A Total Maximum Daily Load Analysis for Eagleville Brook, Mansfield, CT

Final- February 8, 2007

This document has been established pursuant to the requirements of Section 303(d) of the Federal Clean Water Act

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INTRODUCTION

A Total Maximum Daily Load (TMDL) analysis was completed for Eagleville Brook, Mansfield, Connecticut. Eagleville Brook was included on the *2004 List of Connecticut Waterbodies Not Meeting Water Quality Standards* [1] (2004 *List*) due to exceedences of the aquatic life criteria contained within Connecticut's *Water Quality Standards* (WQS) [2]. Under section 303(d) of the Federal Clean Water Act (CWA), states are required to develop TMDLs for waters impaired by pollutants for which technology-based controls are insufficient to achieve water quality standards. The TMDL represents the maximum loading that a waterbody can receive without exceeding water quality criteria which have been adopted into the WQS.

Since the cause of the impairment in Eagleville Brook was unknown at the beginning of this investigation, a Stressor Identification (SI) analysis was completed to determine the most probable cause of the impairment. The SI determined that a complex array of pollutants transported by stormwater was the most probable cause of the impairment. The TMDL was developed using Impervious Cover (IC) as a surrogate parameter for a mix of pollutants conveyed by stormwater. The TMDL is established as the percent of impervious cover (% IC) throughout the watershed that must be achieved to meet the aquatic life criteria and attain the designated aquatic life uses.

Federal regulations require that the TMDL analysis identify the portion of the total loading which is allocated to point source discharges (termed the Wasteload Allocation or WLA) and the portion attributed to nonpoint sources (termed the Load Allocation or LA), which contribute that pollutant to the waterbody. In this case, the WLA and LA are expressed in terms of % IC, again as a surrogate for the mix of pollutants conveyed by stormwater. In addition, TMDLs must include a Margin of Safety (MOS) to account for uncertainty in establishing the relationship between pollutant loadings and water quality. Seasonal variability in the relationship between pollutant loadings and WQS attainment was also considered in these TMDL analyses.

TMDLs that have been established by states are submitted to the Regional Office of the Federal Environmental Protection Agency (EPA) for review. The EPA can either approve the TMDL or disapprove the TMDL and act in lieu of the state. TMDLs provide a scientific basis for developing and implementing a Water Quality Management Plan or TMDL Implementation Plan (Plan), which describes the control measures necessary to achieve acceptable water quality conditions. Therefore, Plans derived from TMDLs typically include an implementation schedule and a description of ongoing monitoring activities to confirm that the TMDL will be effectively implemented and that WQS are achieved and maintained. Public participation during development of the TMDL analysis and subsequent preparation of the Plans is vital to the success of resolving water quality impairments. This document also includes recommendations for a water quality monitoring plan, as well as a discussion of the TMDL Implementation Plan.

WATERBODY DESCRIPTION AND PRIORITY RANKING

Eagleville Brook was listed on the *2004 List* for not meeting aquatic life use support goals, but the cause was unknown. Eagleville Brook has a 2.4 square mile drainage area and is tributary to an impoundment of the Willimantic River, Eagleville Pond. The Eagleville Brook watershed drains a portion of the University of Connecticut (UCONN) campus located in the Storrs section of Mansfield, Connecticut. There are two separate sections of the upper Eagleville Brook watershed that are piped underground beneath the UCONN campus (Figure 1). One section is underground for approximately 600 feet and drains an intermittent section of the upper watershed. The section downstream of Swan Lake is underground for approximately 1,700 feet and daylights just downstream of a strip mall of the north side North Eagleville Road. A portion of the UCONN campus drains to the northeast to the Fenton River watershed (Figure 1).

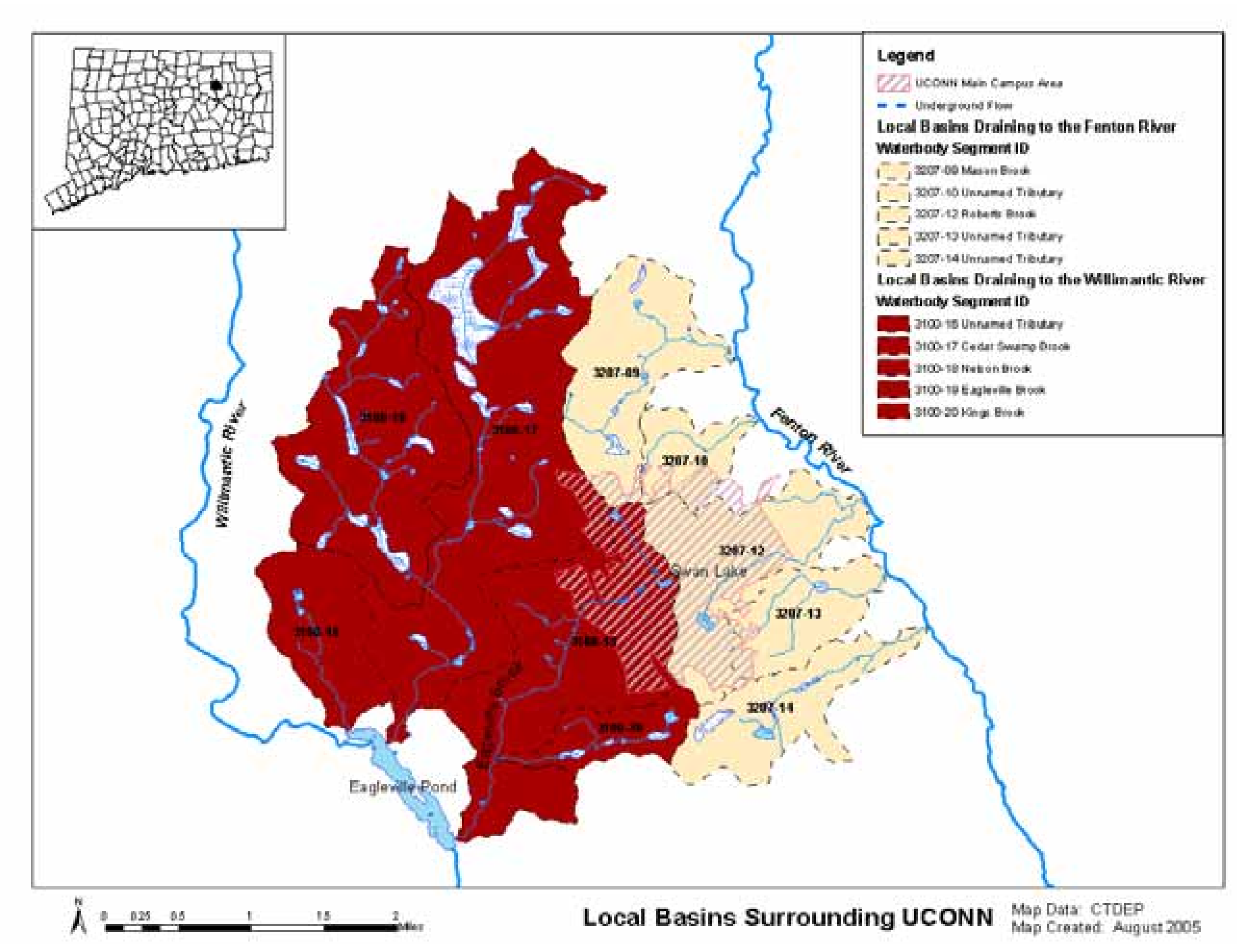


Figure 1. Map of Eagleville Brook and local basins draining the area surrounding the University of Connecticut Campus (campus outline indicated by crosshatching).

It has been determined through biological monitoring that aquatic life use goals are not being met in Eagleville Brook. All sites were identified as impaired following assessment methodology outlined in Connecticut's Consolidated Assessment and Listing Methodology [3] (See Table 2. Aquatic life use support categories and contributing decision criteria for wadeable streams *in* CALM Document). The Inland Fisheries Division has conducted fish population surveys in Eagleville Brook and has observed low fish densities (Table 1) and large amounts of habitat unoccupied by fish. It was noted that stretches of Eagleville Brook upstream of Separatist Road were almost devoid of fish and sediment deposition from stormwater runoff was impacting instream fish habitat. A follow up survey was conducted by the Bureau of Water Management in October 2003 that included an extensive benthic invertebrate assessment of Eagleville Brook (Table 2, Figure 2). The "% of Reference" column in Table 2 compares the scores from the sites in Eagleville Brook to the reference site, Roaring Brook using the Rapid Bioassessment Protocol (RBP) III Benthic Community Score. In general, sites that have a RBP III score < 54% of reference are listed as not meeting the aquatic life designated use. As a result of these low RBP III scores, and other supporting fisheries data, Eagleville Brook was listed as a "T" on the *2004 List* which indicates that the waterbody is currently under study and a TMDL is planned for development (Table 3).

