality standards and, if not, the criteria to determine if this plan, or a related TMDL, needs to be revised; and
- **Monitoring:** A monitoring component to evaluate the effectiveness of the implementation efforts over time.

Source: *CTDEP (2010), Accessed January 2011*.

The 1998 Action Plan and 2004 Supplement have served as the foundation for the development of this WBP. The 2011 update to the Action Plan has focused on incorporating the Nine Elements of Watershed Planning (EPA, 2008a). The WBP was developed through a collaborative process that

included all identified stakeholders referred to as the Watershed Stakeholders, including but not limited to the following:

State: DEEP, NYSDEC
Federal Agencies: USGS, USDA-NRCS, EPA-LISO
Westchester County Department of Planning
Municipalities: Lewisboro, NY; New Canaan, Norwalk, Wilton, Weston, Redding and Ridgefield, CT
Non-governmental organizations: Norwalk River Watershed Initiative, Norwalk River Watershed Association, Harbor Watch/River Watch, Trout Unlimited, Norwalk Maritime Aquarium, Regional Planning Agencies (SWRPA and HVCEO), Sierra Club of Fairfield County, South Norwalk Electric and Water (SNEW), Southwest Conservation District, Connecticut Fund for the Environment/Save the Sound, Dibner Fund, Fairfield Community Foundation
Watershed residents

The planning process was led by a volunteer steering committee consisting of representatives from the DEEP, City of Norwalk, Town of New Canaan, Town of Wilton, the Norwalk River Watershed Initiative coordinator, the Norwalk River Watershed Association, a local resident and SWRPA. Two stakeholder meetings were held during the planning process to solicit input from the community. The first stakeholders meeting on June 24, 2010 reviewed the existing watershed conditions, impairments to the Norwalk River and tributaries, and the goals established by the existing plans. The first stakeholders meeting helped shape water quality objectives and recommendations.

The second stakeholders meeting held on September 29, 2010 focused on the results of the pollution load model, the status of the existing TMDL, and potential recommendations to reduce the NPS contamination that would be incorporated into the WBP. Recommended actions to address the water quality goals and objectives (Goals D and E) were developed by HDR|HydroQual and circulated to watershed stakeholders for comments, and input regarding implementation. Watershed stakeholders also developed a list of recommendations based on a survey of the action items from the 2004 supplement. As draft sections of the WBP were developed they were circulated to the steering committee for review and comment. Additional input was also received from watershed municipalities during various stages of the planning process. The final WBP reflects these discussions and the comments received.

1.3 WBP Organization

This WBP has been prepared to provide a blueprint for the watershed stakeholders to implement controls and track progress on a watershed basis. The WBP reviews the strategies for addressing water quality needs in the Norwalk River and its tributaries' along with an implementation plan. Both structural and non-structural practices are recommended on a watershed-wide basis and at smaller scales (targeted sub-watersheds and site specific). The watershed-wide perspective highlights the relationship between existing land uses and water quality, so that the controls envisioned at this broader level will bring consistency among various watershed municipalities in achieving an overall pollutant load reduction.

Site-scale recommendations focus attention on addressing impairments at selected sites or smaller geographical regions where the controls undertaken will make meaningful reductions in pollutant loads to improve water quality in the Norwalk River watershed and its tributaries. These sites are direct contributors of indicator bacteria and nutrients and will require specific investigation and implementation strategies to achieve the desired water quality goals. Additional targeted recommendations are provided, to address concerns around specific sub-watersheds or river reaches, such as transportation corridor and atmospheric deposition. Additional monitoring or investigations are suggested to improve the understanding or characterization of these sources in order to support the development of specific management measures.

The plan summarizes financial and technical considerations for best management practices (BMPs) and low impact development practices (LIDs) for indicator bacteria and nutrient controls. Based on performances and costs compiled from literature, the stakeholders can pursue specific projects and explore the necessary funding mechanisms from federal, state and municipal sources. Additional information supporting the development of the WBP has been included as appendices at the end of this document.

Source: Gretchen Yengst - Loving Focus Photograph

2. WATERSHED MANAGEMENT GOALS AND OBJECTIVES

We envision a restored Norwalk River Watershed system: one that is healthy, dynamic and will remain so for generations to come: one that offers clean water and functioning wetlands; one in which a diversity of freshwater and diadromous fish as well as other wildlife and plants are once again sustained: one in which the river system is an attractive community resource that enhances quality of life, education, tourism recreation: and above all, one in which growth respects this vision and all people participate in the stewardship of the watershed.

The vision statement for the watershed was developed by the NRWIC for the 1998 Action Plan and served as the backbone for developing management goal and objectives during the 2011 update and creation of this WBP. This section presents overall management goals for the Norwalk River watershed and its tributaries and specific objectives to achieve these goals. These goals and objectives have been developed based on a review of the 1998 Action Plan, 2004 Supplement, comments received during two watershed stakeholders meeting held in 2010, and through consultation with watershed stakeholders throughout the planning process.

2.1 Management Goals

Goal A: Plan Development and Implementation
To develop an affordable and effective WBP that can be implemented collaboratively by watershed stakeholders.

Goal B: Habitat Restoration
To preserve and enhance habitat features to protect and increase diversity of floral and faunal species. The WBP must seek to improve wildlife habitat, to foster fisheries, enhance species diversity and to restore diadromous fish passage.

Goal C: Land Use/Flood Protection/Open Space
To promote balanced growth which preserves property values and protects and enhances the watershed's natural resources for future generations. This will be done by:
(1) providing that new development is within the carrying capacity of the environment,
(2) promoting economic development without adversely impacting the watershed, and
(3) creating performance standards by which all the development and renovations can be evaluated.

Goal D: Water Quality
To restore and protect surface and ground water to meet State water quality standards throughout the watershed such that the Norwalk River supports its designated and existing uses (e.g., fishing, swimming, and drinking water).

Goal E: Non-point Source Runoff Management
To reduce the cumulative impacts of development and NPS pollution on the Norwalk River and its tributaries through sustainable land use practices.

Goal F: Stewardship and Education
To educate citizens about the boundaries and functions of the Norwalk River Watershed; the specific needs for protection of and improvement to the river system, the benefits of a healthy watershed to individuals and communities, and the opportunity for the public to speak out on issues and to participate in the stewardship of the watershed.

2.2 Management Objectives

Objectives have been identified for each of the management goals to help facilitate implementation efforts. It must be emphasized that the objectives and recommendations were developed to help achieve specific goals; implementation may also serve to address other watershed management goals or objectives. The WBP focuses on improving water quality through the reduction of non point source pollution, addressed in watershed management goals D and E, with addition recommendations developed by watershed stakeholders to support the preservation and enhancement of natural resources. Generalized and specific recommendations to achieve the plan objectives, including implementation strategies' ranking, schedule, milestones, performance evaluation criteria, costs, and funding sources are presented in Section 5 on Watershed Recommendations and Section 6 on Management Measures.

Source: Gretchen Yengst - Loving Focus Photograph

Goal A: Plan Implementation

Objective A-1: Continue to work with all watershed stakeholders to undertake an implementation planning process and tracking progress over time

Objective A-2: Conduct additional field assessments to improve understanding of the watershed pollution sources and update the characterization and implementation aspects accordingly

Goal B: Habitat Restoration

Objective B-1: Control or diminish the prevalence of invasive species

Objective B-2: Minimize loss of habitat values coincident with land use practices

Objective B-3: Restore diadromous and resident fish passage

Objective B-4: Preserve and restore in-stream habitat

Objective B-5: Maintain, enhance and increase riparian buffer areas

Goal C: Land Use/Flood Protection/Open Space

Objective C-1: Identify appropriate areas for public access to the rivers and streams and increase public access where appropriate

Objective C-2: Promote inclusive land use planning for natural resource conservation

Objective C-3: Recognize the importance of maintaining and increasing open space to ensure proper functioning of the watershed.

Objective C-4: Reduce the frequency and severity of flooding

Goal D: Water Quality

Objective D-1: Eliminate illicit discharges from storm sewers

Objective D-2: Improve solid waste and liquid waste management throughout the watershed

Objective D-3: Reduce the impact of road sand and salt on water quality and stream habitat

Objective D-4: Maintain adequate baseflows in the Norwalk River and its major tributaries

Objective D-5: Eliminate or reduce the anthropogenic impacts to in-stream water quality

Objective D-6: Reduce nitrogen loads from groundwater

Objective D-7: Reduce nitrogen loads from atmospheric deposition

Objective D-8: Continue water quality monitoring and data collection and assessment

Goal E: Non-point Source Runoff Management

Objective E-1: Reduce the cumulative impacts of development and expand efforts to promote and implement LID practices

Objective E-2: Ensure municipal regulations support the implementation of LID practices

Objective E-3: Advocate for a state and local permitting framework that best protects water resources from the impacts of non-point source runoff

Objective E-4: Adopt land use practices that reduce the impacts of non-point source runoff

Objective E-5: Manage bacterial contamination from waterfowl and domestic/hobby animals

Goal F: Stewardship and Education

Objective F-1: Develop a mechanism to monitor The Action Plan, implement such a mechanism, and foster watershed stewardship

Objective F-2: Provide information and education about the Norwalk River Watershed

Objective F-3: Expand coordination and communication with watershed municipalities.

Keeping the water quality and non-point source runoff management goals in perspective (goals D and E), the work performed as part of the plan update included the following specific tasks: (a) completion of watershed characterization; (b) definition of watershed recommendations to improve water quality and protect aquatic resources; (c) identification of potential areas for implementation of best management practices and low impact development practices and also the strategies for reducing nutrient and bacteria loads to the Norwalk River and its tributary watersheds; and (d) development of an implementation program consistent with the management goals, which includes an implementation schedule, milestones, performance criteria, cost information, and estimated load reductions aimed at delisting impaired waterbodies.

Specific actions are not meant to be viewed as an assignment to any one party, but rather a community-wide effort transcending municipal boundaries and traditional jurisdictions. Measuring the success for each of the actions is important to communicate progress in terms of WBP implementation, to enable stakeholders to learn from the accomplishments and failures, and to provide a framework for tracking improvement in water quality. Recommended actions identified to help achieve the above goals and the proposed strategies for implementation are discussed in Sections 5 and 6.

3. WATERSHED CHARACTERIZATION

Information presented in this section is primarily derived from the 1998 Action Plan and 2004 Supplement (NRWIC 1998; 2004) with information updated as necessary to reflect current conditions in the watershed. Additional information on the history of the watershed can be found in 1998 Action Plan.

3.1 Watershed Description

The Norwalk River Watershed encompasses portions of seven municipalities in the States of Connecticut and New York. Six of them are located in Fairfield County (CT), namely: New Canaan, Norwalk, Redding, Ridgefield, Weston and Wilton. Lewisboro is located in Westchester County, NY. The main stem of the Norwalk River and two major tributaries, Comstock Brook and Silvermine River, constitute the primary waterways in the watershed. Watershed covers a drainage area of approximately 40,000 acres or 64.1 square miles and has a population of approximately 103,000 people (2010 census) (Table 3-1).

Table 3-1. Land Area and Percent of Municipalities

Municipalities	Town Area (in square miles)	Town Area within the Norwalk Watershed (in square miles)	% of Town within the Watershed	% of Watershed Area
New Canaan	23.3	5.9	25.3	9.1
Norwalk	27.7	12.7	45.8	19.7
Redding	32.2	3.4	10.6	5.3
Ridgefield	34.8	13.7	39.4	21.02
Weston	20.8	0.4	1.9	0.6
Wilton	26.8	24.1	90.0	37.4
Lewisboro, NY	29.3	4.3	14.6	6.7
Total	194.9	64.5	-	100.0

For this plan, the watershed boundary covers the headwaters in the Great Swamp in Ridgefield to the fresh water boundary, at Wall Street in Norwalk, approximately three miles upstream of the Norwalk Harbor. The approximate stream lengths of main stem of the Norwalk is 20 miles; main stem of the Silvermine River is eight miles, with its tributaries adding 21 miles; and the main stem of Comstock Brook is three miles, with its tributaries adding 16 miles.

The average yearly air temperature is 51 degrees Fahrenheit, with an average precipitation of 47 inches. The climate in the watershed is marked by four well-defined seasons, modified slightly by its proximity to the LIS. Breezes from the ocean tend to moderate the climate somewhat, producing cooler summers and warmer winters than are found further inland. Average temperatures in Fairfield County (CT) range from above 70° F in the warmest months to an average below 26° F during coldest months of the year, with average annual temperatures of approximately 51°F (National Climatic Data Center, 2010). Between 1990 and 2010 annual average precipitation in the areas was 49 inches; primarily in the form of rain from April through October, and in the form of rain, freezing rain, ice, sleet or snow between November and March (NOAA, 2011).

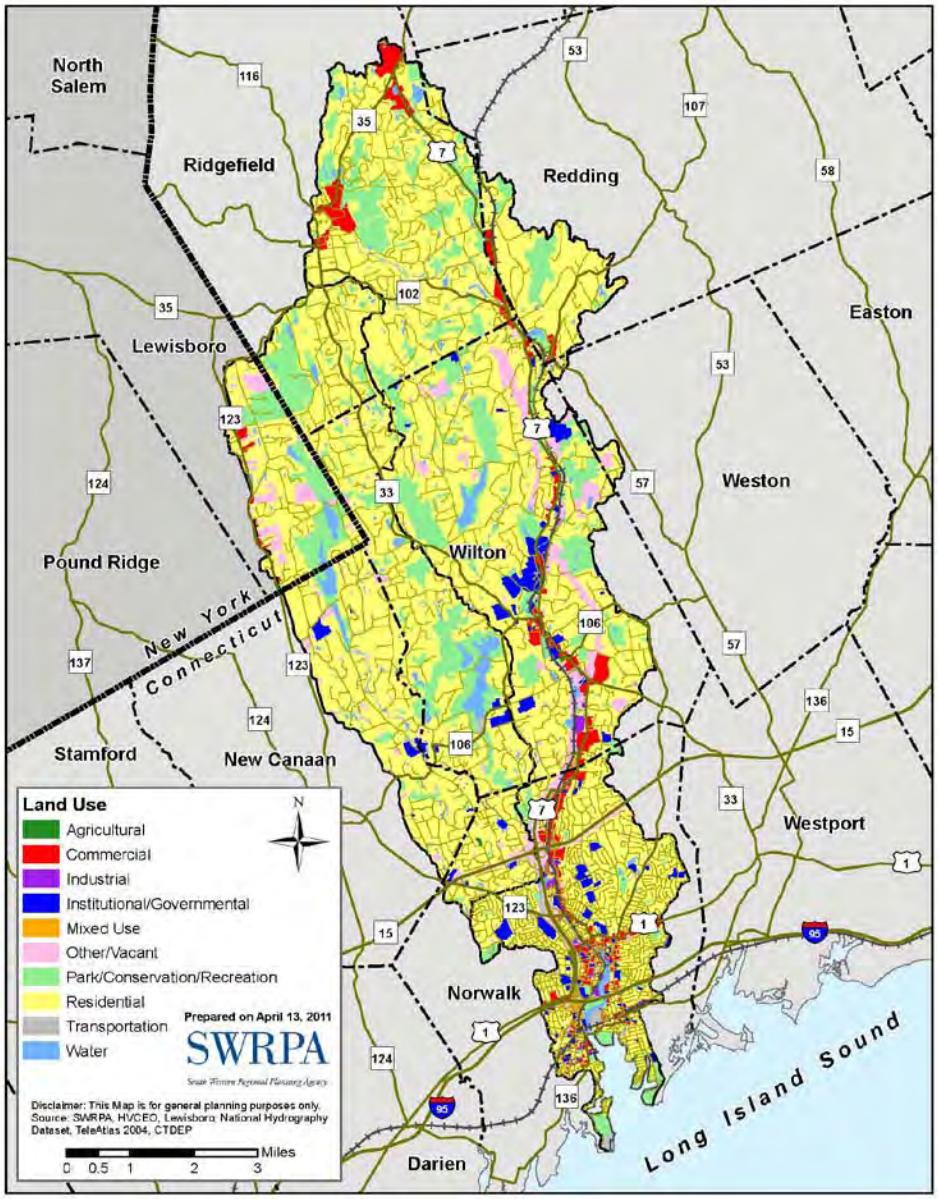


Figure 3-1. Land Use Map of the Norwalk River Watershed

Like much of New England, early development centered around navigable rivers and the coastline, with the town green and churches serving as the social and cultural centers of the community. Rivers served as both ports and commercial hubs, aiding the movement of goods and serving as a source for powering manufacturing facilities. With rivers, railroads, and later highways serving as major the economic drivers, development patterns in the watershed are primarily centered on and around this infrastructure (Figure 3-1). Transportation corridors bisecting the watershed include The Merritt Parkway (CT 15), U.S. 7, U.S. 1, I-95 and Metro North Rail Road. Approximately 67% of the watershed has been developed with commercial and light industry uses, and residential neighborhoods. Approximately 10% of the watershed is used as a transportation network and to support institutional and governmental facilities. The remaining 23% is made up of woodland, open lands, water, and wetlands. Table 3-2 summarizes the land use distribution used to support the watershed characterization.

Table 3-2. Norwalk River Watershed Land Use Type

Land Use type	Area (square miles)	Percent
Agricultural	< 1	< 1
Commercial	2.0	3
Industrial	< 1	< 1
Institutional/Governmental	1.6	2
Mixed Use	< 1	< 1
Other	3.1	5
Open Space/Recreation	10.1	16
Residential	40.3	63
Transportation	4.8	7
Water	1.5	2
Total	64.1	100

Source: SWRPA, Regional Land Use and Zoning Maps (2011), HVCOE Regional Zoning (2009), Westchester County Parcel Based Land use (2009)

Major issues in the watershed include frequent flooding, erosion and sedimentation, and water quality impairment from point and NPS pollution. Frequency and severity of storms and flooding have increased in the watershed over the past two decades. Changing weather patterns and an increase in impervious surfaces have contributed to frequent flooding in the watershed.

3.2 Demographic Profile

Proximity to the employment and cultural opportunities in Connecticut, New York City and Westchester mixed with the charm of Southern New England make the municipalities in the watershed highly desirable places to live. Table 3-3 shows the population density of towns in the Norwalk River Watershed. Norwalk is the most densely populated with a population density of 2,378 people per square mile. In comparison, Redding has the fewest people per square mile, with a population density of only 286 people per square mile (Figure 3-2). The difference in density clearly illustrates the variability of land use within the watershed, with a direct correlation between increased density and increased impervious coverage.

Table 3-3. Population Density for Municipalities of the Norwalk River Watershed

Town	Total Land Area (sq mile)	2010 Population	Population Density (persons/sq mile)	1998 Population	Population Density (persons/sq mile)	Change in Population	Change in Density (persons/sq mile)
New Canaan	23	19,738	858	17,840	776	1,898	83
Norwalk	36	85,603	2,378	78,331	2,176	7,272	202
Redding	32	9,158	286	7,920	248	1,238	39
Ridgefield	35	24,638	704	20,944	598	3,694	106
Weston	21	10,179	485	8,637	411	1,542	73
Wilton	27	18,062	669	15,993	592	2,069	77
Lewisboro	29	12,411	428	11,313	390	1,098	38

Source: U.S. Census Bureau (2010); NRWIC (1998)

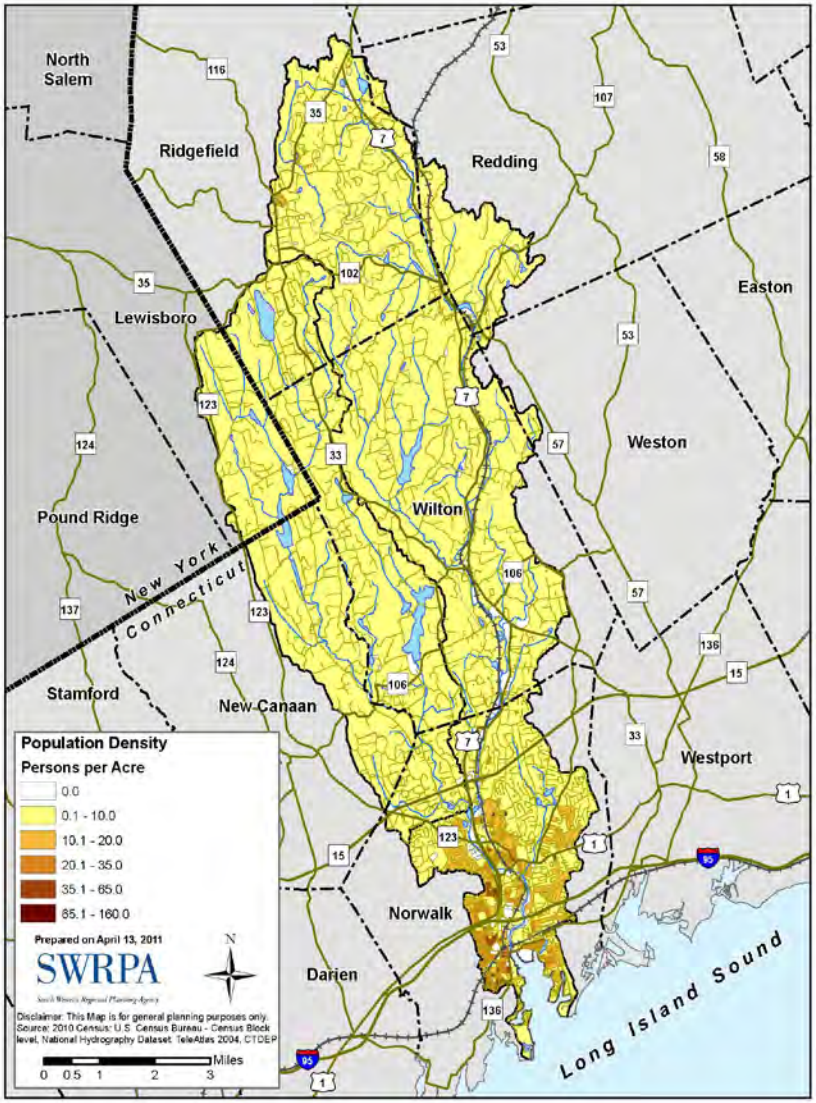


Figure 3-2. Population Density

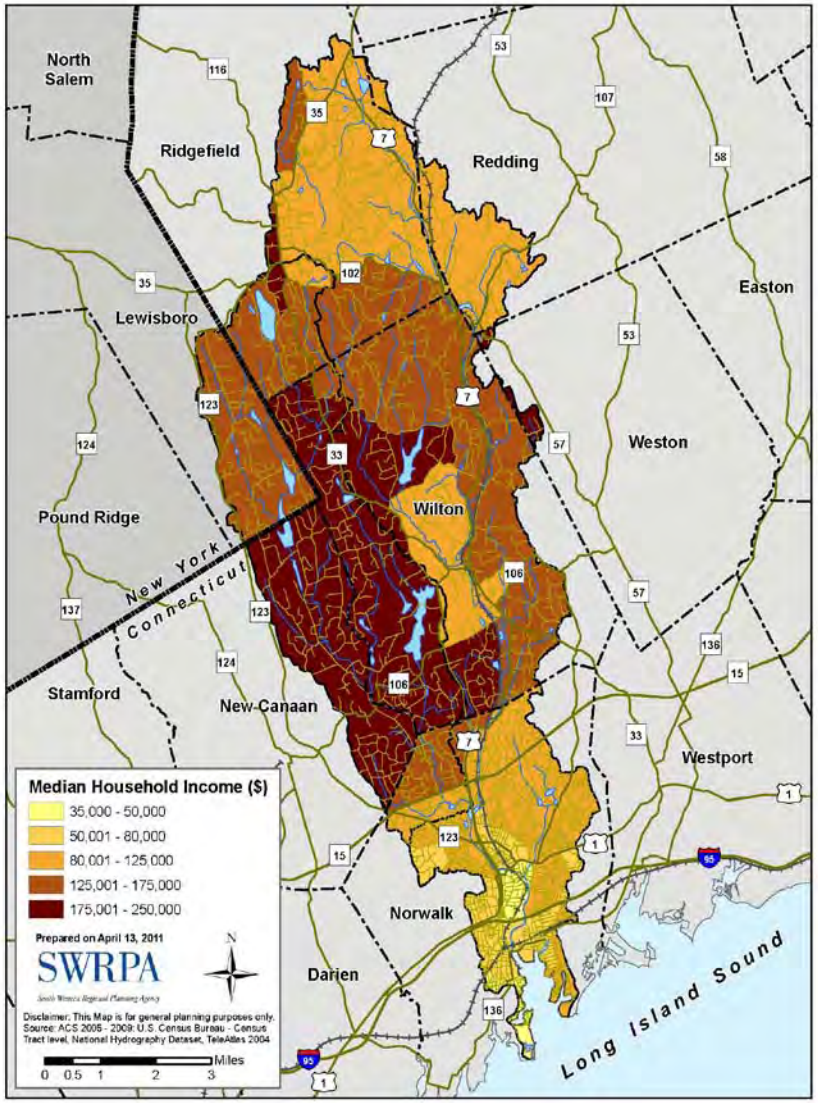


Figure 3-3. Median House Hold Income

Median family incomes for the six Connecticut communities range from $75,000 in Norwalk to $206,000 in Weston (Figure 3-3, Table 3-4). This is higher than the state median family income of $67,721 (U.S. Census Bureau, 2009). Higher levels of income have been correlated with a greater ability to manipulate the land through such activities as residential and commercial development, clearing of second growth forests, in-stream alterations, and lawn development with its associated lawn care services.

Table 3-4. Median Household Income of Municipalities in the Norwalk River Watershed

	New Canaan	Norwalk	Redding	Ridgefield	Weston	Wilton	Lewisboro
Median Household Income	$163,457	$75,695	$122,596	$128,500	$206,469	$153,179	$154,730

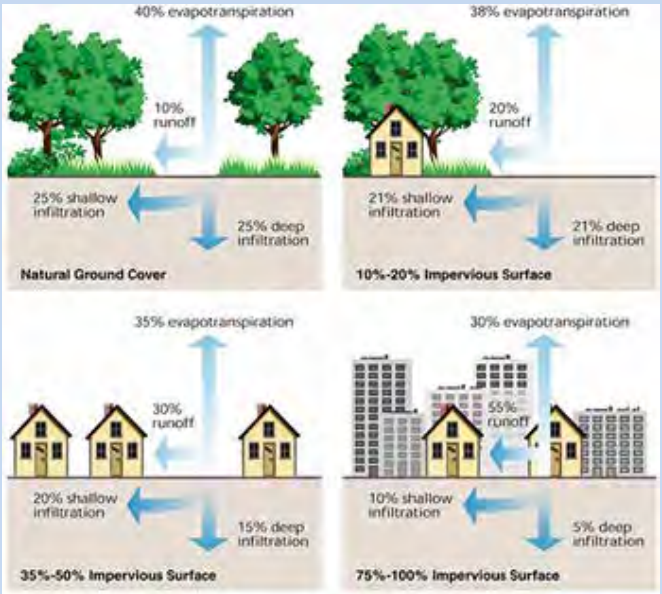
Source: 2005-2009 American Community Survey 5-year Estimates, U.S. Census Bureau

Population growth is expected to continue throughout the watershed, although at a slower pace than in the previous decade. Potential growth is limited because much of the watershed is either built out, or undeveloped parcels are designated as open space. The scarcity of developable land combined with the tremendously high real estate values has pushed developers to look toward land with steep slopes, wetlands and other unfavorable conditions that make them more vulnerable to natural hazards. As population increases, so does the level of impervious surfaces, such as roofs and roadways (Figure 3-4). As the amount of impervious coverage climbs, the level of pollutants in surface water increases, surface water temperatures rise, and erosion caused by storm flows increases. The need for cohesive watershed based planning involving watershed municipalities' is essential to ensure an overall water quality improvement in the Norwalk River watershed.

Impervious cover prevents rain water from absorbing into the ground and results in increased surface runoff. This disruption of the natural water cycle leads to a number of changes, including:

- Increased volume and velocity of runoff
- Increased frequency and severity of flooding
- Peak (storm) flows many times greater than in natural basins
- Loss of natural runoff storage capacity in vegetation, wetlands, and soil
- Reduced groundwater recharge
- Decreased base flow (the ground water contribution to stream flow). This can result in streams becoming intermittent or dry, and also affects water temperature.

As little as 10 percent impervious cover in a watershed can result impact a stream.



Source: Federal Interagency Stream Restoration Working Group

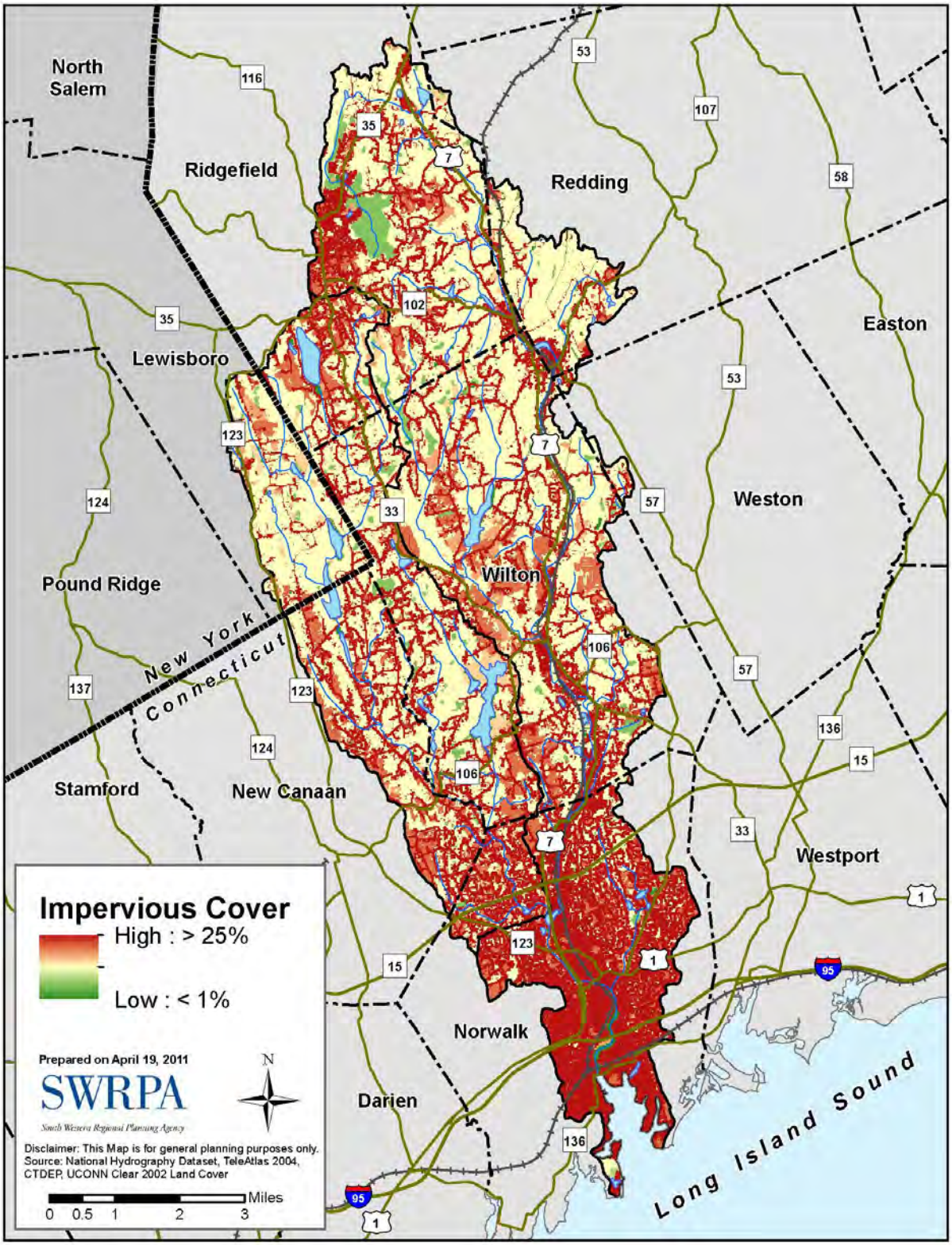


Figure 3-4. Watershed Impervious Cover

3.3 Geological Perspective

Prior to the present-day political boundaries being established, the watershed was defined solely by the geologic processes which molded it. Millions of years ago, this area was a vast open sea called Iapetus (Cappel, 1992). Sediments accumulating from the bordering highlands gradually changed into hardened sedimentary rocks, which were later transformed by heat and pressure from the intense movements of the earth's crust that occurred some 350-575 million years ago. Different degrees of folding, warping, uplift, and crystallization yielded metamorphic rock, creating the rock formations which are visible in road cuts and outcroppings in the region. Movement of glaciers southward 12,000 years ago modified the landscape, forming hills and valleys, and brought pieces of bedrock from as far away as Canada. Soils were altered, leaving glacial till as the predominant soil composition: surficially, the glacial scour created shallow soil cover over bedrock and ground water, and left the landscape strewn with boulders (Figure 3-5). Retreating ice also left behind its terminal moraine, forming Long Island and subsequently, Long Island Sound. Today's river valley shows the scars of its formation, with the river flowing through the resulting valley before discharging to the Sound.

3.4 Inland Wetland

Inland wetlands and watercourses are important for many reasons. They are essential in providing an adequate supply of surface and ground water; they promote hydrological stability and control flooding and erosion; they purify ground and surface waters; and they enable animals and plant life to exist. The role of wetlands in sediment and pollutant renovation, especially in attenuating the effects of nutrients, is an important function that protects water quality in all surface waterbodies, including the Long Island Sound. Many inland wetlands and watercourses have been destroyed or are in danger of destruction because of unregulated use. The deposition, filling or removal of material, the diversion or obstruction of water flow, and the erection of structures and other uses have despoiled, polluted, and eliminated wetlands and watercourses throughout the watershed. Such unregulated activity has had, and will continue to have, a significant, adverse impact on the environment and ecology of this watershed.