Table 1. Site description and number of fish collected during electrofishing surveys completed by CTDEP. A map of the site numbers is provided in Figure 2.

Site Description	Site Number	Number of Fish Collected			
		2002	2003	2004	2005
Eagleville Brook downstream Hunting Lodge Rd	1	1	0	0	1
Eagleville Brook upstream Separatist Rd	2	6	1	1	0
Eagleville Brook upstream Hillyndale Rd	3	1	8	7	0
Eagleville Brook adjacent N. Eagleville Rd (above Kings Brook)	4	Not sampled	5	1	1
Eagleville Brook adjacent N. Eagleville Rd (below Kings Brook)	5	Not Sampled	12	31	9

Table 2. Site description and characteristics of benthic invertebrate assessments completed by CTDEP on October 24, 2003. A map of the site numbers is provided in Figure 2.

Site Description	Site Number	Number of Taxa	EPT Taxa [A]	% of Reference	Assessment
Eagleville Brook downstream Hunting Lodge Rd	1	16	4	25 %	Impaired
Eagleville Brook upstream Separatist Rd	2	8	1	20 %	Impaired
Eagleville Brook upstream Hillyndale Rd	3	19	9	50 %	Impaired
Eagleville Brook adjacent N. Eagleville Rd (above Kings Brook)	4	22	13	45 %	Impaired
Eagleville Brook adjacent N. Eagleville Rd (below Kings Brook)	5	13	6	45 %	Impaired
Roaring Brook	Reference	38	23	100 %	Non-Impaired (Reference)

Table 3. The status of impairment for Eagleville Brook and the TMDL development priority as documented on the 2004 *List*.

Waterbody Name	Waterbody Segment ID	Waterbody Segment Description	303(d) Listed (Yes/No)	Impaired Use Cause	Priority [B]
Eagleville Brook_01	CT 3100-19_01	From the mouth at Eagleville Pond upstream to confluence with Kings Brook, Mansfield.	Yes	Aquatic Life- Cause Unknown	T
Eagleville Brook_02	CT 3100-19_02	From confluence with Kings Brook to headwaters near UCONN campus.	Yes	Aquatic Life- Cause Unknown	T

A EPT Taxa represent the number of taxa in the Order Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) and is a general indicator of sensitive organisms.

B T indicates that the waterbody was currently under study at the time the list was last revised and a TMDL was planned for development within two years of list revision if warranted.

Figure 2. Map showing location of fish and macroinvertebrate sampling locations along Eagleville Brook. Sites numbers correspond with Tables 1 and 2.

POLLUTANT OF CONCERN AND POLLUTANT SOURCES

An impairment to the aquatic life in Eagleville Brook was identified using bioassessment protocols as outlined in Connecticut's *Consolidated Assessment and Listing Methodology* [3]. Although bioassessments can identify impaired aquatic communities, they often do not identify the cause of impairment. Such is the case with Eagleville Brook - the cause of the aquatic life impairment was unknown. A Stressor Identification (SI) analysis was completed to evaluate all potential stressors and determine the most likely candidate cause (see Appendix 1 for a description of the SI Analysis).

The SI analysis determined that the most probable cause of the aquatic life impairment in Eagleville Brook is a complex array of pollutants transported by stormwater. Since the impairment cannot be attributed to a specific pollutant, impervious cover (IC) was used as a surrogate measure of the complex array of pollutants transported by stormwater. There are several citations in the Federal Regulations that support the use of surrogate measures for TMDL Development. For example, 40 CFR §130.7 (c)(1)(i) "states that TMDLs may be established using a pollutant-by-pollutant or <u>biomonitoring approach</u>." In addition, 40 CFR §130.2-(i) states that "TMDLs can be expressed in terms of either mass per time, toxicity, or <u>other appropriate measure</u>." It is recognized that IC may not be the direct factor causing the impairment, but that there is a strong enough relationship to use IC as a surrogate measure in situations when a Stressor Identification analysis has determined that stormwater is the primary candidate cause of the aquatic life impairment. For impaired streams with less than 12% IC upstream, factors other than stormwater will be investigated using the Stressor Identification Procedures employed by the Department (TMDL support doc page 3).

The Department has developed a TMDL Support Document that documents the relationship of IC and macroinvertebrates in Connecticut streams [4] (see Appendix 2). As described in detail in Appendix 2, there is a strong correlation between pollutant loads, stormwater flows, and runoff from impervious land cover in the watershed. Therefore, it is reasonable to rely on the surrogate measure of % IC to represent stormwater flows (and the effect of stormwater flows on pollutant loads and hydrology) that ultimately contribute to aquatic impairment in Eagleville Brook. The IC TMDL support document provides a scientific basis that IC is an appropriate surrogate measure of impacts caused by stormwater (i.e. "other appropriate measure") and aquatic life use assessments using macroinvertebrates (i.e. "biomonitoring approach") provide an appropriate endpoint to measure progress of implementation. The support document also recommends that this approach be used for developing TMDLs where there is a clear linkage between measured aquatic life impacts and stormwater discharging from areas dominated by IC. Eagleville Brook meets the criteria of applicable streams discussed in the CT support document: the stream has benthic monitoring locations with RPB III level of effort, the stream has an upstream drainage area <50 square miles, and stressor identification analysis indicates the complex array of pollutants and hydrologic stress associated with stormwater is the cause of impairment.

APPLICABLE SURFACE WATER QUALITY STANDARDS

The Surface Water Classification for Eagleville Brook _01 and Eagleville Brook _02 is B/A. The B/A surface water classification means that Eagleville Brook is not meeting the goal of Class A Water Quality Criteria and attainment of Class A designated uses. Connecticut's Water Quality Standards establish surface water classifications and the applicable aquatic life criteria for benthic invertebrates which inhabit lotic waters. Aquatic life criteria for Class A waters are as follows:

> <u>Benthic Invertebrates which inhabit lotic waters</u>
> A wide variety of macroinvertebrate taxa should normally be present and all functional feeding groups should normally be well represented. Presence and productivity of aquatic species is not limited except by natural conditions, permitted flow regulation or irreversible cultural impacts. Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. Taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Coleoptera (beetles), and Trichoptera (caddisflies) should be well represented.

WATER QUALITY TARGET

The TMDL for Eagleville Brook was developed using the percent IC as a surrogate for a complex array of pollutants transported by stormwater runoff that impacts aquatic life. The aquatic life criteria is referenced in Connecticut's Water Quality Standards [2] (see previous section), and assessment of attainment of aquatic life criteria is described in *Consolidated Assessment and Listing Methodology* [3]. A TMDL Support Document was developed and recommended the TMDL target of 12% IC for Connecticut streams with similar watershed size to Eagleville Brook [4]. The 12% IC threshold represents the level of imperviousness (in the contributing watershed) below which the brook is capable of supporting a macroinvertebrate community that meets aquatic life use goals in Connecticut Water Quality Standards. The 12% IC threshold is within the range of % IC values generally reported in the literature [5, 6, 7] and, more specifically, in other New England States such as Maine [8] (see Appendix 2 for further information).

The TMDL Target is 12% Impervious Cover

As discussed in the margin of safety (MOS) section below, a 1% IC Margin of Safety (MOS) was subtracted from the TMDL target to account for uncertainty in the analysis, resulting in a combined WLA and LA target of 11%. The goal of the TMDL is to reduce impacts from stormwater on the aquatic life in Eagleville Brook. Meeting the TMDL goals will be assessed by measuring the aquatic life directly and not by measuring the IC reduction.

WASTELOAD ALLOCATION (WLA) AND LOAD ALLOCATION (LA)

For this TMDL analysis, it is not feasible to draw a clear distinction between stormwater originating from NPDES-regulated point sources and non-NPDES regulated sources (point and non-point) because insufficient data are available for each parcel in the watershed and the fact that stormwater discharges are highly variable in frequency and duration. Therefore, this TMDL applies the 11% IC target to all stormwater drainage area affecting both regulated and non-regulated sources in the watershed (WLA=LA=11% IC), in order to reduce pollutant loads and restore hydrologic and biological integrity of the watershed as a whole. Although Eagleville Brook is not currently within an Urban Area regulated under Connecticut's MS4 permit, allocations made in this manner will not preclude the watershed from being included in the MS4 Program in the future.

The WLA and LA Target is 11% Impervious Cover

This 11% IC target for WLA and LA can also be expressed as a % reduction in impervious cover compared to current conditions, and can provide a benchmark for implementation of best management practices (BMPs) to reduce the impacts of impervious cover on aquatic biota living in the stream. The WLA and LA % IC target, and any required percent reduction to meet the target, will be applied to both the WLA and LA because of the practical difficulty of separating stormwater loadings contributed by background, nonpoint, and point sources.