Two types of inland wetlands predominant within the Norwalk River Watershed: one is the alluvial and floodplain wetlands which are located primarily along the Norwalk River and its tributaries; and the other is the poorly drained and very poorly drained soils which are located adjacent to alluvial soils and throughout the watershed. Approximately 15% of the watershed contains wetlands. Wetlands are more common in the northern portion of the watershed with fewer wetlands in the southern portion, reflecting a more intensive use of the land over time in the southern portion (Figure 3-6).

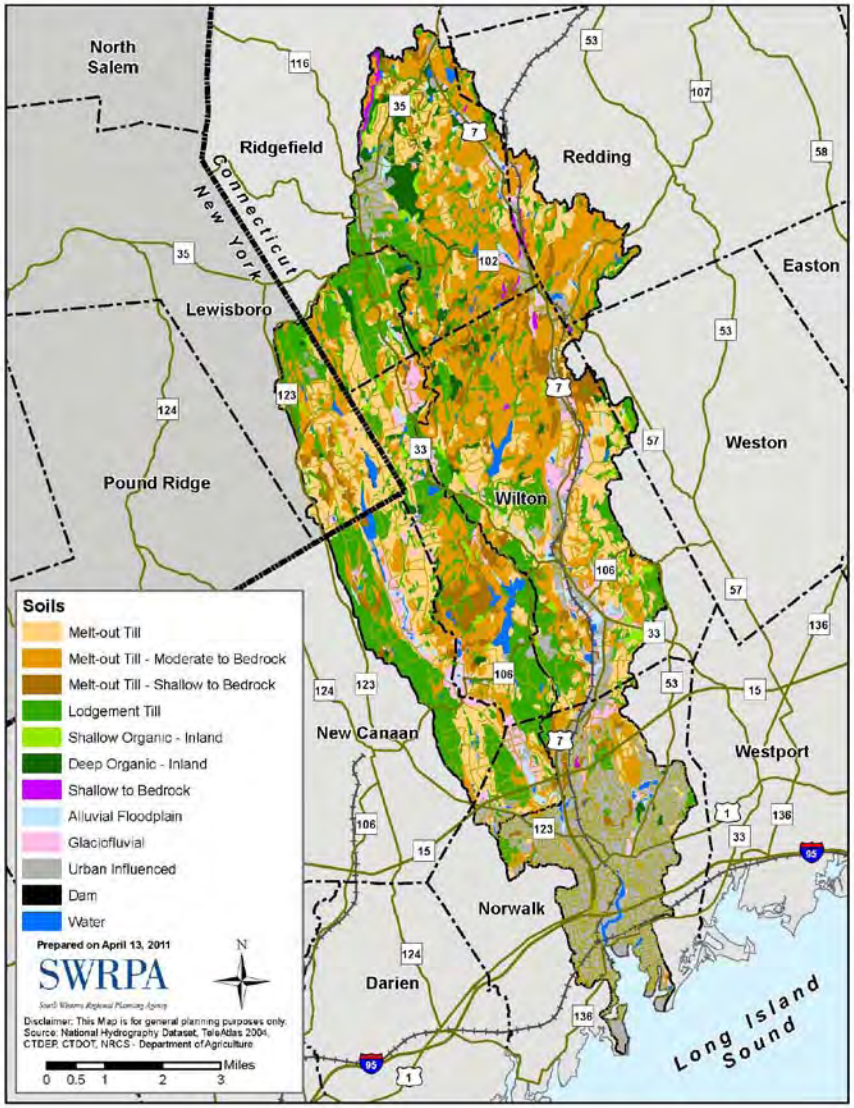


Figure 3-5. Watershed Soils

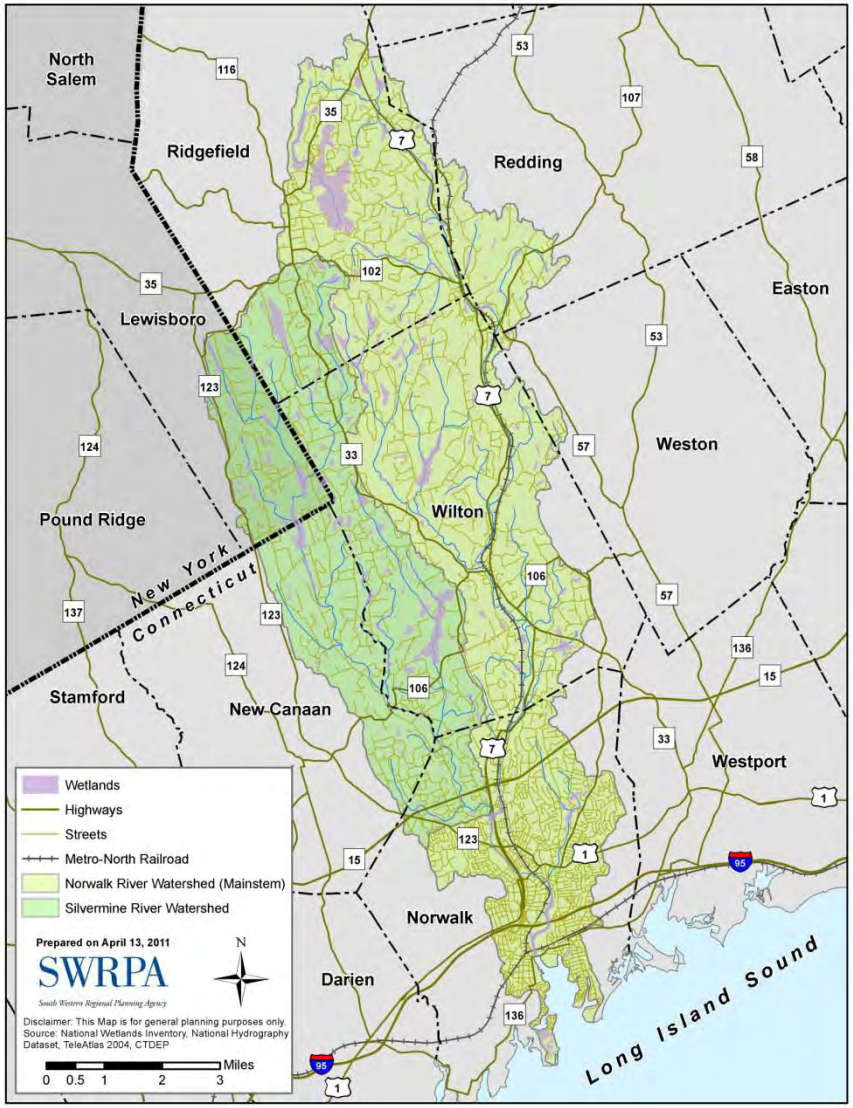


Figure 3-6. Inland Wetlands

3.5 Water Quality Considerations

Both surface and groundwater sources are used to provide water supply to the residents. Recreation is primarily limited to recreational boating at the mouth of the river and the inner harbor and fishing in the entire Norwalk River and its tributaries. The water quantity and quality aspects pertinent to the impairment of the Norwalk River or its tributaries were considered in the development of this WBP.

The watershed exhibits generally good water quality, as reviewed later in this section on ambient water quality data analysis. However, there remain portions of the watershed which are stressed. The watershed faces continuous threats and impacts to water quality from potential nonpoint sources of pollution, such as Stormwater runoff, failing septic systems, and atmospheric deposition of pollutants. The watershed is characterized by mixed land use, with urban and more commercialized and industrialized sectors in the southern portion of the watershed and a high degree of residential settlement elsewhere. Habitat conditions in the watershed vary from extremely good to severely disturbed. Impaired sites are general found along developed lands adjacent to watercourses, excessive algae growth occurs behind impoundments and dams during the summer months, water flow is restricted in certain stream segments, and streambank manipulation is common in both commercial and residential settings. These conditions, plus many others, affect the viability of fish species and populations.

About 66% of the households obtain water from three local public water supply systems: Norwalk First District Water Company, Norwalk Second District Water Company, and Bridgeport Hydraulic Company. Public surface supplies are in the form of reservoirs in Wilton (Second District) and Lewisboro (First District). Public subsurface supplies are large municipal wellfields (such as the Kellogg-Deering wellfield in Norwalk) and several smaller community systems located within the watershed. The remaining 34% of households get water from private wells.

3.5.1 Impoundments

According to the Dam Safety Inventory data collected by the DEEP, 110 registered dams are present in the watershed. Fifty-one dams have been constructed on the Norwalk River and its tributaries in the Wilton area. This inventory identified 10 dams in New Canaan, 23 in Ridgefield, 10in Redding, 16 in Norwalk, and 3 in Lewisboro, New York (Figure 3-7). However, only about seven of these dams are on the mainstem of the Norwalk River. According to the inventory, there are eight dams on the Silvermine River's mainstem. These dams on the Norwalk and Silvermine rivers are considered "run of river," which means that the inflow into the impoundment is equal to the outflow; and provide very little in terms of flood control.

Source: Alexis Cherichetti - Flock Process Dam

The 1997 Stream Walk Assessment identified 13 dams on the Norwalk River and 26 on the Silvermine. This difference may be attributable to the fact that the DEEP inventory does not record small, non-permitted dams (less than six feet in height) which are irregularly constructed out of boards and rocks.

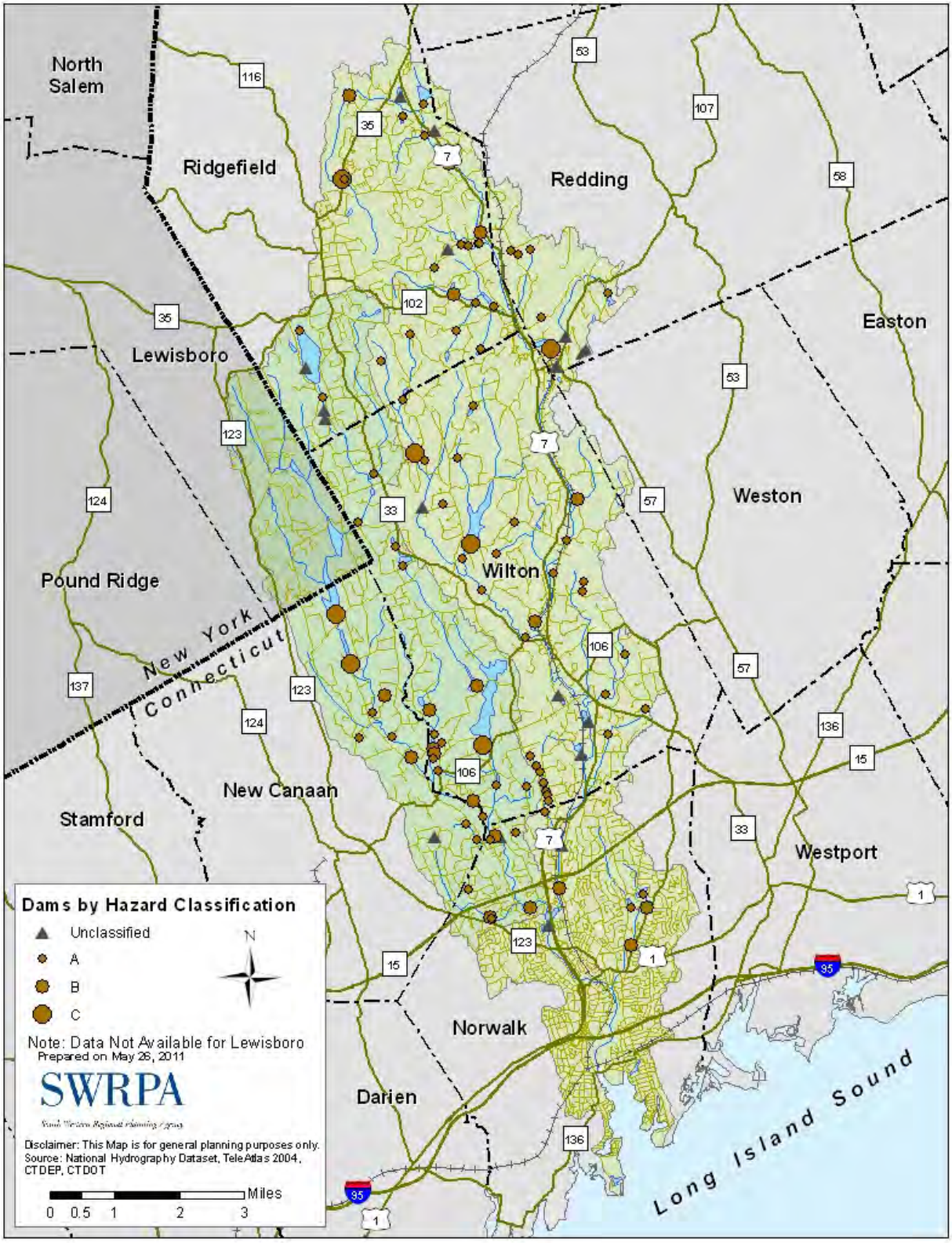


Figure 3-7. Dams in the Norwalk River Watershed

Two flood control dams are present in the watershed: one at the "Great Swamp" in Ridgefield and the other, Spectacle Brook, in Wilton. Both dams affect peak flows of the Norwalk River during flooding conditions. Each contains a wildlife pool regulated by flash boards which allows minimal storage of water for release during dry summer months.

There are eight water supply dams in the Norwalk River Watershed. These dams can provide some flood control protection during periods of heavy rainfall in the summer when they are partially empty. When full, these dams provide about 325 acre-feet of impounded water in this watershed. This type of flood control is not generally accepted because of the uncertainties of summer storms and drawdown of reservoirs.

The rest of the dams in the watershed are privately owned by homeowners and businesses. Many of these dams were constructed as impoundments for recreational or aesthetic purposes.

The presence of these dams in the watershed causes many problems. The Flock Process and Merwin Meadows Dams impeded diadromous fish migration and all seven of the dams on the Norwalk River's main stem impede local fish migration. In addition, the numerous dams located throughout the watershed also increase detention time and reduce the attenuation of nutrients. This, in turn, promotes the growth of plants and algae, resulting in eutrophication.

3.5.2 Municipal Wastewater Treatment Facilities

Fifty-six percent of the households in the Norwalk River Watershed dispose of their wastes in public sewage disposal systems. The remaining households dispose of their sewage through on-site septic systems. There are four municipal wastewater treatment plants providing wastewater treatment service in the Norwalk River Watershed: one in Norwalk (18 million gallons per day (gpd)), one in Georgetown (permitted for 245,000 gpd, currently discharging 60,000 gpd), and two in Ridgefield (1,000,000 gpd). There is also one small private sewage treatment plant in the watershed, the School Sisters of Notre Dame in Wilton, which is permitted to discharge 20,000 gallons per day to the waterway. Wastewater from the areas sewered in Wilton is piped to the Norwalk plant.

All wastewater treatment facilities are permitted through the National Pollution Discharge Elimination System (NPDES). Each of the wastewater treatment facilities are designed and/or operated to provide an advanced level of treatment.
Indicator bacteria concentrations in the Norwalk River are generally in excess of the state water quality standards in several river reaches, limiting recreational uses of the waterways. The Norwalk Harbor and the Norwalk Islands have historically been one of the most productive areas for shellfish along the Connecticut coastline. The Norwalk Harbor area has been historically "closed," classified as "Prohibited" and "Restricted-Relay," to the direct harvesting of shellfish for consumption, due to elevated indicator bacteria levels. In this WBP, the coastal waters supporting shellfish harvesting were not analyzed and discussed, although the management measures undertaken for the control of indicator bacteria in the freshwater portions will also help to benefit the coastal water quality.

3.6 Connecticut Water Quality Standards

The water quality standards (WQS) direct overall policies and actions at a local level to improve and manage the State water resources, as required by Section 303 of the federal Clean Water Act (CWA) and Section 22a-426 of the Connecticut General Statutes. Connecticut's WQS address:

- Restoration of the quality of the State's surface and groundwater resources to support a healthy aquatic environment, enable recreation uses, be suitable for industrial purposes, and provide high quality drinking water for the citizens of the State
- Protection of existing high quality surface and ground waters from degradation
- Segregation of drinking water supplies from waters used for waste assimilation
- Adoption of standards that promote State economy, while protecting the environment.

Table 3-5 summarizes the appropriate classifications assigned by the DEEP for various waterway segments in the Norwalk River watershed. The classifications are designated as either Class AA, A, B, C or D for surface waters, which are defined as below:

AA – drinking water supply, fish and wildlife habitat, recreational (may be restricted), agricultural and industrial supply;
A – potential drinking water supply, fish and wildlife habitat, recreational uses, agricultural supply and navigation
B – recreational, fish and wildlife habitat, agricultural and industrial supply, and navigation

Note that a C or D indicates that the waters are not likely to attain designated uses or meet WQS and that classifications are expressed as a water quality goal, for example as B or A.

The federal CWA requires each state to develop a prioritized list of waterbodies where existing controls on point and non-point sources of pollutants are inadequate to meet WQS and support designated uses. The CWA also mandates that States develop and adopt Total Maximum Daily Loads (TMDLs) for those waters affected by pollutants. The TMDL establishes the maximum amount of a pollutant that may be introduced into waterbody that still allows for the attainment and maintenance of WQS, after the application of technology-based or other required pollution controls.

Table 3-5. Existing Stream Reach Classifications

Waterway	Classification
Norwalk River from headwaters in Ridgefield to the Wall Street Bridge in Norwalk	B
Norwalk River below the Wall Street Bridge into the inner harbor area	SB
Lower portion of Silvermine River where it meets Belden Hill Brook to above Deering Pond in Norwalk	A
Comstock Brook	AA and A
Belden Hill Brook, Mayapple Brook and Bryant Brook in Wilton	A

Source: Compiled based on Table 3 of CTDEP (2005) on Applicable Indicator Bacteria Criteria for the Subject Waterbodies

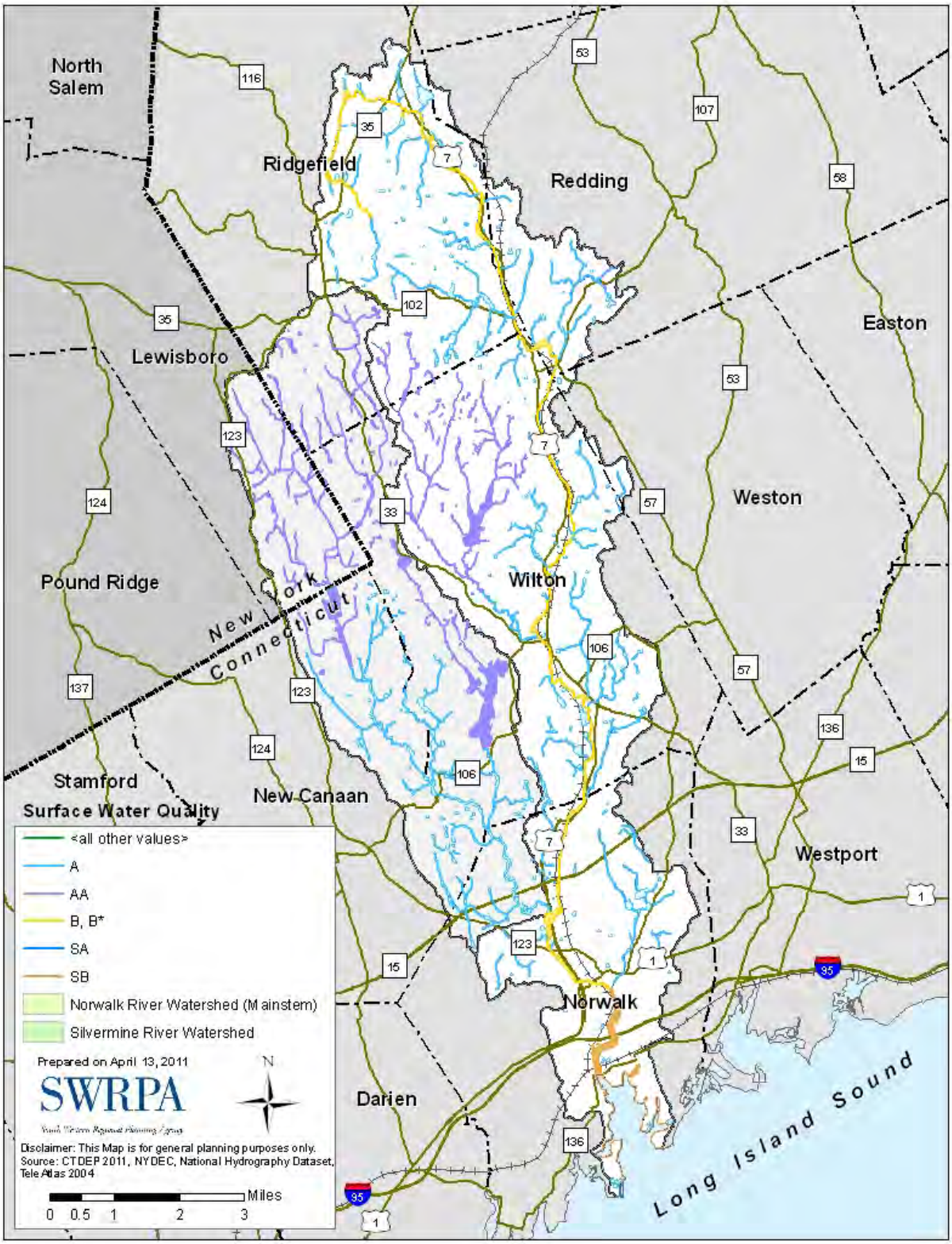


Figure 3-8. Norwalk River Water Quality Classifications

The *2008 State of Connecticut Integrated Water Quality Report* reviews the latest list of impaired waterbodies (often known as the 303(d) list), indicating surface waters in the State do not meet, or are not expected to meet (even with required pollution controls), state WQS and may require TMDLs. Table 3-6 identifies waterbodies found within the Norwalk River Watershed that are included in the 303(d) List (CTDEP, 2008). The table also provides information on the supporting designated uses.

The designations used in Table 3-6 are as follows: Y indicates that the designated use is fully supported; N reflects that the designated use is not supported and U indicates that DEEP has not assessed due to sparse or no data available for assessment. For the designated uses, AQ corresponds to the aquatic life, REC is for recreational uses, and FISH corresponds to the fish consumption.

Table 3-6. Summary of Water Quality Conditions in the Norwalk River and Tributaries

ID305B	Name	Location	Designate Use Met			
			River Miles	AQ	REC	FISH
CT7300-00_01	Norwalk River-01	From Wall Street (Commerce Street) crossing (head of estuary/saltwater limit), Norwalk, US to confluence with Bryant Brook (DS of Wolfpit Road crossing), Wilton. (Segment includes Winnipauk Mill Pond and Deering Pond)	5.63	N	N	Y
CT7300-00_02	Norwalk River-02	From confluence with Bryant Brook (DS of Wolfpit Road crossing), US to Old Mill Road crossing (between Danbury Road (Route 7) and Railroad tracks southeast of Georgetown), Wilton.	5.61	Y	N	Y
CT7300-00_03a	Norwalk River-03a	From Old Mill Road crossing (between Danbury Road (Route 7) and Railroad track, southeast of Georgetown), Wilton, US to confluence with Georgetown WPCF outfall, Redding.	0.84	N	N	U
CT7300-00_03b	Norwalk River-03b	From confluence with Georgetown WPCF outfall, US to just US of Railroad crossing*, Redding.	0.20	U	N	U
CT7300-00_03c	Norwalk River-03c	From US of Railroad crossing*, US to Factory Pond outlet dam outlet, Redding. (Factory Pond is a separate waterbody, between segment-03c and -04).	0.11	U	U	U
CT7300-00_04	Norwalk River-04	From INLET to Factory Pond (just DS of Danbury Road (Route 7) crossing), Wilton, US to confluence with Cooper Pond Brook (DS of Branchville Road, east of intersection with Route 7), Ridgefield.	0.70	U	N	Y
CT7300-00_05	Norwalk River-05	From confluence with Cooper Pond Brook (DS of Branchville Road, east of intersection with Route 7), Ridgefield, US to headwaters at Little Pond outlet dam (US of confluence with Ridgefield Brook from west, on west side parallel to Route 7), Ridgefield.	4.85	U	N	Y
CT7300-02_01	Ridgefield Brook-01	From confluence with Norwalk River (DS of headwaters at Little Pond outlet dam, west side of Route 7), US to Taylors Pond outlet dam (US of Limestone Road crossing), Ridgefield.	1.05	U	N	Y
CT7300-02_02	Ridgefield Brook-02	From INLET to Taylor Pond (on southwest portion of pond, east of Barrow Mountain), US (south) to headwaters at outlet of Lounsebury Pond in southwest portion of Great Swamp, Ridgefield. (Segment includes outfall of Ridgefield POTW, upper Great Swamp area)	3.22	N	N	Y

* Location changed to reflect current conditions, the 'underground (pipe) section' and base of factory pond dam have been daylighted

CT7300-07_01	Cooper Pond Brook-01	From mouth at confluence with Norwalk River (DS of Ethan Allen Highway (Route 7) crossing), US to Candees Pond outlet dam, Ridgefield.	0.41	U	U	Y
CT7300-07_02	Cooper Pond Brook-02	From INLET to Candees Pond, US to headwaters at unnamed pond (on south side of Florida Hill Road, at intersection with Ivy Hill Road), Ridgefield. (Segment includes Grimes Pond and Johns Pond)	1.89	U	U	Y
CT7301-00_01	Comstock Brook (Wilton)-01	From mouth at confluence with Norwalk River (segment-02, just DS of Lovers Lane crossing), US to confluence with Barretts Brook (outlet for Popes Pond, parallel to Route 33, at intersection with Signal Hill Road), Wilton.	2.02	Y	U	Y
CT7301-00_02	Comstock Brook-02 (Wilton)	From confluence with Barretts Brook (outlet for Popes Pond, parallel to Route 33, at intersection with Signal Hill Road), US to HW (just west and parallel with Grey Rocks Road), Wilton.	2.29	U	U	Y
CT7302-00_01	Silvermine River-01	From Mouth at confluence with Norwalk River (northwest INLET to Deering Pond portion of river), US to Merritt Parkway (Route 15) crossing), Norwalk. (Segment includes Davis Pond)	0.98	U	N	Y
CT7302-00_02	Silvermine River-02	From Merritt Parkway (Route 15) crossing), Norwalk, US to Grupes Reservoir outlet dam (US of Valley Road crossing), New Canaan.	5.49	Y	N	Y

Source: Compiled from CTDEP (2008) State of Connecticut Integrated Water Quality Report, August 2008.

High levels of nutrients (both phosphorus and nitrogen) can cause water quality concerns in the tributaries and mainstem of the river and eventual delivery of nutrients into LIS. Several impoundments in the Norwalk River watershed such as Great Swamp have been identified to have excessive algal growth (NRCS, 1997; 1999). Localized nutrient inputs such as lawn fertilizers, failed septic systems and illicit discharges contribute to these water quality concerns.

Most of DEEP's assessment is based on monitoring of the water quality conditions and in-stream surveys to determine if a certain species is present or not in a waterbody. The WQS for nutrients are essentially narrative at this time in the upper drainage areas and numeric targets will need to be determined through water quality modeling of the entire system and setting appropriate targets for each segment of the mainstem and the tributaries. In the downstream end, the hypoxic conditions in the western end of LIS require a 10% reduction in TN loads from various non-point sources of pollution. This WBP suggests strategies that can help in achieving the 10% TN load reduction in the near future and also recommends that detailed water quality characterization studies be undertaken to set numeric TN and TP reduction targets for individual impoundments with eutrophication concerns.

In Connecticut's freshwaters *Escherichia Coli* (*E. coli*) is considered as indicator bacteria, which originates from the intestinal tracts of humans and other warm blooded animals. The water quality standards for *E. coli* in the fresh water portion of Norwalk River and its tributaries include: (a) not-to-exceed 235 colonies/100milliliter (mL) for bathing areas, 410/100mL for non-designated swimming areas or 576/100mL (all other water contact recreation) for single samples; and (b) not-to-exceed geometric mean of 126 colonies/100 mL for any group of samples. Since only the freshwater portions of the Norwalk River and its tributaries are covered in this WBP, the *E. coli* targets used by DEEP (CTDEP 2005) to develop load allocations for the non-point sources within the Norwalk River and its tributaries are applied without any further modifications

3.7 Analysis of Ambient Water Quality Monitoring Data

Available ambient water quality monitoring data indicate generally good water quality in the Norwalk River, with respect to its ability to support aquatic life. However, there are continuous threats and impacts to water quality from the following:

- Non-point sources, such as runoff from commercial and industrial areas that contains high concentrations of sediments, hydrocarbons, and metals, and direct precipitation (i.e., atmospheric deposition of nitrogen).
- High levels of indicator bacteria which can be attributed to wildlife and domestic animal sources, improperly functioning septic systems and occasional sewer overflows.
- Stormwater discharges (Stormwater runoff and permitted discharges) throughout the watershed.

In developing the TMDL for the Norwalk River DEEP reviewed the extensive ambient water quality monitoring data for *E. coli* and fecal coliform (CTDEP, 2005). Specific surveys were conducted by the Department of Agriculture/Bureau of Aquaculture in the early 1990s along the Norwalk River from the harbor northward. In addition, Harbor Watch/River Watch (HW/RW) has conducted water quality monitoring for physical/chemical parameters at more than 20 sites from Georgetown to Norwalk Harbor since 1999. These monitoring programs have identified and documented pollution sources including illegal wastewater discharges, failing septic systems, raw sewage discharges, pavement runoff and raw sewage discharges from marinas, as well as changes in wildlife species composition.

Monitoring data from HW/RW collected over the past 10 years in various reaches of the Norwalk River watershed were provided to support this study. Locations of monitoring stations are shown in Figures 3-9 and 3-10, for the upper and lower reaches of the Norwalk River watershed, respectively. The summaries of water quality data for three key parameters chosen for this analysis, namely, dissolved oxygen (DO), Fecal coliform (FC) and *E. coli* are provided in Tables 3-7 through 3-9.

Dissolved oxygen is a critical water quality parameter for characterizing the health of an aquatic system. It is a measurement of oxygen dissolved in water which is available to fish and other aquatic life. The DO content of water results from the photosynthetic and respiratory activities of the flora and fauna in the system, and the mixing of atmospheric oxygen with waters through wind and stream current action. Levels above 5 milligrams per liter (mg/L) are generally considered to be healthy for most forms of aquatic life and a level below 3 mg/l is stressful to most vertebrates and other forms of aquatic life. The overall DO levels are very good and can support most forms of aquatic life. However, in the upper reaches of Norwalk River some hotspots exist, near NR20 and NR21 (located in the upper reaches of Norwalk River in Ridgefield, as shown in Figure 3-9), where the DO levels below 5 mg/L have been observed. Table 3-7 shows the range of DO values and also lists the number of observations with less than 5 or 3 mg/L as threshold values.