To calculate the % impervious cover reductions required to achieve the WLA and LA target:

Percent IC reduction = ((IC Current Condition – IC Target)/IC Current Condition) x 100

where IC Target = 11%

To calculate the Current Condition, Eagleville Brook was divided into three sections - Map ID 1,2,3 (Table 4, Figure 3). The % IC values for each section were derived from 2002 land cover data using an ArcView® Impervious Surface Analysis Tool (ISAT) developed by the Nonpoint Education for Municipal Officials (NEMO) at the University of Connecticut and the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (http://nemo.uconn.edu/tools/impervious_surfaces/measure/isat.htm). The general trend of the current IC condition is highest IC occurs near the headwaters of Eagleville Brook (UCONN Campus) and decreases downstream (Figure 3).

For Eagleville Brook_01, from the mouth of Eagleville Brook to Kings Brook (Map ID 1), no reduction in % IC is required because the current condition of 5 % IC is less than the WLA and LA IC target of 11% (Table 4). The TMDL implementation objective in this section of Eagleville Brook is anti-degradation, which requires the maintenance and protection of the existing water quality condition [C]. It is consistent with the geography of the watershed that most of the stormwater related stressors that contribute to the degraded aquatic life in Eagleville_01 are located upstream in Eagleville Brook _02. The reduction in % IC required upstream in Eagleville_02 will likely benefit the aquatic life in Eagleville_01 as well.

C Connecticut's anti-degradation policy is outlined in Appendix E of WQS [2].

Eagleville Brook_02 was divided into two sub-sections (designated as Map ID 2 and 3) based on differences in % IC in the upper portion of Eagleville Brook. The upper section (Map ID 3) drains a portion of the UCONN Campus and contains a small pond (known locally as Swan Lake) near the Chemistry Building Complex. This section (Map ID 3) was 27% IC based on 2002 landcover data. The percent reduction of IC required to meet the IC target is 59% in this section.

The lower section (Map ID 2) is a mix of UCONN campus and lightly developed residential and averaged 14% IC based on the 2002 landcover data. The percent reduction of IC required to meet the IC target is 21% in this section.

EPA's November 15, 2006 guidance entitled "Establishing TMDL 'Daily' Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No.05-5015, (April 25, 2006) and Implications for NPDES Permits," recommends that TMDL submittals express allocations in terms of daily time increments. In this case, the TMDL's % IC targets are not explicitly expressed in terms of a daily increment. However, they are, in effect, daily targets because they will achieve reductions in stormwater runoff volume in all storm events whenever they occur (e.g., on any given day) throughout the year.

Table 4. Summary of TMDL analysis for Eagleville Brook.

Waterbody Name and Segment ID	Map ID	Waterbody Segment Description	Percent Impervious Cover				TMDL Implementation Objective
			TMDL Target	WLA and LA	MOS	Current Condition	
Eagleville Brook_01 CT 3100-19_01	1	From the mouth at Eagleville Pond upstream to confluence with Kings Brook, Mansfield.	12 %	11%	1%	5 %	Anti-degradation
Eagleville Brook_02 CT 3100-19_02 (Map ID 2)	2	From confluence with Kings Brook to headwaters near UCONN campus.	12 %	11%	1%	14 %	21 % Reduction in % IC accomplished by improved stormwater management
Eagleville Brook_02 CT 3100-19_02 (Map ID 3)	3	Unnamed Pond on UCONN Campus (contained within CT 3100-19_02)	12 %	11%	1%	27%	59 % Reduction in % IC accomplished by improved stormwater management

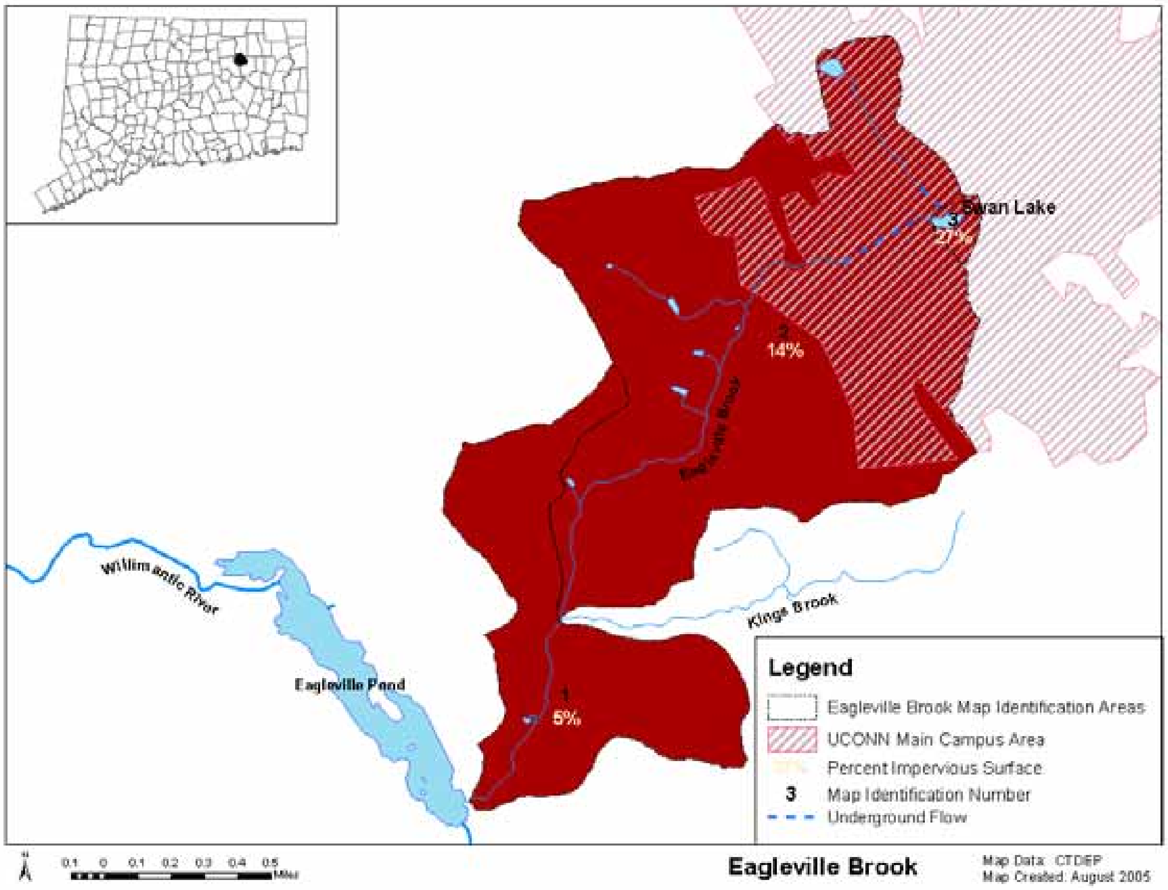


Figure 3. Eagleville Brook watershed showing the Map Identification Numbers 1-3 and the corresponding % IC values derived using ISAT from the 2002 Land Cover data.

MARGIN OF SAFETY (MOS)

TMDL analyses are required by law to include a MOS to account for uncertainties regarding the relationship between load and wasteload allocations, and water quality. The MOS may be either explicit or implicit in the analysis. The TMDLs 12% IC Target was derived by choosing the actual IC threshold below which sites met aquatic life criteria [4]. The 1% difference between the TMDL IC target and the WLA and LA IC target provides a numerical or explicit MOS.

SEASONAL ANALYSIS

Stormwater events that occur over the entire year contribute to the aquatic life impairments documented in Eagleville Brook. Therefore, the percent IC targets and the expected IC reductions to satisfy the IC targets are applicable year round. Benefits realized from IC reductions will occur in all seasons. There is no need to apply different targets on a seasonal basis because the stormwater controls to be implemented to meet the IC targets will reduce adverse impacts (pollutant loading and damaging flows) for the full spectrum of storms throughout the year. Therefore, the TMDL adequately accounts for all seasons.

TMDL IMPLEMENTATION PLAN

As emphasized earlier in this document, IC is being used in this TMDL as a surrogate for the impacts that pollutants and other stressors from stormwater have on aquatic life in streams. The goal of the TMDL is to reduce impacts from stormwater on the aquatic life in Eagleville Brook. In the absence of actual IC reduction, stormwater management techniques that offset the negative effect of IC should be implemented in the Eagleville Brook watershed. Meeting the TMDL will be assessed by measuring the aquatic life directly. Tracking the IC elimination / disconnection or equivalent IC reduction in the watershed during BMP implementation may be used as an interim measure to assess progress. It should be noted that the necessary reductions in % IC discussed above reflect reductions from current conditions. Future development activities have the potential to increase impervious cover, and should be constructed and operated to limit the effect of stormwater from impervious cover on the aquatic life in Eagleville Brook.

Successful implementation will be best accomplished through incorporating an adaptive management strategy. The strategy will include 1) reducing IC where practical, 2) disconnecting IC from the surface waterbody, 3) minimizing additional disturbance to maintain existing natural buffering capacity, and 4) installing engineered BMPs to reduce the impact of IC on receiving water hydrology and water quality. The *University of Connecticut Campus Sustainable Design Guidelines* [9](e.g. see page 11, Goal 1), *2004 Connecticut Stormwater Manual* [10], and *Stormwater TMDL Implementation Support Manual* [11] provide good background information for new site design, as well as technical guidance for stormwater BMPs for existing sites. It will be necessary to choose the appropriate strategies to reduce stormwater runoff on case by case basis and the overall effectiveness of reducing stormwater loads will be evaluated as described in the following section, Water Quality Monitoring Plan.

WATER QUALITY MONITORING PLAN

Surface water chemistry and benthic macroinvertebrate data will be collected from the Eagleville Brook by CTDEP Bureau of Water Management as described in the CTDEP Rotating Basin Ambient Monitoring Strategy [12]. Benthic macroinvertebrates will provide the primary metric to measure the progress of meeting Aquatic Life Support in Eagleville Brook. The Bureau of Water Management will coordinate with the Inland Fisheries Division to collect fish population data in Eagleville Brook. Fish population data will provide an additional measure of aquatic life support in Eagleville Brook.

REASONABLE ASSURANCE

The Department will work with watershed partners, including the Town of Mansfield, University of Connecticut, and conservation organizations to implement better stormwater management in the Eagleville Brook watershed. Although the watershed area surrounding Eagleville Brook was below the threshold for inclusion in the initial list of the Connecticut's MS4 Permit Program, the Commissioner has the authority under definitions contained in Sections 22a-423 of the Connecticut General Statutes and Section 22a-430-3(a) of the Regulations of Connecticut State Agencies to include "those additional municipally-owned or municipally-operated Small MS4s located outside an Urbanized Area as may be designated by the Commissioner. " This option could be pursued if future biological monitoring indicates non - attainment of aquatic life goals in Eagleville Brook.

PROVISIONS FOR REVISING THE TMDL

The DEP reserves the authority to modify the TMDL as needed to account for new information made available during the implementation of the TMDL. Modification of the TMDL will only be made following an opportunity for public participation and be subject to the review and approval of the EPA. New information, which will be generated during TMDL implementation includes monitoring data, new or revised State or Federal regulations adopted pursuant to Section 303(d) of the Clean Water Act, and the publication by EPA of national or regional guidance relevant to the implementation of the TMDL program. The DEP will propose modifications to the TMDL analysis only in the event that a review of the new information indicates that such a modification is warranted and is consistent with the anti-degradation provisions in Connecticut Water Quality Standards. The subject waterbodies of this TMDL analysis will continue to be included on the *List of Connecticut Water bodies Not Meeting Water Quality Standards* until monitoring data confirms that aquatic life uses are fully supported.

PUBLIC PARTICIPATION

The Department has presented the TMDL and received comment at meetings: 1) with the University of Connecticut; 2) watershed stakeholders; and 3)other New England States and EPA Region 1; and 4) at scientific meetings with the New England Association of Environmental Biologists.

In addition, a *Notice of Intent to Adopt a TMDL Analysis for Eagleville Brook* was published in the legal classified sections of the Hartford Courant and Willimantic Chronicle [13] on August 30, 2006. Comments were received and the Department has prepared a *Response to Comments* document [14] that will be included in the final submittal of the TMDL for approval to EPA.

REFERENCES

(1) Connecticut Department of Environmental Protection, 2004. *List of Connecticut Water bodies Not Meeting Water Quality Standards*. Bureau of Water Management, 79 Elm Street, Hartford, CT 06106-5127.

(2) Connecticut Department of Environmental Protection, 2002. *Connecticut Water Quality Standards*. Bureau of Water Management, 79 Elm Street, Hartford, CT 06106-5127.

(3) Connecticut Department of Environmental Protection. 2002. *Connecticut consolidated assessment & listing methodology for 305 (b) and 303(d) reporting.* 79 Elm Street, Hartford, CT 06106.

(4) Connecticut Department of Environmental Protection, 2005. *Percent Impervious Cover as a Surrogate Target for TMDL Analyses in Connecticut.* Bureau of Water Management, 79 Elm Street, Hartford, CT 06106-5127.

(5) ENSR Corporation. 2005. *Pilot TMDL applications using the impervious cover method*. ENSR International, Westford, MA.

(6) Center for Watershed Protection, 2003. Watershed Protection Research Monograph No.1, *Impacts of Impervious Cover on Aquatic Systems,* March 2003.

(7) Arnold, C.L. and C.J. Gibbons, *Impervious Surface Coverage: The Emergence of a Key Environmental Indicator, Journal of the American Planning Association*, vol. 62, no. 2, Spring 1996, pages 243-258.

(8) Maine DEP, *Percent Impervious Cover TMDL Guidance for Attainment of Tiered Aquatic Life Uses*, Draft 7, August 18, 2005.

(9) JJR Smithgroup. 2004. University of Connecticut Campus Sustainable Design Guidelines.

(10) Connecticut Department of Environmental Protection. 2004. *Connecticut stormwater quality manual.* 79 Elm Street, Hartford, CT 06106.

(11) ENSR Corporation. 2006. Stormwater TMDL Implementation Support Manual. 2 Technology Park Drive. Westford, MA.

(12) CTDEP. 1999. *Ambient monitoring strategy for rivers and streams rotating basin approach*. State of Connecticut, Department of Environmental Protection, Bureau of Water Management, 79 Elm Street, Hartford, CT 06106-5127.

(13) Public Notice. August 30, 2006. In Legal Classified Section of Hartford Courant and Willimantic Chronicle.

(14) CTDEP. 2006. *Response to Comments for A Total Maximum Daily Load Analysis for the Eagleville Brook, Mansfield, Connecticut and supporting documents.* State of Connecticut, Department of Environmental Protection, Bureau of Water Management, 79 Elm Street, Hartford, CT 06106-5127.

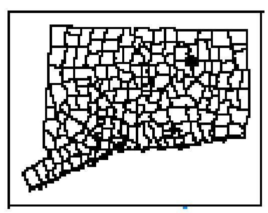
Appendix 1. Stressor Identification

Waterbody: Eagleville Brook

Impairment Description:
Designated Use Impairment: Aquatic Life Use Support
Total Length of Impaired Segment(s): 2.4 square miles
Surface Water Classification: Class B/A
TMDL Priority: Targeted for TMDL Development within 2 years

Segment	Waterbody Segment ID	Description	Cause
Eagleville Brook_01	CT 3100-19_01	From the mouth at Eagleville Pond upstream to confluence with Kings Brook, Mansfield.	Cause Unknown
Eagleville Brook_02	CT 3100-19_02	From confluence with Kings Brook to headwaters near UCONN campus.	Cause Unknown

Watershed Description:
Drainage Basin Area: 2.4 square miles
Tributary To: Willimantic River via Eagleville Pond
Sub regional Basin Name & Code: Willimantic River 3100
Regional Basin: Willimantic
Major Basin: Thames
Watershed Towns: Mansfield
Phase II General Permit applicable: No
Applicable Season: No seasonal restrictions



Landuse for Sub regional Basin 3100:

Land Use Category	Percent Composition
Forested	74
Urban/Developed	12
Open Space	10
Water/Wetland	2
Agriculture	2

Data Source: Connecticut Land Use Land Cover Data Layer LANDSTAT (1995) Thematic Mapper Satellite Imagery.

Stressor ID Procedure

The process of evaluating data to determine the most likely candidate causes of biological impairment has been the subject of many recent efforts [1-4]. The Stressor Identification (SI) Procedure followed here by CTDEP is similar to the approaches outlined in these references and basically involves 4 steps:

1) Listing the Candidate Causes;
2) Analyzing the Evidence;
3) Characterizing the Causes;
4) Identifying the Probable Candidate Cause.

These steps can lead to identifying the most likely candidate cause for aquatic life impairments that have an undetermined cause. Ultimately, identification of the most probable cause can lead to management actions to eliminate or control the cause. The specific aquatic life impairments that were examined for Eagleville Brook were low numbers of sensitive EPT taxa and low fish abundance.