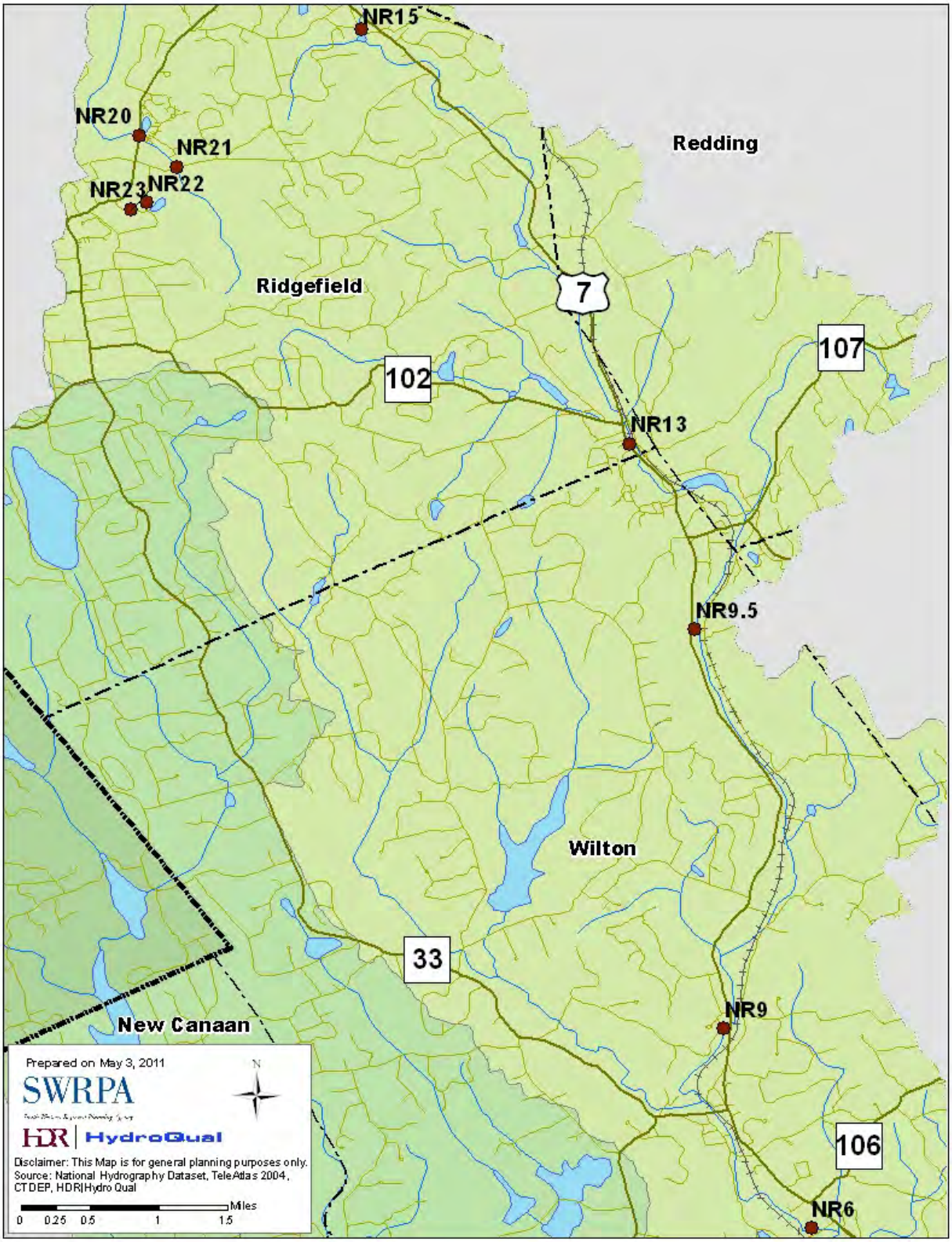


Figure 3-9. Monitoring Locations in the Upper Reaches of Norwalk River Watershed

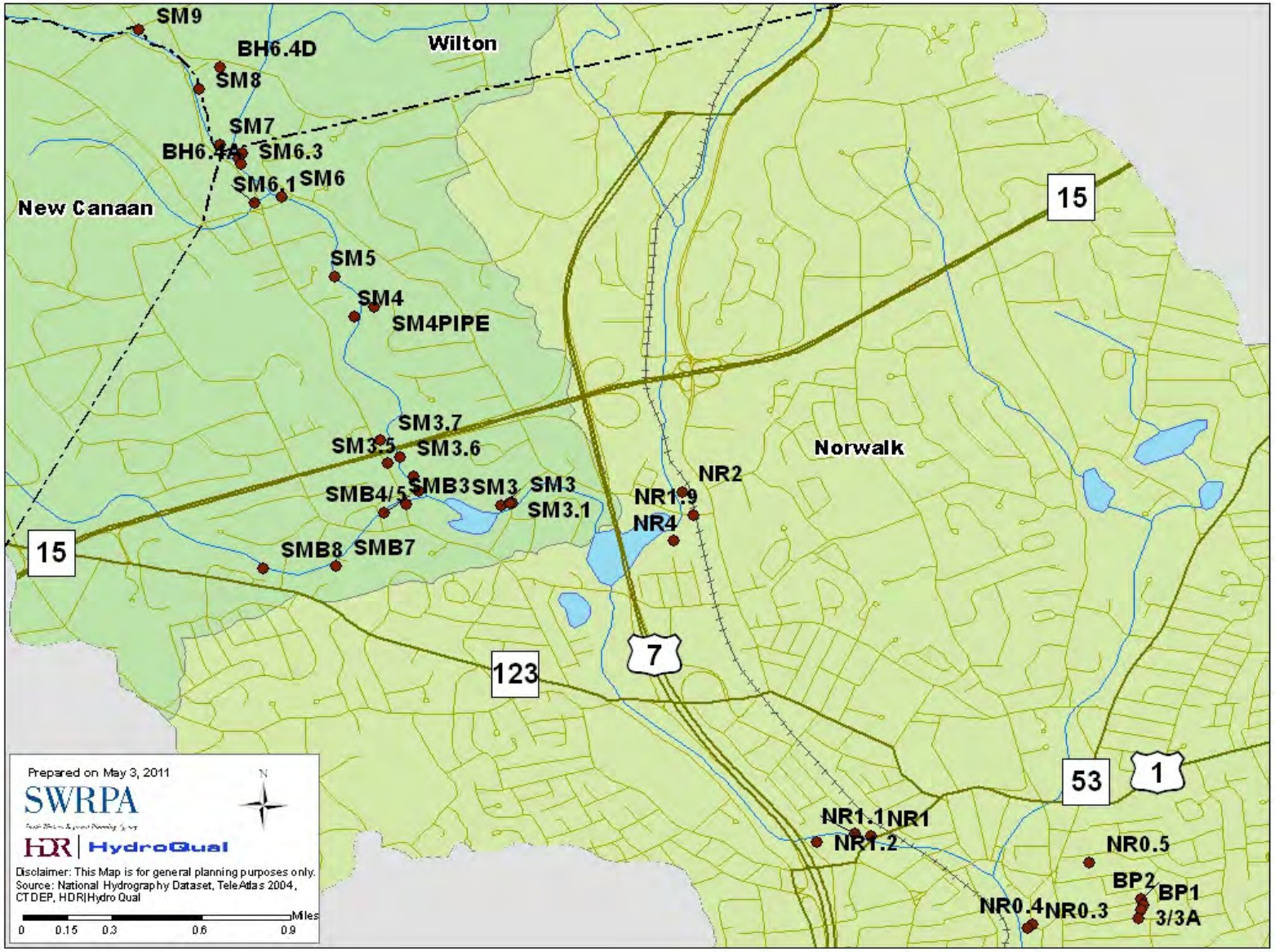


Figure 3-10. Monitoring Locations in the Lower Reaches of Norwalk River Watershed

Table 3-7. Summary of Water Quality Data: Dissolved Oxygen

Station ID	Total Number of Observations	Minimum DO Observed [mg/L]	Maximum DO Observed [mg/L]	Average DO [mg/L]	Number of Observations with DO < 5 mg/L	Number of Observations with DO < 3 mg/L
GS1	-	-	-	-	-	-
GS2	-	-	-	-	-	-
GS3	-	-	-	-	-	-
NR1	245	7.1	15.7	10.0	-	-
NR10	33	4.7	10.7	8.5	1	-
NR11	33	7.7	11.2	9.1	-	-
NR13	243	6.0	16.5	9.7	-	-
NR15	244	6.5	18.1	9.4	-	-
NR2	33	8.8	13.3	10.2	-	-
NR20	244	2.6	17.7	8.4	27	1
NR20.1	-	-	-	-	-	-
NR21	245	1.9	14.5	6.6	64	10
NR22	232	4.0	16.2	8.7	1	-
NR23	234	5.4	15.2	9.8	-	-
NR2SD	7	8.0	9.9	8.9	-	-
NR4	247	7.2	16.5	10.6	-	-
NR4.1	2	8.5	9.1	8.8	-	-
NR4.2	2	8.4	8.5	8.5	-	-
NR4pipe	8	7.5	8.9	8.2	-	-
NR6	245	6.0	17.1	10.0	-	-
NR9	245	6.4	15.8	9.8	-	-
NR9.5	245	6.4	16.1	9.6	-	-
SM3	212	6.6	15.3	9.5	-	-
SM3.1	-	-	-	-	-	-
NR4.3	1	8.4	8.4	8.4	-	-
NR4.4	1	8.3	8.3	8.3	-	-

Source: HW/RW monitoring data through Spring 2010

Although the DEEP has formally adopted *E. coli* as the indicator bacteria, FC data were also available from the HW/RW monitoring program. For the treatment plant effluents, the DEEP standards for FC comprise of a geometric mean of less than 200 CFU/100mL over a 30-day period and a single sample maximum of 400 CFU/100mL.

The DEEP standards for *E. coli* comprise of a geometric mean of 126 colonies/100mL with a single sample maximum value set based on the recreational uses: 256 colonies/100mL for swimming reaches, 410 colonies/100mL for non-swimming reaches and 576 colonies/100mL for other recreational uses.

The HW/RW data were divided into wet and dry categories using the rainfall data available at Danbury and Westchester County Airport. Tables 3-8 and 3-9 show the summaries of indicator bacteria concentrations observed during wet and dry weather periods, respectively, at the various HW/RW monitoring locations. The locations where the geometric means for FC and *E.coli* are in excess of 200 and 126 colonies/100mL are highlighted in these tables.

Table 3-8. Summary of FC/*E. coli* Data Observed During Wet Weather

Station ID	Total Number of Observations	Minimum Fecal Coliform Observed [CFUs/100mL]	Maximum Fecal Coliform Observed [CFUs/100mL]	Geometric Mean of Fecal Coliform Observed [CFUs/100mL]	Station ID	Total Number of Observations	Minimum E. coli Observed [CFUs/100mL]	Maximum E. coli Observed [CFUs/100mL]	Geometric Mean of E. coli Observed [CFUs/100mL]
GS1	1	194	194	194	**GS1**	-	-	-	-
GS2	1	140	140	140	**GS2**	-	-	-	-
GS3	1	70	70	70	**GS3**	-	-	-	-
NR1	82	45	12,300	603	**NR1**	87	42	9,600	491
NR10	13	54	1,920	300	**NR10**	13	27	1,680	185
NR11	13	74	2,760	506	**NR11**	13	60	2,500	384
NR13	86	8	20,400	294	**NR13**	86	8	18,000	245
NR15	85	30	10,200	344	**NR15**	86	18	9,100	295
NR2	13	130	18,300	877	**NR2**	13	120	11,900	671
NR20	88	14	10,600	520	**NR20**	87	12	9,800	415
NR20.1	-	-	-	-	**NR20.1**	-	-	-	-
NR21	87	4	19,000	567	**NR21**	88	2	11,000	473
NR22	84	0	146,000	76	**NR22**	46	0	9,000	25
NR23	85	4	18,000	523	**NR23**	58	2	13,000	491
NR2SD	11	250	15,800	2181	**NR2SD**	-	-	-	-
NR4	86	0	9,300	552	**NR4**	86	0	6,900	448
NR4.1	1	440	440	440	**NR4.1**	1	0	0	-
NR4.2	1	500	500	500	**NR4.2**	-	-	-	-
NR4pipe	6	0	4,200	82	**NR4pipe**	6	0	3,520	71
NR6	85	16	100,000	375	**NR6**	87	16	100,000	321
NR9	84	8	6,200	244	**NR9**	86	8	5,100	209
NR9.5	84	4	9,200	156	**NR9.5**	86	4	7,720	128
SM3	72	22	12,400	461	**SM3**	73	20	11,780	410
SM3.1	6	0	2,300	1392	**SM3.1**	6	0	2,200	1334
NR4.3	-	-	-	-	**NR4.3**	-	-	-	-
NR4.4	-	-	-	-	**NR4.4**	-	-	-	-

Source: HW/RW monitoring data through Spring 2010

Table 3-9. Summary of FC/*E. coli* Data Observed During Dry Weather

Station ID	Total Number of Observations	Minimum Fecal Coliform Observed [CFUs/100mL]	Maximum Fecal Coliform Observed [CFUs/100mL]	Geometric Mean of Fecal Coliform Observed [CFUs/100mL]	Station ID	Total Number of Observations	Minimum E. coli Observed [CFUs/100mL]	Maximum E. coli Observed [CFUs/100mL]	Geometric Mean of E. coli Observed [CFUs/100mL]
GS1	-	-	-	-	**GS1**	-	-	-	-
GS2	-	-	-	-	**GS2**	-	-	-	-
GS3	-	-	-	-	**GS3**	-	-	-	-
NR1	155	12	40,000	340	**NR1**	158	12	31,000	248
NR10	20	8	3,320	107	**NR10**	20	8	2,560	83
NR11	20	24	2,620	274	**NR11**	20	24	2,000	217
NR13	157	4	2,150	137	**NR13**	158	6	1,820	119
NR15	158	6	6,500	166	**NR15**	157	0	3,000	142
NR2	20	76	1,580	378	**NR2**	20	67	1,080	289
NR20	158	8	6,500	198	**NR20**	158	4	5,300	166
NR20.1	1	224	224	224	**NR20.1**	1	188	188	188
NR21	158	4	18,000	267	**NR21**	158	4	16,200	221
NR22	153	0	114,000	52	**NR22**	99	0	71,000	56
NR23	152	2	19,000	184	**NR23**	107	0	17,900	127
NR2SD	19	10	55,000	1254	**NR2SD**	1	340	340	340
NR4	155	12	2,800	274	**NR4**	158	12	2,200	216
NR4.1	1	570	570	570	**NR4.1**	-	-	-	-
NR4.2	1	630	630	630	**NR4.2**	-	-	-	-
NR4pipe	4	8	236	42	**NR4pipe**	4	0	8	6
NR6	154	6	3,000	175	**NR6**	158	4	2,000	145
NR9	157	0	2,380	114	**NR9**	158	0	2,200	94
NR9.5	159	0	4,000	83	**NR9.5**	159	0	3,600	67
SM3	139	16	6,800	182	**SM3**	139	12	6,700	149
SM3.1	8	160	40,000	2448	**SM3.1**	6	160	38,000	1907
NR4.3	1	570	570	570	**NR4.3**	-	-	-	-
NR4.4	1	575	575	575	**NR4.4**	-	-	-	-

Source: HW/RW monitoring data through Spring 2010

There is a general increasing trend in FC concentrations towards the downstream locations, during both wet and dry weather periods. However, there are a number of hotspots including NR21 and NR23 in the upper reaches of Norwalk River in Ridgefield and SM3.1 in the Silvermine River, with high concentrations of bacteria even during dry weather.

As shown in Tables 3-7 and 3-8, the trends in *E. coli* for not meeting the WQS are consistent with the observations made on the FC data. The upper and lower reaches of the Norwalk River and the monitoring stations SM3 and SM3.1 along the Silvermine River appear to have elevated bacteria concentrations. It must be emphasized that these datasets collected over the past 10 years may have 1-2 samples per month in some locations and very limited number of observations in other locations. Due to high variability in bacteria concentrations and suspected illicit discharges from the streamwalk surveys (NRCS, 1997; 1999) and HW/RW monitoring data, targeted additional monitoring is needed to pinpoint specific sources and pursue appropriate control measures.

A graphical visualization of the dry and wet weather monitoring results can be an effective tool to facilitate the hotspot identification and planning process. To support this, the entire Norwalk River ands its tributary watersheds were divided into smaller sub-watersheds. Targeted planning efforts could be undertaken at this sub-watershed scale involving one or more impaired segments. The sub-regional and local basin (sub-watershed) delineations developed by UCONN (http://cteco.uconn.edu/guides/Local_Basin.htm) were adopted as the starting point. Some sub-watersheds along the main stem of Norwalk River were rather large. Therefore, additional sub-watersheds were created in this project based on watershed topography. Figure 3-11 shows the sub-watersheds delineated here to support the overall watershed characterization and estimation of pollutant loads. The association between sub-watersheds and the impaired segments identified by DEEP is shown in Figure 3-12 (CTDEP, 2008).

Figure 3-13 shows the identified hotspots for indicator bacteria during dry weather. The likely sources of bacteria during dry weather include illicit discharges to storm sewers or excessive waterfowl and wildlife contributions in the impoundments that discharge into the waterways. Starting from around NR21, the high levels of indicator bacteria could be seen all the way up to NR9.5 in the Town of Wilton.

From station NR9 in the downstream end of the Town of Wilton through the Norwalk Harbor, including the lower reaches of the Silvermine River, the bacteria levels during dry weather were excessively high. The upper reaches of Silvermine River and Comstock Brook have water supply diversions and do not have sufficient data to assess the adequacy of bacterial water quality to meet the state standards. However, the failing septic systems and illicit discharges into storm sewers could be attributed to high bacterial levels in the lower reaches of Wilton, City of Norwalk, and into the Norwalk Harbor.

Bacterial water quality did not meet the state standards in every reach of the Norwalk River watershed and its tributaries during wet weather periods.

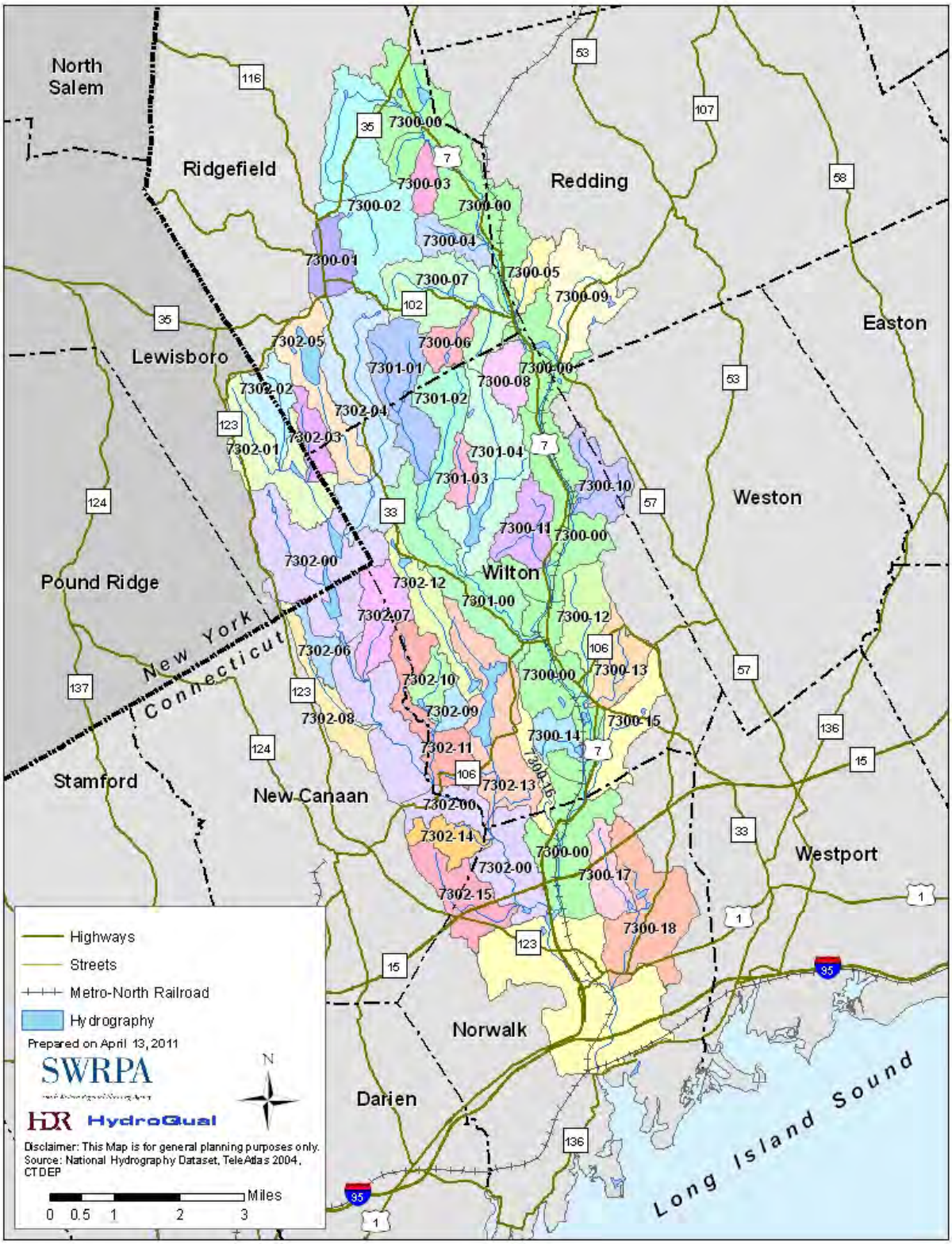


Figure 3-11. Sub-watersheds in the Norwalk River and its Tributaries

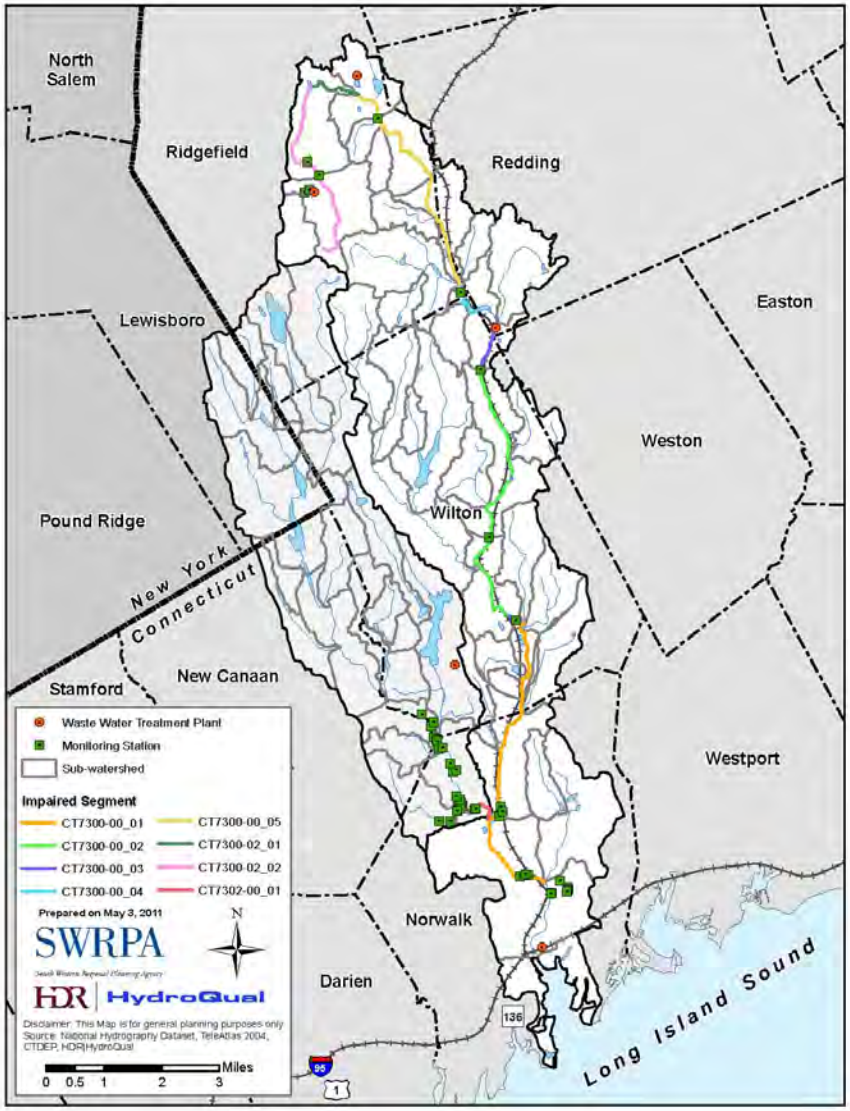


Figure 3-13: Impaired Segments

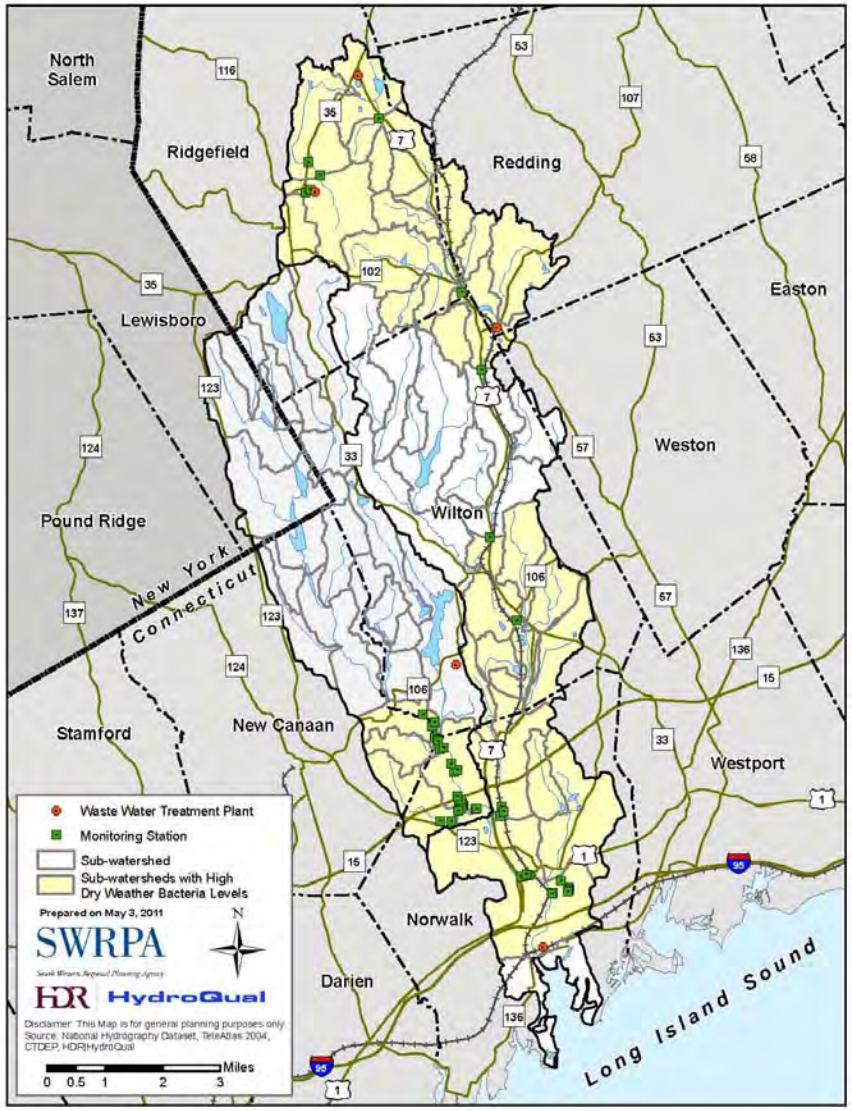


Figure 3-13: Sub-watersheds with High Bacteria Levels during Dry Weather

4. ESTIMATION OF POLLUTANT LOADS

Numerous mathematical models have been developed to characterize nutrient pollution loads for the State of Connecticut watersheds including the Norwalk River basin and its tributaries. These models have ranged from simple Rainfall-Runoff Modeling Program developed by HydroQual as part of LIS TMDL development (NYSDEC and CTDEP, 2000), to a parameter-intensive complex HSPF model developed by AQUA TERRA and HydroQual (2001). Moore et al. (2004) and Penn State (2007) developed modeling frameworks for the entire New England region that included Norwalk River watershed as a very small component. A mid-range model, in ArcView based Generalized Watershed Loading Functions (AVGWLF) framework, was developed by Farley and Rangarajan (2006) for the States of Connecticut and New York to support the tracking of pollutant load reductions from in-basin drainage areas contributing to the Sound. These models have been applied in the past to develop pollutant loads for parameters such as total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS). However, none of these models were applied to characterize pollutant loads for indicator bacteria.

Due to limited budget available in this project to support model development and calibration, the readily available mid-range AVGWLF model developed by Farley and Rangarajan (2006) was chosen to characterize the sediment (TSS is taken as surrogate parameter for sediments), TN and TP loads from the Norwalk River watershed. The goal was to resurrect this model application and update it based on available monitoring data to enable its use for pollutant load assessments. The reductions in nutrient and sediment loads can be estimated by associating expected pollutant reduction effectiveness of individual management measures. A brief description of the selected model with key assumptions and limitations is provided in the following section. Additional details on the model along with the calibration process for nutrients are provided in Appendix C.

A limitation for this approach is that the previous AVGWLF model application did not involve simulation of the indicator bacteria. This model was originally developed to support watershed planning efforts to reduce nutrient loads (Evans et al., 2002; 2003; and 2007) and has been updated very recently in 2009-10 to characterize the loads and reductions for management measures for indicator bacteria. Based on discussions with the developer (personal communications with Dr. Barry Evans, Penn State, July 2010), there were no published journal/conference articles or reports available as of July 2010 on the application of AVGWLF to indicator bacteria load estimation. In addition, the simulations performed by HDR|HydroQual with default indicator bacteria parameters (e.g., Fecal Coliform and *E. coli*) provided in the AVGWLF guidance document yielded unrealistic results (an order or two larger in magnitude in comparison to the monitored data available from HW/RW).

A simple approach has been developed in this project that uses hydrologic inputs from AVGWLF and associates event mean concentrations (EMCs) to calculate the pollutant loads for indicator bacteria. The DEEP had applied a flow-duration pollution load estimation concept (CTDEP, 2005) to quantify loads for various indicator bacteria for the different reaches identified in the 2008 list of impaired waterbodies (CTDEP, 2008). For the purposes of planning and evaluating the effectiveness of various management measures to reduce indicator bacteria loads, the procedure developed by DEEP (CTDEP, 2005) and associated load reductions for the various impaired segments were adopted in this project.

4.1 Key Model Features and Limitations

AVGWLF is a GIS-interface (in ArcView) for the Generalized Watershed Loading Functions (GWLF) model developed at Cornell University (Haith et al., 1992). For pollutant loading, the model is considered to be distributed since it allows multiple land use/cover scenarios, but each area (e.g., sub-watershed or a larger watershed) is assumed to be homogeneous in terms of the area attributes (physical slope, soil type, etc.). Loads from individual source areas (pollutant load generating areas represented by various land use/cover types) are simply aggregated to compute the total watershed loading.

Depending on the locations of the source areas with respect to a watershed outlet, the in-stream transformations can attenuate loading from these areas before reaching the outlet point. GWLF does not explicitly account for spatial routing and the in-stream transformations. This can generally lead to overestimation of loads, which is a conservative approach for the load reduction planning process.

For sub-surface (groundwater) flow and pollutant loads, the model uses a lumped parameter approach involving water balance over the entire watershed or sub-watershed. Another GWLF model limitation is that routing through reservoirs/ponds and diversions between sub-watersheds (e.g., water supply diversion from Comstock Brook) cannot be explicitly represented. Finally, the model has a rigid land use/cover categorical structure and requires consolidation of various land use categories into this specific structure. A major requirement is the specification of low and high density areas in developed areas where different loading rates for various water quality parameters are assigned, in order to compute the overall pollutant load from an urban landscape.

Daily weather data (e.g., precipitation, temperature) are used to generate the surface runoff component of stream flow using Soil Conservation Services (SCS, also known as NRCS) curve numbers. Erosion and sediment yield are computed using monthly erosion calculations based on the Universal Soil Loss Equation (USLE). Surface nutrient losses are determined by applying dissolved nitrogen (N), carbon (C) and phosphorus (P) concentrations to surface runoff for each agricultural source area. Point source discharges can also contribute to dissolved losses and are specified in terms of kilograms per month. Manured areas (including seasonal applications) and septic systems can explicitly be considered. Infiltrated components of nutrients from septic systems are tracked as part of the groundwater pollutant load, and the loads generated as a result of septic system failures are tracked separately.

All urban nutrient inputs are assumed to be solid-phase – the model uses exponential accumulation and washoff function for these loadings. Sub-surface losses are calculated using dissolved N and P concentrations for shallow groundwater contributions to stream nutrient loads, and the sub-surface model considers the entire watershed as single, lumped-parameter contributing area. A schematic of the GWLF model components is shown in Figure 4-1.

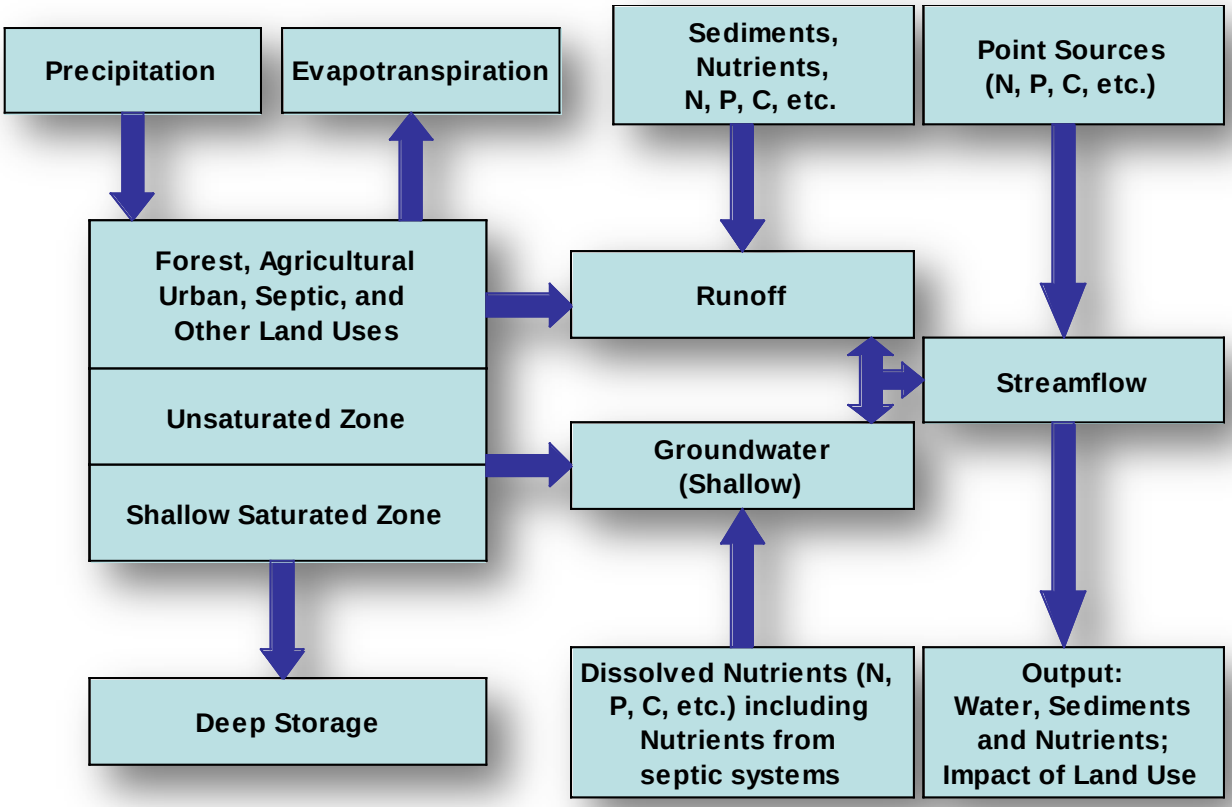


Figure 4-1. GWLF Model Components

4.2 Nutrient and Sediment Load Estimation

Land use/land cover data for the watershed were obtained from the UCONN MAGIC website (http://magic.lib.uconn.edu/) for the Connecticut portion. Data available from the GIS archive of Westchester County (New York) was obtained for the Lewisboro portion of the Norwalk watershed (http://giswww.westchestergov.com/wcgis/Data.htm). As previously indicated, the AVGWLF model explicitly requires high and low density development categories in an urban landscape so that it can associate distinct pollutant load generation factors to these two categories for computing the overall load. The 1995 land cover data distinguishes between these two categories, while the newer 2002 or 2006 land cover datasets have only one urban category.