Candidate Causes

The following data sources were considered to develop a list of candidate causes for the SI analysis for Eagleville Brook:

Biological

- CTDEP fisheries surveys [5]
- CTDEP macroinvertebrate surveys [5]
- CTDEP instream toxicity tests conducted in Eagleville Brook [5]

Chemical

- CTDEP ambient surface water samples [5]
- Consultants Reports pertaining to UCONN landfill remediation [6]
- UCONN stormwater study [7]

Hydrologic

- September 2003 Campus wide Drainage Master Plan Permit Application for Flood Management Certification [8]

Other

- Notes from field visits and visual observations
- Scientific literature and ecological theories
- GIS mapping of watershed

There are no known point source discharges other than stormwater in the Eagleville Brook watershed and therefore the data supported a list of candidate causes related to stormwater and non-point source impacts. After reviewing the available data, the candidate causes listed in Table 1 were explored further using conceptual model diagrams annotated with supporting lines of evidence.

Table 1. Candidate Causes. Potential causes and sources of the observed low fish abundance and lack of sensitive EPT taxa in Eagleville Brook.

Candidate Cause	Potential Sources
Toxic Contamination	Copper roofing, Surface runoff, landfill leachate, unknown sources
Embedded Substrate	Sediment from runoff from local parking lots, winter road sanding, bank erosion
High Flow	Impervious surfaces cause extreme runoff volumes that remove organisms from their habitat
Low Flow	Impervious surfaces disrupt natural hydrologic cycle and cut-off vertical connectivity of surface water and groundwater
Elevated stream temperature	Impervious surfaces heat up water

Analyzing Evidence

Conceptual model diagrams were used to illustrate the link between potential sources, logical causal pathways, and the observed measurement of reduced EPT and fish taxa (Figures1-5). The data and conceptual model diagrams were the used to 1) eliminate causal pathways , 2) identify causal pathways that were weakened, and 3) provide evidence in support of a causal pathway. Data that was ambiguous was noted in the text summaries. Data that supported a causal pathway was highlighted in a yellow box. Data that weakened or refuted a casual pathway was highlighted in a brown box and an arrow points to the location of the disruption in the causal pathway.

Conceptual Model of Toxic Contamination

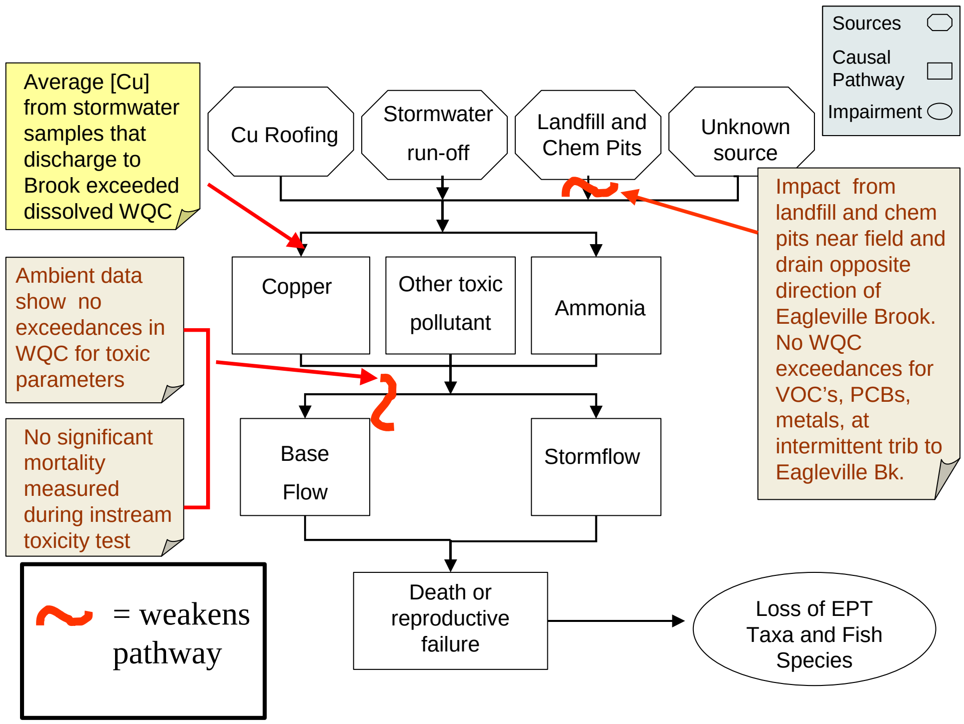


Figure 1. Conceptual model of toxic contamination as the cause of the low abundance of fish and EPT taxa. WQC is water quality criteria and refers to criteria as defined in Connecticut's Water Quality Standards [9] .

Data that weakens or refutes

- Contribution of toxic contamination from landfill and chemical pits to Eagleville Brook Segments _01 and _02 unlikely. The landfill was comprised mostly of bulky waste with no industrial component and therefore reduces the likelihood of potential contaminants. Further, there is a drainage divide across the top of the landfill such that half of the groundwater drains to the Cedar Swamp Brook watershed and half drains towards Eagleville Brook. Some exceedances in water quality criteria were noted near landfill in areas draining to Cedar Swamp Brook. No water quality criteria exceedances for VOC's, PCB's, metals, at intermittent tributary to Eagleville Bk, upstream of the study Eagleville _01 and _02. Contaminated soil in former chemical pit area has been excavated to bedrock and therefore fully remediated. Since instream and groundwater data upstream show no exceedances of water quality criteria, it is unlikely that there is a toxic contribution from the landfill at sites further downstream in Eagleville Brook.

- Ambient water samples collected by CTDEP during non-storm events show no exceedances of water quality criteria.

- Instream toxicity test in Eagleville Brook using the fathead minnow (*Pimephales promelas*) as a test organism, show no significant mortality during base flow conditions.

Data that supports

- A copper roof was installed on the Castleman Engineering Building located on the UCONN campus in 1992. The total area of the copper roof is 1,800 square meters [8]. A study was conducted in 2001 to evaluate runoff from the roof [8] .The average stormwater copper concentration that discharge to Eagleville Brook (n=16 storms) was approximately equal to acute water quality criteria (Table 2). If the average concentration exceeded water quality criteria, then concentrations during some individual storm events were likely higher than criteria.

Table 2. Mean and standard deviation of total and dissolved copper at each sampling station for 16 Storms. Water Quality Criteria for dissolved copper in Eagleville Brook are 14.3 μg/l (acute) and 4.8 μg/l (chronic).

Sampling Station	**Total Copper** (μg/l)	**Dissolved Copper** (μg/l)
1. New Roof	3630 +/- 1760	3340 +/- 1520
2. Roof Drain	1340 +/- 820	1210 +/- 840
3. Lawn Area	20 +/- 8	9 +/- 2
4. Parking Lot	16 +/- 6	8 +/- 2
5. Stormwater system outfall	46 +/- 26	14 +/- 7

From *Copper Roof Stormwater Runoff - Corrosion And The Environment http://www.copper.org/environment/homepage.html*) [8]

<u>Data that is ambiguous</u>

- Since 1988, illicit discharges flowing from the underground portion (under the UCONN campus) of Eagleville Brook have been identified on at least 5 occasions and reportedly corrected for each incident.

- Laboratory toxicity tests indicate very high toxicity to test organism, *Daphnia pulex,* from water collected from copper roof and roof drain, but below the detection limit of the LC 50 test in the outfall of the storm drainage system (Table 3). The toxicity at sites down gradient to the copper roof is suggested to be buffered (i.e. reduced) by interactions with the concrete piping materials, dissolved organic carbon, and other complexing agents. Toxicity testing was only conducted on a single event and it is unclear the magnitude of this storm event. Further toxicity testing would be beneficial to gain a better understanding of these hypothesized reasons for low toxicity at sites down gradient of the roof.

Table 3. 48 -hour LC 50 values for sites sampled on the UCONN campus and Eagleville Brook.

Sampling Station	48 -h LC 50
1. New Roof	< 0.62 %
2. Roof Drain	< 0.62 %
3. Lawn Area	> 100 %
4. Parking Lot	> 100 %
5. Stormwater system outfall	> 100 %

From *Copper Roof Stormwater Runoff - Corrosion And The Environment http://www.copper.org/environment/homepage.html*) [8]

Conceptual Model of Embedded Substrate

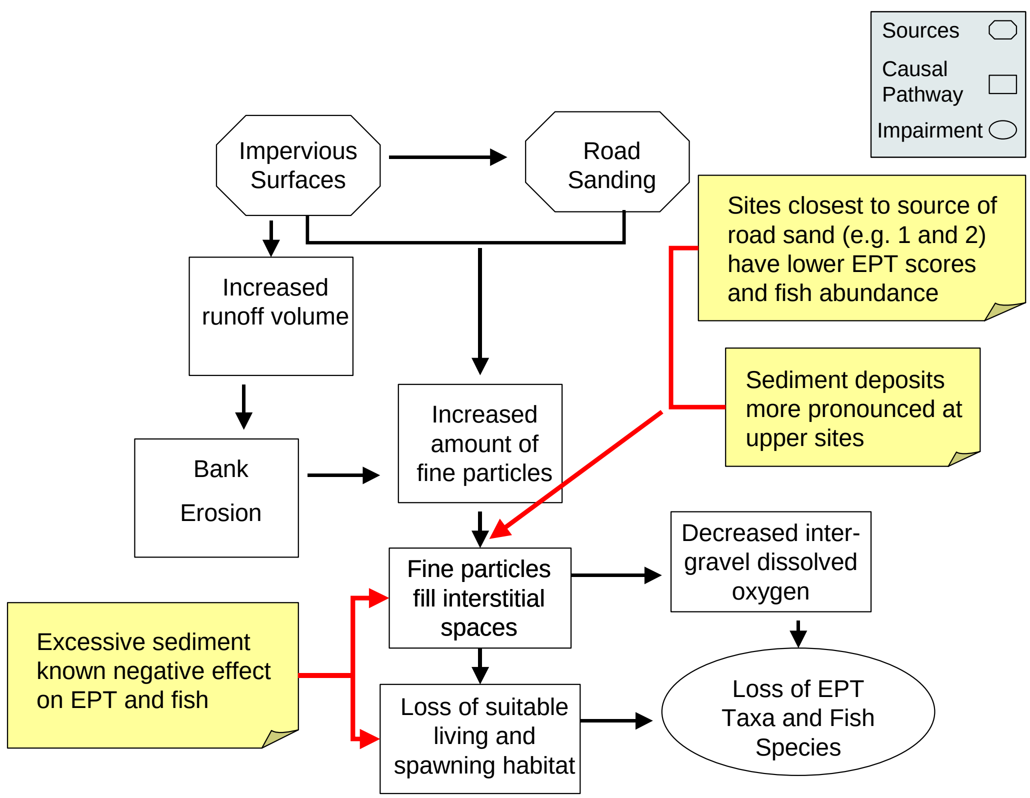


Figure 2. Conceptual model of embedded substrate as the cause of the low abundance of fish and EPT taxa.

Data that weakens or refutes

- none

Data that supports

- Excessive sedimentation has a negative effect on aquatic organisms by reducing interstitial living space for aquatic macroinvertebrates and reducing or eliminating spawning habitat for fish.

- Sites closest to source (i.e. impervious surfaces surrounding UCONN campus) had lower EPT scores and lower fish abundance. Lower EPT scores and lower fish abundance could indicate a reduced availability of suitable habitat for living and reproduction due to embeddedness.

- Stormwater in Eagleville Brook carries sediment loads from sources upstream (**Data Support Photo 1**).

Data Support Photo 1. Sediment deposition and movement through the Eagleville Brook system. Photos were taken on 10/13/2005, 10/16/2005, 10/20/2005, and 10/26/2005 at Eagleville Brook upstream Hunting Lodge Rd (upstream Site 1) over a two-week period with two consecutive storm events. Photos taken by DEP field staff.

- Sediment deposits more pronounced at upper sites noted during field visits (**Data Support Photo 2**).

Data Support Photo 2. Excessive sedimentation observed in Eagleville Brook upstream of Separatist Road (Site 2). Photos taken by DEP field staff.

Conceptual Model of High Flow

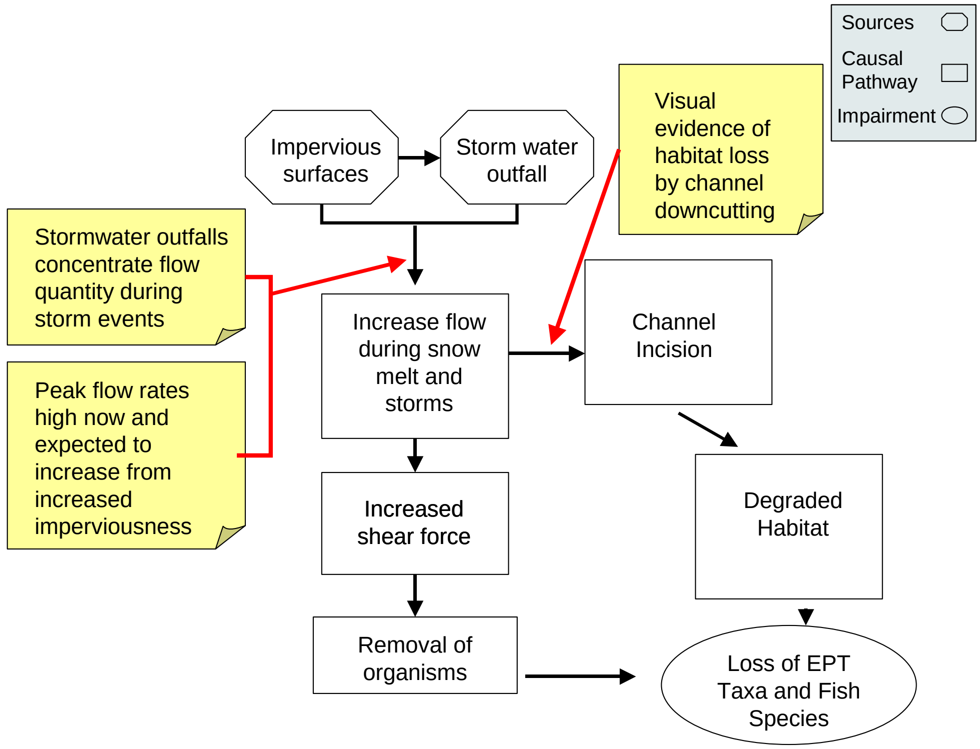


Figure 3. Conceptual model of high flow as the cause of the low abundance of fish and EPT taxa.

<u>Data that weakens or refutes</u>

- None

<u>Data that supports</u>

- Peak discharge rates in Eagleville Brook are high now due to the amount of impervious surface near the headwaters and expected to increase as a result of campus expansion (Table 4). For example, the peak discharge with a 2-year return frequency is expected to increase from 85.61 cfs to 89.49 cfs post-development.

Table 4. Peak discharge in cubic feet per second (cfs) in Eagleville Brook.

Return Frequency (Year)	Peak Discharge (cfs)	
	Current Condition	Post-Development
2	85.61	89.49
10	324.84	331.35
100	960.20	973.99

From: Flood Management Certification - Campuswide Drainage Master Plan, September 2003. Prepared for University of Connecticut, Storrs, CT, by Lenard Engineering, Inc. [8]

- Stormwater outfalls provide concentrated flow volumes and pollutants
- Visual evidence of habitat loss by channel down cutting noted during site visits (**Data Support Photo 3**).

Data Support Photo 3. Channel down cutting and bank erosion observed in at site 1, Eagleville Brook downstream of Hunting Lodge Road on July 6, 2005. Photo taken by DEP field staff.

Conceptual Model of Low Flow

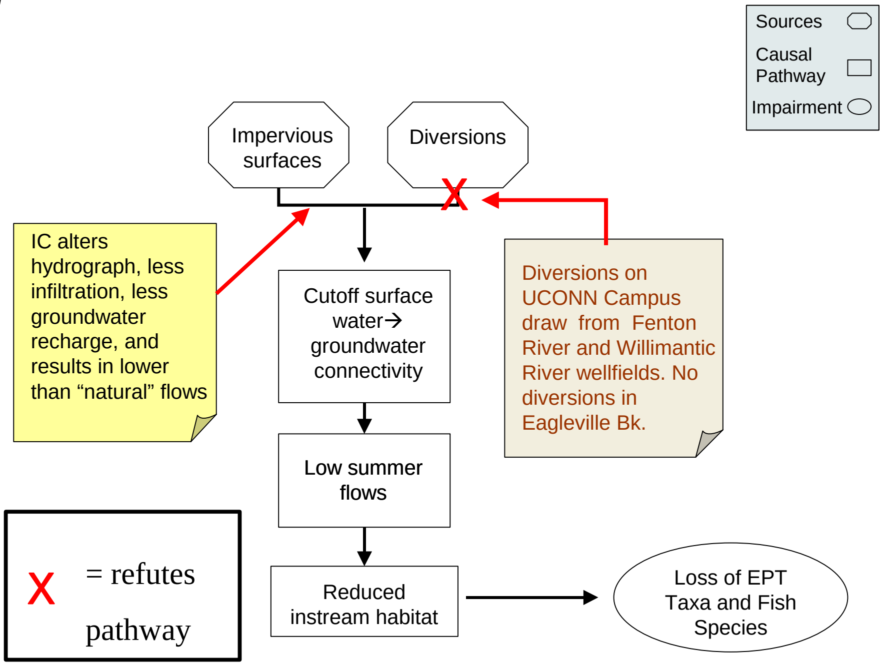


Figure 4. Conceptual model of low flow as the cause of the low abundance of fish and EPT taxa.