The 1995 data was therefore used in AVGWLF to generate component pollutant loads from various sources (Figure 4-2). Data from 1995 and 2006 were reviewed to understand whether the urban land cover had changed substantially since 1995. The overall change between the 1995 and 2006 was minimal in the watershed. The developed category (which includes both low and high density residential) increased from approximately 29.5% in 1995 to about 31% in 2006, and less than 2% of forested lands were lost (Figure 4-3). Since this overall increase in developed land was relatively small (<2%), the estimates developed from 1995 were determined to be adequate for characterizing the relative contributions of various pollutant sources on a watershed basis. As discussed in Appendix C, the inter-basin water transfers by the water providing agencies were accounted for in the water balance analysis and flow calibration process. Water transfer data was obtained from the 2nd district to support the assumptions used in this study.

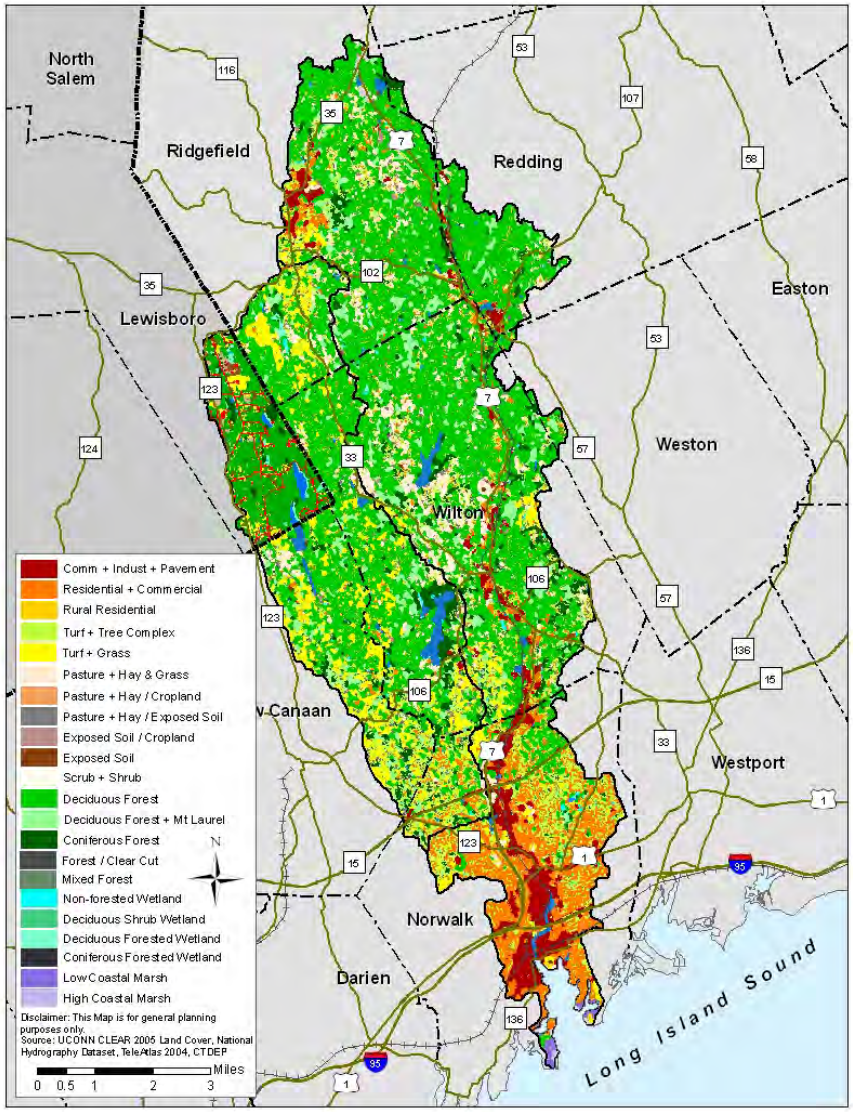


Figure 4-2. Norwalk River Watershed Landover (1995)

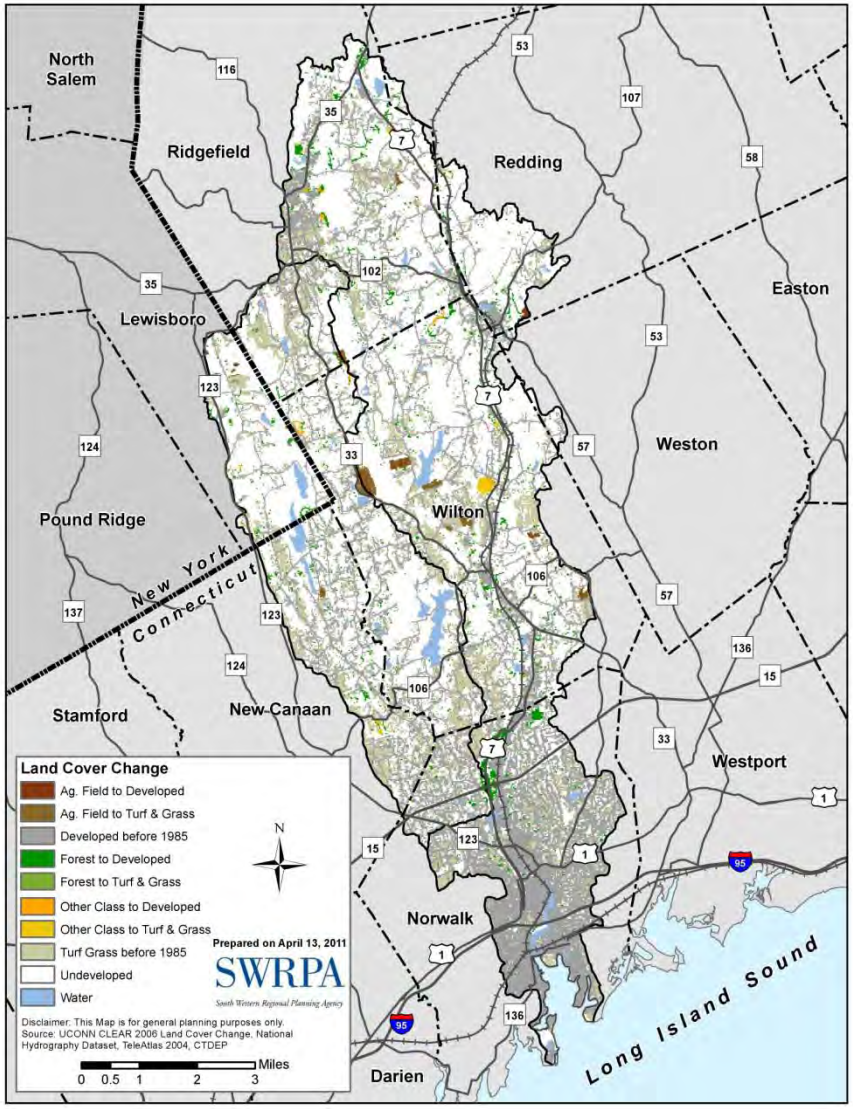


Figure 4-3. 2006 Change in Landover

Calculated annual TN, TP and TSS loads from each sub-watershed is summarized in Table 4-1. The results were calculated based on the AVGWLF model validation period (1996-2009) and an annual average is shown in this table, which excludes loading from point sources (wastewater treatment plants).

Table 4-1. Annual Pollutant Loads from Each Sub-watershed

Basin ID	TN (lb/yr)	TP (lb/yr)	Sediment (lb/yr)*	Basin ID	TN (lb/yr)	TP (lb/yr)	Sediment (lb/yr)*
7300-01	3761	472	199	**7300-15**	6306	816	237
7300-02-01	7007	819	382	**7300-16**	2803	375	113
7300-02-02	7033	836	344	**7300-00-07**	3035	397	123
7300-00-01	5170	582	267	**7300-17**	3421	427	153
7300-03	1438	166	77	**7302-02**	2510	235	156
7300-00-02	5106	572	262	**7302-03**	1959	222	100
7300-04	2075	233	115	**7302-01**	4442	290	343
7300-05	1530	159	96	**7302-05**	6444	769	307
7300-00-03	4591	501	261	**7302-04**	11364	1326	566
7300-06	1838	220	88	**7302-06**	1542	186	74
7300-07	8225	951	423	**7302-00-01**	8483	712	570
7300-08	2086	235	112	**7302-07**	4287	505	206
7300-09	5637	574	317	**7302-08**	3825	461	179
7300-00-04	5006	553	253	**7302-00-02**	7948	964	373
7300-10	3234	354	171	**7302-12**	3932	439	201
7300-11	3895	459	180	**7302-13**	10023	1213	450
7301-03	1473	167	77	**7302-10**	2022	247	124
7301-04	8913	1011	458	**7302-09**	966	107	49
7301-01	6464	763	322	**7302-11**	6500	797	306
7301-02	4711	539	247	**7302-00-03**	3702	459	151
7301-00	10015	1199	466	**7302-14**	2442	297	111
7300-00-05	9325	1074	445	**7302-15**	6466	856	243
7300-00-06	7099	881	301	**7302-00-04**	8793	1242	302
7300-12	4270	482	204	**7300-18**	12292	1566	476
7300-13	4007	461	191	**7300-00-08**	12697	1730	591
7300-14	2359	316	106	**7300-00-09**	22786	2460	1110

* Includes only loading from runoff

4.3 Indicator Bacteria Load Estimation

Modeling bacteria loading is more complex than modeling nutrients and sediment in a watershed. Concentrations of indicator bacteria can vary based on environmental conditions (e.g., water temperature, dry and wet weather periods, etc.) and depending on the time of travel there can be a significant decay of indicator bacteria along the waterways. To accurately account for these conditions a dynamic hydrologic, hydraulic and water quality model is needed to allow a direct comparison of monitored versus modeled values. Due to budgetary considerations a simpler method was adopted here to estimate the indicator bacteria loads.

Overall bacteria loads from the entire watershed or sub-watersheds were estimated using flows computed from the hydrology portion of the AVGWLF model for various land use categories, which were then associated with corresponding event mean concentrations (EMCs). EMCs are estimated as flow-weighted average concentrations of a pollutant from observed data collected

during several wet weather periods. Table 4-2 summarizes the EMCs for specific indicator bacteria (fecal coliform or *E. coli*) compiled from literature published by the EPA, academic institutions and other organizations. Some of these references did not have values for *E. coli*, the indicator bacteria identified by the DEEP. In such cases, the fecal coliform EMC values were reviewed and a reduction was applied based on professional judgment. The final column in Table 4-2 shows the values selected for load estimation in this project.

It must be noted that some of the categories shown in Table 4-2 were clustered to match with the specific land use categories used in the AVGWLF model so as to multiply the appropriate runoff volumes with EMC values and determine the corresponding pollutant loads. A larger EMC value was assumed for the wetland category to account for the potential impacts from waterfowl and wildlife.

Table 4-2. EMC Values for Indicator Bacteria

Land Use Type	NSQD (Pitt et al., 2004a & 2004b)	WTM (Caraco, 2001)	SCCWRP (Stein et al., 2007)	RUNQUAL (Evans et al., 2007)	NURP (EPA, 1983)	Selected Values
	E. coli	Fecal coliform	*E. coli*	Fecal coliform	*E. coli*	*E. coli*
Agriculture	-	-	-	-	-	**10,000**
Low Density Residential	7,500	20,000	6,000	9,600	17,000	**8,000**
High Density Residential	7,500	20,000	6,000	9,600	17,000	**8,000**
Commercial/ Institutional	4,000	20,000	4,000	9,600	16,000	**8,000**
Open Space	8,000	-	6,000	-	-	**10,000**
Transportation	-	20,000	1,000	-	-	**2,000**
Wetland	-	-	-	-	-	**60,000**
Forest	-	-	-	-	-	**600**
Hay/Pasture	-	-	-	-	-	**10,000**
Industrial	1,500	20,000	1,500	-	14,000	**8,000**

There was no direct way of interpreting AVGWLF hydrology model outputs to develop load estimates from failing septic systems. Therefore, we used a simple approach outlined in the AVGWLF help menu (http://www.avgwlf.psu.edu/). A failure rate of 3% for the septic systems was assumed for individual households with a sewage generation rate of two billion organisms per capita per day. Information provided on Sewer Service area maps provided by SWRPA, Housatonic Valley Council of Elected Officials (HVCEO) and Westchester County (NY) was used to estimate septic system density. These septic density data were used to compute the overall load from septic system failures in individual sub-watersheds. The indicator bacteria loads generated from individual land use categories are summarized in Table 4-3 for each of the sub-watersheds within the Norwalk River watershed and tributaries.

There was no detailed calibration and validation of the model performed in this project to establish a direct correlation between load estimates and observed values, taking into account the physical and climatic aspects for the watershed. Therefore, the load estimates developed here should only be used to support a watershed-wide planning process and prioritize pollution control measures, and not interpreted in an absolute sense to pinpoint specific sources of pollution.

The targets for reductions in bacteria loads are discussed in the following section. Expected load reductions from short and long-term management strategies on a watershed-basis are discussed in Section 6 on Management Measures.

Table 4-3. Summary of *E. coli* Loads by Land Use Type (Billion organisms/year)

Basin ID	Watershed	Hay/Pasture	Agriculture	Forest	Wetland	Transitional	Low Developed	High Developed	Septic Loading	Total
7300-01	Norwalk	663	-	73	238	700	11369	12759	2383	**30185**
7300-02-01	Norwalk	699	37	572	21700	635	19604	11259	5272	**59778**
7300-02-02	Norwalk	330	24	843	15016	295	7765	10733	6343	**41350**
7300-00-01	Norwalk	314	-	681	6194	217	4414	9172	4126	**25119**
7300-03	Norwalk	614	37	196	102	74	1644	394	1221	**4281**
7300-00-02	Norwalk	1062	-	741	2027	93	5000	5515	4302	**18738**
7300-04	Norwalk	6	24	375	-	82	1343	787	1788	**4405**
7300-05	Norwalk	11	-	316	-	120	230	364	1048	**2090**
7300-00-03	Norwalk	780	36	666	4557	371	2687	7356	3109	**19563**
7300-06	Norwalk	50	-	298	509	8	937	816	1903	**4521**
7300-07	Norwalk	583	24	1232	-	275	8179	7365	7351	**25010**
7300-08	Norwalk	11	-	361	1112	85	903	1787	1786	**6045**
7300-09	Norwalk	1362	12	897	1117	151	4645	9397	3638	**21220**
7300-00-04	Norwalk	397	12	490	3048	311	6083	17429	3239	**31009**
7300-10	Norwalk	287	24	552	610	58	1763	3315	2668	**9277**
7300-11	Norwalk	1780	61	418	406	43	4820	5638	3494	**16661**
7301-03	Comstock	623	-	188	-	43	2208	1122	1220	**5404**
7301-04	Comstock	2490	231	1191	2233	217	6942	8129	7618	**29051**
7301-01	Comstock	1890	122	843	3858	171	6755	3590	6032	**23260**
7301-02	Comstock	1201	-	642	4162	206	5306	4403	3946	**19866**
7301-00	Comstock	5868	281	964	1219	326	10703	14398	8809	**42568**
7300-00-05	Norwalk	2254	73	999	4062	345	10005	23364	7374	**48476**
7300-00-06	Norwalk	474	158	569	1826	422	5816	25498	6104	**40867**
7300-12	Norwalk	2174	-	543	2327	27	2603	6427	3571	**17673**
7300-13	Norwalk	39	110	495	407	167	2470	11725	3166	**18578**
7300-14	Norwalk	231	12	244	-	194	2246	2074	2575	**7577**
7300-15	Norwalk	406	170	364	1112	259	8246	23978	6026	**40561**
7300-16	Norwalk	455	405	147	-	183	4332	7591	2795	**15908**
7300-00-07	Norwalk	-	-	243	101	201	2078	9310	3004	**14938**
7300-17	Norwalk	61	195	201	-	144	10897	8339	3130	**22968**
7302-02	Silvermine	1853	683	375	6604	4	3319	870	1297	**15004**
7302-03	Silvermine	414	73	307	305	39	1139	1798	1693	**5769**
7302-01	Silvermine	2037	597	903	25257	-	8426	3530	471	**41220**
7302-05	Silvermine	2417	85	652	12375	209	7303	8321	5813	**37176**
7302-04	Silvermine	1938	183	1365	1319	387	18824	15408	9854	**49278**
7302-06	Silvermine	352	-	158	-	54	3213	1902	1416	**7095**
7302-00-01	Silvermine	838	159	1578	6807	89	14658	9233	3549	**36912**
7302-07	Silvermine	341	24	557	-	124	4640	7062	3857	**16606**
7302-08	Silvermine	1035	219	343	-	120	7820	6643	3406	**19586**
7302-00-02	Silvermine	834	232	965	102	284	8272	12080	7485	**30252**
7302-12	Silvermine	562	134	566	-	50	2925	4629	3330	**12198**
7302-13	Silvermine	1742	634	925	4164	89	10887	15989	9677	**44106**
7302-10	Silvermine	38	12	260	-	355	2583	669	1568	**5485**
7302-09	Silvermine	-	-	171	-	-	354	1268	837	**2630**
7302-11	Silvermine	143	12	797	101	372	4355	12216	6020	**24017**
7302-00-03	Silvermine	494	73	276	-	81	6070	11290	3429	**21713**
7302-14	Silvermine	133	110	279	203	12	4774	3034	2442	**10987**
7302-15	Silvermine	975	426	455	710	23	12545	12784	7248	**35168**
7302-00-04	Silvermine	872	293	381	915	486	12327	25229	10109	**50613**
7300-18	Norwalk	149	657	329	4663	256	41577	44381	11514	**103526**
7300-00-08	Norwalk	1632	463	360	3961	2533	13352	48138	10012	**80450**
7300-00-09	Norwalk	2084	719	142	6500	2630	57495	158127	7713	**235410**
Total		**47999**	**7839**	**28488**	**153930**	**14619**	**408851**	**658639**	**231781**	**1552146**

4.4 *Load Reduction Targets*

Table 4-4 reviews the status of TMDLs in various impaired water segments in the Norwalk River and its tributaries, developed from a review of 305b assessment (CTDEP, 2008) and the TMDL report (CTDEP, 2005).