Data that weakens or refutes

- No documented diversions in Eagleville Brook watershed

Data that supports

- Impervious cover alters hydrograph which results in decreased groundwater recharge

Conceptual Model of Elevated Temperature

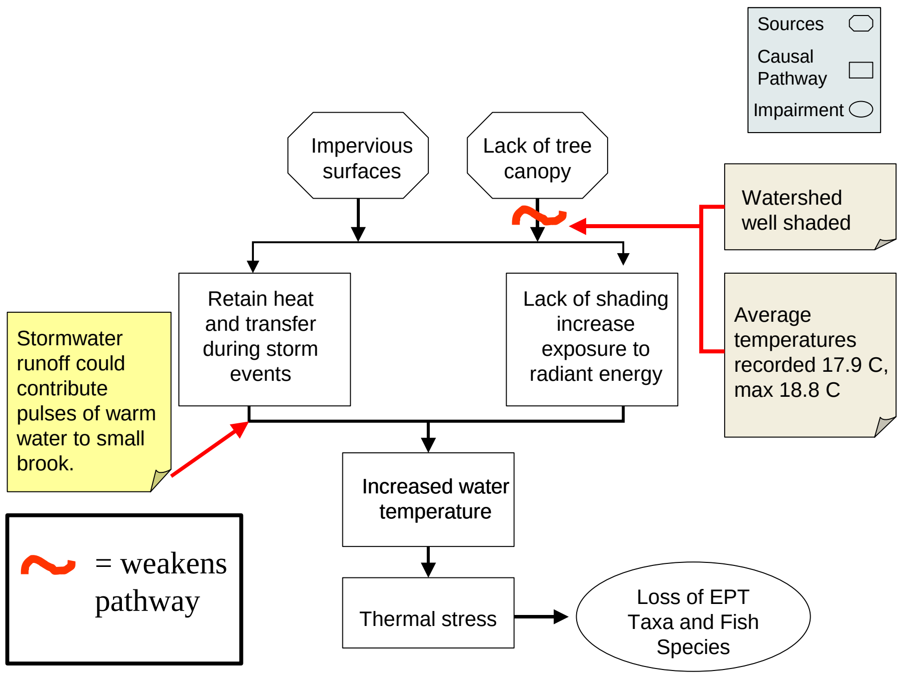


Figure 5. Conceptual model of elevated stream temperature as the cause of the low abundance of fish and EPT taxa.

Data that weakens or refutes

- Average water temperatures recorded during field sampling was 17.9 C (Range 16.0-18.8 C). These data include dates during summer, worst-case scenario conditions.

- Most of watershed well shaded (**Data Support Photo 4**).

Data Support 4. Watershed is well shaded. This is a typical of Eagleville Brook _01 and _02. This is site 4, adjacent North Eagleville Road. Photo taken by DEP field staff.

<u>Data that supports</u>

- Consistent with scientific literature, stormwater may contribute pulses of warm water heated by impervious surfaces to Eagleville Brook during storm events.

Identifying the Probable Cause

All available data and causal pathways were examined for each candidate cause. The weight of evidence supports several different contributions from stormwater flows as being the most probable cause of the observed biological impairment (low EPT taxa and fish abundance). These include possible chemical contamination (copper), substrate impacts due to sedimentation, habitat loss due to channel down cutting, high peak flow rates, and potential pulses of warm water during stormwater events. It cannot be determined which of these stormwater constituents is most likely to cause the impairment. However, the weight of evidence supports that the interactions of this complex array of stormwater constituents with the aquatic biota in Eagleville Brook is the likely cause of the low numbers of fish and sensitive EPT Taxa. A management strategy that reduces the effect of stormwater on the aquatic biota in Eagleville Brook will be necessary to meet aquatic life goals in the brook.

Probable Cause of Impairment: Complex array of pollutants transported by stormwater runoff .

References

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[2] Suter, G.S. et al. 2002. *A Methodology for Inferring the Causes of Observed Impairment in Aquatic Ecosystems*. Env. Tox. & Chem 21(6) 1101-1111.

[3] Norton, S.B. et al. 2002. *Determining Probable Causes of Ecological Impairments In The Little Scotio River, Ohio, USA: Part 1. Listing Candidate Causes and Analyzing Evidence.*. Env. Tox. & Chemistry 21(6) 1112-1124.

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Appendix 2. Percent Impervious Cover as a Surrogate Target for TMDL Analyses in Connecticut.

Percent Impervious Cover as a Surrogate Target for TMDL Analyses in Connecticut

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15 pages with 2 Tables and 5 figures
Last Revised December 14, 2006

Introduction
Impervious cover (IC) is a description of land cover such as roads, parking lots, and building rooftops that changes the natural dynamics of the hydrologic cycle, and has become a variable of great interest as a measurement of human disturbance as it relates to aquatic communities in streams. Studies from many areas of the country have documented that streams become degraded and are unable to support sensitive taxa of fish and aquatic macroinvertebrates at higher IC levels. A recent review of IC by the Center for Watershed Protection [1] (http://www.cwp.org) noted that several stream quality indicators decrease as IC levels increase. In general, this trend becomes pronounced within the 10-25% IC range and impairment is almost inevitable when the watershed IC exceeds 25%.

The amount of IC affects both the quality and quantity of water resources by disrupting the natural hydrological cycle. IC prevents precipitation from infiltrating through the ground thus increasing surface runoff (quantity) and its ability to transport pollutants to the receiving water (quality). Under natural conditions (e.g. IC < 10%), approximately 10% of rainfall can be characterized as surface runoff. Under more urbanized conditions (e.g. IC >10 %), as much as 55% of rainfall can be characterized as surface runoff [2]. Water quality is also affected because watersheds with more IC have less buffering capacity provided by the passage through natural soils. An excellent overview of the effects of impervious cover has been recently been published in Chapter 2 of the Connecticut Stormwater Quality Manual [3]. A review of stream studies by the Center for Watershed Protection [1] (Table 1) provides strong evidence on the impacts IC has on hydrology, chemistry, and biology of streams that support using IC as a surrogate measure of impacts to aquatic life for TMDL Analysis.

This support document provides an approach for developing appropriate IC thresholds for Connecticut based on GIS derived estimates of IC and macroinvertebrate data collected by the Department. IC thresholds can then be used as a goal for TMDL development. This approach is recommended for use in developing TMDLs where there is a clear linkage between measured aquatic life impacts and stormwater discharging from areas dominated by IC.

Basis for use of % Impervious Cover as a Surrogate

Section 303(d)(1)(C) of the Clean Water Act (33 U.S.C. Section 1313(d)(1)(C)) provides that each State shall establish, for waters listed pursuant to Section 303(d)(1)(A), the total maximum daily load ("TMDL") for those pollutants which EPA has identified as suitable for such calculation. The term "total maximum daily load" is not specifically defined in the Clean Water Act. While TMDLs are intended to address impairments resulting from pollutants, there is nothing in EPA's regulations that forbid expression of a TMDL in terms of a surrogate for pollutant-related impairments.

EPA's regulations state that TMDLs can be expressed in several ways, including in terms of toxicity (often an aggregate measure of more than one pollutant), or by some "other appropriate measure" [40 C.F.R. §130.2(i)]. They also state that TMDLs may be established using a biomonitoring approach as an alternative to the pollutant-by-pollutant approach [40 C.F.R. § 130.7(c)(1)]. This flexibility in the expression of TMDLs supports reliance on a surrogate where, as in this case, there is a reasonable rationale and the TMDL is designed to ensure attainment with water quality standards.

A combination of pollutants found in storm water, including sediment (from runoff and instream sources) and associated pollutants contributes to aquatic life impairments in more urbanized streams. Often, there is no information that indicates that any pollutant is causing or contributing to an exceedance of any pollutant specific water quality criterion. Nor is there sufficient information available to identify specific pollutant loadings which, in combination, are contributing to the aquatic life impairment. Quantifying these pollutant loadings is especially difficult given the variability in types and amounts of pollutants associated with storm water, and the range in magnitude of storm events.

On the other hand, there is a strong correlation between pollutant loads, storm water flows, and runoff from impervious landcover in the watershed [1,2]. Therefore, it is reasonable to rely on the surrogate measure of % impervious cover to represent the combination of pollutants that contribute to aquatic life impairments.