Table 4-4. Status of Impairment and TMDL Development

Name	ID305B	303(d) Listed	Impaired Use Cause	Applicable WQS	TMDL Status
Norwalk River	CT7300-00_01	Y	Contact Recreation Indicator Bacteria	B*	C
	CT7300-00_02	Y	Contact Recreation Indicator Bacteria	B	C
	CT7300-00_03a	Y	Contact Recreation Indicator Bacteria	B	C
	CT7300-00_03b	Y	Contact Recreation Indicator Bacteria	B	C
	CT7300-00_03c	Y	Contact Recreation Indicator Bacteria	B	C
	CT7300-00_04	Y	Contact Recreation Indicator Bacteria	B*	C
	CT7300-00_05	Y	Contact Recreation Indicator Bacteria	B*	C
Ridgefield Brook	CT7300-02_01	Y	Contact Recreation Indicator Bacteria	B	C
	CT7300-02_02	Y	Contact Recreation Indicator Bacteria	B	C
Cooper Pond Brook	CT7300-07_01	Y	Contact Recreation Indicator Bacteria	B	NC
	CT7300-07_02	Y	Contact Recreation Indicator Bacteria	B	NC
Comstock Brook	CT7301-00_01	Y	Contact Recreation Indicator Bacteria	B	NC
	CT7301-00_02	Y	Contact Recreation Indicator Bacteria	B	NC
Silvermine River	CT7302-00_01	Y	Contact Recreation Indicator Bacteria	B/A	C
	CT7302-00_02	Y	Contact Recreation Indicator Bacteria	B/A	C

NOTE: (i) C indicates a completed TMDL and NC indicates a TMDL to be developed after the CTDEP assesses the river segments for indicator bacteria water quality conditions; (ii) * *E. coli* standards for these segments include a geometric mean of 126/100mL and a single sample maximum of 410/100mL; and (iii) *E. coli* standards for other segments include a geometric mean of 126/100mL and a single sample maximum of 576/100mL.

The contributors of indicator bacteria include both point and non-point sources, such as stormwater runoff, hobby farms, pets, wildlife, waterfowl, illicit discharges, surface water base flow, and improperly functioning septic systems. Potential sources have been identified in Table 2 of the 2005 TMDL based on land-use distribution in each of the waterbodies. These sources are summarized here in Table 4-5 for reference.

Table 4-5. Potential Sources of Bacteria for Each Waterbody

Waterbody Name	Non-point Sources	Point Sources
Norwalk River	Wildlife, Waterfowl, Improperly Functioning Septic Systems, Surface Water Base Flow (Cooper Pond Brook and Gilbert and Bennett Brook)	Regulated Urban Runoff/Storm Sewers, Wastewater Treatment Plants, Illicit Discharges
Ridgefield Brook	Wildlife, Surface Water Base Flow (Steep Brook)	Regulated Urban Runoff/Storm Sewers, Wastewater Treatment Plant
Silvermine River	Horse/Pet Farms, Wildlife, Waterfowl, Improperly Functioning Septic Systems	Regulated Urban Runoff/Storm Sewers

Source: CTDEP 2005 TMDL, Table 2

The municipal wastewater treatment plant discharges are governed by the National Pollution Discharge Elimination System (NPDES) administered by the DEEP. Discussions here will therefore focus only on the non-point sources and regulated urban runoff/storm sewers.

TMDL calculations performed by DEEP (CTDEP, 2005) using the Cumulative Distribution Function Method (see Appendix B of CTDEP, 2005, for details) are summarized for reference in Table 4-6 for the various impaired waterbody segments. Note that the higher percentage reduction of 76% developed by DEEP (CTDEP, 2005) based on observations at Monitoring Site 790 has been assumed to be protective of WQS for indicator bacteria in the entire segment of CT7300-00_01 in Norwalk River.

The recent water quality monitoring data discussed in Section 3 on Watershed Characterization was analyzed in terms of the geometric mean for *E. coli* at various HW/RW monitoring sites and also on the proximity of individual sites to specific impaired waterbody segments. A statistical roll-back procedure (Ott, 1995; NYSDEC, 2003) was used to determine the percent reductions necessary in each segment. This procedure compares the geometric mean of observed values to the applicable geometric mean criterion, and determines the difference between these geometric mean values as the percent reduction in pollution loads necessary to meet the WQS (see Figure 4-4). An example for the segment CT7300-02_02 is discussed here.

The water quality monitoring stations NR20, NR21, NR22 and NR23 are located in segment CT7300-02_02. The highest geometric mean of 473/100mL for *E. coli* was observed at NR21. As a conservative planning goal, if the reductions in indicator bacteria loads could be reduced to achieve a geometric mean of 126/100mL at NR21 during wet weather, then the entire CT7300-02_02 will comply with the applicable WQS. Using the statistical roll-back procedure, an overall reduction of 74% would be needed to achieve the desired water quality goal.

In reality however, the elimination of dry weather sources such as failing septic systems or illicit discharges must also be addressed in order to improve the water quality significantly. Therefore, the percent reductions based on wet weather data developed as part of the 2005 TMDL can be used as targets for wet weather non-point sources and permitted urban stormwater discharges.

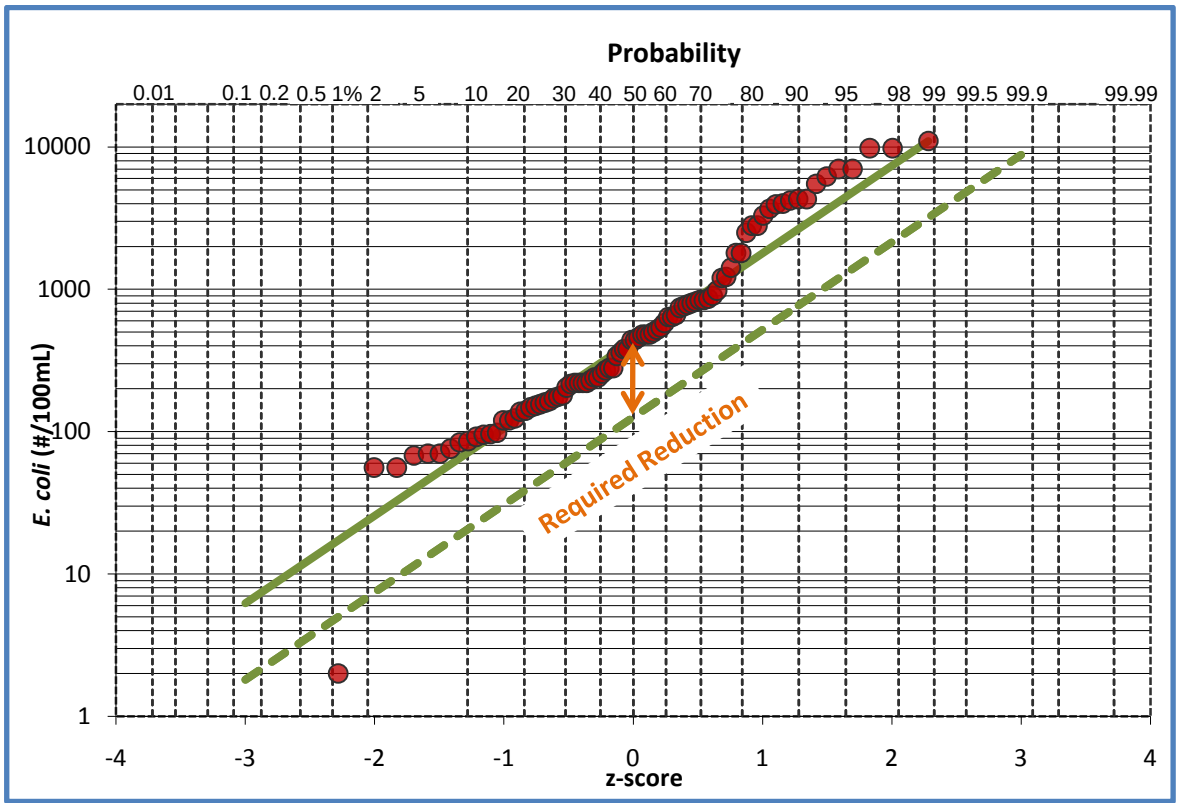


Figure 4-4. Percent Reduction in *E. coli* Loads to Meet WQS at CT7300-02_02

Short-term management measures should be undertaken for controlling indicator bacteria loads from wet weather sources and eliminate dry weather sources. This approach involves an adaptive management strategy to address dry weather sources first and continue to monitor the waterways to characterize improvements in water quality conditions. Reductions such as illicit discharges would also reduce the extent of bacterial water quality exceedances observed during wet weather. The targets for wet weather sources could then be adjusted based on this new monitoring data, which would provide the footprint for undertaking long-term management measures to further reduce the wet weather pollutant loads. Percent reductions were estimated based on wet weather data for each impaired segment derived using nearby HW/RW monitoring stations and included in Table 4-6. Also included are the TMDL load allocations for non-point sources, established by DEEP (CTDEP, 2005).

Table 4-6. Summary of TMDL Analysis

Waterbody	Impaired Segment 305B	Percent Reductions Needed to Meet Applicable WQS			
		TMDL	WLA	LA	Based on HW/RW Wet Weather Data
Norwalk River	CT7300-00_01	76	76	76	82
	CT7300-00_02	38	38	38	40
	CT7300-00_03a	5	9	3	61
	CT7300-00_03b	5	9	3	61
	CT7300-00_03c	5	9	3	61
	CT7300-00_04	54	53	55	49
	CT7300-00_05	39	42	37	58
Ridgefield Brook	CT7300-02_01	51	60	45	NC
	CT7300-02_02	51	60	45	74
Cooper Pond Brook	CT7300-07_01	ND	ND	ND	NC
	CT7300-07_02	ND	ND	ND	NC
Comstock Brook	CT7301-00_01	ND	ND	ND	NC
	CT7301-00_02	ND	ND	ND	NC
Silvermine River	CT7302-00_01	66	67	65	91
	CT7302-00_02	66	67	65	NC

NOTE: 1. Watershed Load Allocation (WLA) refers to percent reductions needed in point sources such as treatment plants; 2. Load Allocation (LA) refers to percent reductions needed in non-point sources of pollution; "ND" indicates that there were insufficient data in the 2005 TMDL analysis to support the development of pollutant reduction targets. Since the HW/RW data was also unavailable to appropriately derive percent reductions, these reaches are indicated with an "NC."

4.5 Observations on Pollution Sources and Potential Controls

Based on the extensive pollutant load modeling effort described in this section, some general conclusions were derived in order to guide the development of load reduction strategies (management measures). Specific observations made during HW/RW field visits or water quality monitoring programs are summarized in Section 5 on Watershed Recommendations with potential corrective actions. Some general conclusions about NPS pollution and the extent are summarized here.

Non-point sources include wildlife, improperly functioning septic systems, surface water base flow, urban runoff and horse/hobby farms. The BMPs for the management of non-point sources include septic system testing and maintenance, nuisance wildlife control plans, pet waste ordinances and LID practices. The contribution of bacteria from surface water base flow could be addressed by implementing non-point source BMPs in drainage areas of tributaries with known high levels of *E. coli* densities, such as Steep Brook, Cooper Pond Brook, and Gilbert and Bennett Brook.

Failing or improperly maintained septic systems contribute to DO swings and/or elevated indicator bacteria concentrations in the upper reaches of Norwalk River and in Silvermine River. As we move downstream towards densely urbanized areas, the illicit discharges into storm sewers appear to cause elevated indicator bacteria concentrations.

Based on the NRCS streamwalk surveys, several ponds in the Norwalk River watershed have been documented to have excessive algal growth and eutrophication. This occurs primarily due to phosphorus loads from contributing drainage areas such as fertilizer application in lawns. In addition to the 10% TN load reductions required by the LIS TMDL, effluent limits for TP from point sources and targeted reductions in TP from non-point sources would also need to be established to reduce eutrophication potential in these impoundments.

Waterfowl (e.g., non-migratory geese) observed near the impoundments were attributed to elevated indicator bacteria concentrations. The indicator bacteria have enhanced ability to survive in surface waters and sediment when ambient temperatures more closely approximate those of warm-blooded animals, from which the bacteria originate. In addition, the resident wildlife populations are likely to be more active during the warmer months and more migratory species are present during the summer. The DEEP has developed statewide (that includes both migratory and non-migratory) population estimates for Canadian geese and ducks to be 24,000 and 57,000 during the 2011 breeding season. No specific estimates for the Norwalk River watershed are available. These factors combine to make the summer, recreational period representative of "worst-case" conditions.

As described in Mullaney et al. (2002), groundwater contributes significant amount of TN to the sound. Septic systems are designed to infiltrate into the ground thereby transferring some of the TN loads into the groundwater that appears as baseflow in the stream at a later time. As much as 40-45% of the TN loads have been attributed to groundwater, although some of these loads could result from infiltrated TN from septic systems, natural sources may also be contributing factors. Since the residence time of TN in groundwater can be as much as 50 years, this load component becomes the most challenging to control.

Urban stormwater runoff is estimated to contribute about 20-25% of TN loads and, from a control standpoint, emerges as a source that could potentially be controlled using NPDES MS4 programs for the watershed municipalities. Some portion of this load could be attributed to manicured lawns in urban settings with varying levels of fertilizer applications (e.g., golf courses, residential and commercial property lawns, and municipal owned areas such as parks). Similarly the indicator bacteria loads could be contributed by domestic pets and hobby farm animals. These sources could potentially be reduced using public outreach and education programs aimed at reducing the overall pollutant loads to the waterways and encouraging LID practice. Under the MS4 permit, municipalities are required to implement minimum control measures in their Stormwater Management Plans to reduce the discharge of pollutants, protect water quality, and satisfy the appropriate water quality requirements of the Clean Water Act. The six minimum control measures are:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-construction Runoff Control
- Pollution Prevention/Good Housekeeping

It must be emphasized that the cost of controlling loads from urban and suburban land uses could be quite expensive and must be compared with the cost of controlling non-urban sources of pollution. On a watershed-wide basis, an offset or trading program could help in reducing the overall TN loads in the Norwalk River and its tributaries sooner.

The modeling framework used here does not explicitly account for atmospheric deposition. Most of the TN load from this source is carried to the waterways by urban runoff. Literature values compiled during the development of LIS TMDL indicated that the atmospheric deposition could contribute about 13% of the TN loads (NYSDEC and CTDEP, 2000). Similar large fractions have been reported in other large drainage areas such as Savannah Harbor and Chesapeake Bay. Again, this source is among the most challenging ones to control or at least cost prohibitive in terms of frequent street sweeping and treatment of stormwater using process-based BMPs/LIDs such as bioretention, grass swales or natural/constructed wetland systems (for additional information see Table 6-2).