Estimates of Impervious Cover

Estimates of the percent impervious cover of the total land cover (% IC) for 1985, 1990, 1995, and 2002 by local basin were obtained from the Center for Land Use Education and Research at the University of Connecticut (E. Wilson, Personal Communication). The % IC values were derived from land cover data using an ArcView® Impervious Surface Analysis Tool (ISAT). ISAT multiplies IC coefficients by each land cover classes to obtain an estimate of total impervious cover by area (such as a local drainage basin). These IC coefficients were developed using nine Connecticut towns that have accurately measured IC. Actual IC measurements from these nine towns were used to "truth" the computer interpretation of IC and provide IC coefficients for use statewide. Further information on ISAT can be found on the University of Connecticut's website http://nemo.uconn.edu/impervious_surfaces/index.htm.

Applicable Streams
Monitoring sites included in this analysis are listed in Table 2 and Figure 1. These sites represent benthic monitoring sites that were sampled by CTDEP as part of the rotating basin approach from 1996 to 2001 [4] , and more recently a group of sites selected based on a probabilistic sampling design [5]. Sites were limited to only those in which Rapid Bioassessment Protocol (RBP) III [6] level of effort were completed. The RPB III level of effort consists of a two square meter kick net sample collected from erosional riffle habitat, 200 organism sub sample, and organism identification to the lowest taxon possible (generally species level).

The impact of IC was measured as the % IC of the total land cover upstream of the monitoring location. For monitoring locations in smaller streams (e.g. local basins), IC measurements were delineated to the upstream extent of the local basin boundary. Similarly, for monitoring locations contained in subregional basins, IC measurements were delineated to the upstream extent of the subregional basin boundary. One difficulty of linking upstream landcover and its calculated IC percentage to the location of monitoring sites is that the spatial distribution of IC is not taken into account. This creates a greater potential for error in estimating the effect of IC above monitoring locations in large watersheds because IC clusters located far upstream of the monitoring location may not effect the macroinvertebrates at the monitoring location. Whereas in smaller watersheds, IC is more likely to have an effect on the macroinvertebrates at the monitoring location. For this reason, the analysis was limited to monitoring locations with upstream drainage areas of < 50 square miles.

In addition to excluding monitoring locations with large watersheds upstream, monitoring locations within one mile downstream of a sewage treatment plant discharge were also excluded from the analysis. Also, monitoring sites on streams that have a portion of the upstream basin in states bordering Connecticut were excluded because IC estimates were not readily available for other states.

As a result of the qualifiers mentioned above, the **Applicable Streams** effectively are those with monitoring locations with RPB III level of effort on streams with < 50 square miles drainage upstream, beyond 1 mile of a sewage treatment plant discharge, and no portion of the drainage in another state. Care should be taken when making inferences to monitoring sites in streams that may exhibit different characteristics.

Results
A total of 125 sites met the criteria as outlined in **Applicable Streams** above and were considered in this analysis. Sites were evaluated 1) graphically using scatter plots and box plots and 2) using summary statistics. Since IC estimates were available for four years - 1985, 1990, 1995, and 2002 - the IC dataset from the closest year preceding the monitoring date was used in all cases.

Scatter plots from the **Applicable Streams** in Connecticut showed that taxa richness (total number of taxa) and EPT taxa (taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera) generally decreased with increasing IC (Figure 2). As a group, EPT taxa can be characterized as sensitive taxa and often occur in decreased abundance in response to environmental stress.

Applicable Streams were further separated in two groups - 1) those that met Connecticut aquatic life criteria as assessed using RBP % of reference score [7] and 2) those that did not meet Connecticut's aquatic life criteria. The general trend observed in these data was that the % IC was lower for streams that met Connecticut's aquatic life criteria than sites that did not meet Connecticut's aquatic life criteria, although there was some overlap in the upper quartile of the "meet" group with the lower quartile of the "do not meet" group (Figure 3).

Figure 4 demonstrates a "threshold" effect in that as the %IC increases to approximately 12%, no **Applicable Streams** met Connecticut's aquatic life criteria (i.e. >54% reference community). Based on this analysis, the Department believes that 12% IC is a good threshold for aquatic life impairments. It is recognized that IC may not be the direct factor causing the impairment, but that there is a strong enough relationship to use IC as a surrogate measure in situations when a Stressor Identification analysis has determined that stormwater is the primary candidate cause of the aquatic life impairment. For impaired streams with less than 12 % IC upstream, factors other than stormwater will be investigated using the Stressor Identification Procedures employed by the Department.

Impervious Cover Target for TMDLs in Connecticut

The 12 % IC threshold value can be used as the surrogate TMDL target, and to further define a surrogate Wasteload Allocation (WLA) and Load Allocation (LA) target for stormwater caused aquatic life impairments in Connecticut. This 12% IC threshold observed for **Applicable Streams** represents a level of imperviousness below which is capable of supporting a macroinvertebrate community that meets aquatic life use goals in Connecticut Water Quality Standards. The 12% IC threshold is within the range of % IC values generally reported in the literature (e.g. ~ 10 %)[1,8] and, more specifically, in other New England States. For example, the State of Maine recently proposed IC targets that ranged from 6-15 % to support their tiered aquatic life use categories based on an analysis of macroinvertebrate and IC data [9]. This provides more confidence in using IC as a surrogate measure for TMDL development in Connecticut where stormwater impacts are the likely cause of aquatic life impairments in streams.

In accordance with federal law, TMDLs must include a WLA to account for point source contributed pollutant loads, a LA to address non-point pollutant loads, and a margin of safety (MOS) to account for uncertainty in the analysis. The IC TMDL is equal to the 12% TMDL Target or threshold value. The IC WLA and LA target developed for **Applicable Streams** is 11%, and the 1% difference (12% threshold - 11 % WLA and LA target = 1 % IC) represents the numerical (or explicit) MOS in the TMDL analysis.

Using the actual threshold below which aquatic life standards are attained provides a reasonable TMDL target, and an explicit 1% MOS. The 11% IC target is applied statewide to all stormwater drainage areas, whether regulated or unregulated, in the watershed (WLA = LA) in order to reduce pollutant loads and restore hydrologic and biological integrity of the watershed as a whole.

Relating these concepts of WLA, LA, and MOS to TMDL development using IC as a surrogate for the mass of a specific pollutant or mix of pollutants discharged to a surface waterbody from stormwater runoff requires associating reductions in IC, or the negative effects of IC through stormwater Best Management Practices (BMP's), with reductions in the point and non-point loading of unspecified pollutants needed to achieve acceptable water quality conditions. The 11% IC target for WLA and LA can be translated into a surrogate TMDL objective that is applicable to streams with aquatic life impairments caused primarily by stormwater. This IC TMDL objective can be expressed in terms of % reduction in WLA and LA, and can provide a benchmark for implementation of BMP's to reduce the impacts of IC on aquatic biota living in streams. The WLA and LA % IC target, and any required percent reduction to meet the TMDL objective will be applied to both the WLA and LA because of the practical difficulty of separating stormwater loadings contributed by background, nonpoint, and point sources.

Basis for Aggregate Wasteload Allocation

Forty C.F.R. Section 130.2(h) provides that point source discharges (interpreted by EPA to mean discharges subject to the NPDES permit program) must be addressed by the wasteload allocation component of a TMDL. Discharges involving process wastewater, non-contact cooling water, and other non-storm water discharges are assigned individual waste load allocations pursuant to this regulation. Stormwater discharges, however, are less amenable to individual wasteload allocations. In recognition of this fact, EPA's November 22, 2002 guidance entitled "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Stormwater Sources and NPDES Permit Requirements Based on Those WLAs," provides that it is reasonable to express allocations for NPDES-regulated storm water discharges from multiple point sources as a single categorical or aggregate wasteload allocation when data are insufficient to assign each source or outfall individual WLAs. EPA's guidance recognizes that the available data and information usually are not detailed enough to determine waste load allocations for NPDES-regulated storm water discharges on an outfall-specific basis. In the case of Connecticut urban streams, CT DEP has determined that because the storm water discharges are highly variable in frequency and duration, it is not feasible to establish specific wasteload allocations for each storm water outfall. It is impossible to determine with any precision or certainty the actual and projected loadings for individual discharges or groups of discharges. During the implementation of the TMDL, DEP will assign responsibilities to storm water dischargers as necessary to meet instream water quality standards.

TMDL Implementation

Implementation of the an IC TMDL for stormwater will be best accomplished through incorporating an adaptive management strategy. The strategy will include 1) reducing IC where practical, 2) disconnecting IC from the surface waterbody, 3) minimizing additional disturbance to maintain existing natural buffering capacity, and 4) installing engineering BMPs to reduce the impact of IC on receiving water hydrology and water quality. The goal is to reduce the effects of the complex mixture of stormwater pollutants to the receiving stream. The previously cited *2004 Connecticut Stormwater Manual* [3] provides good background information for new site design, as well as technical guidance for stormwater BMPs for existing sites. The effect of these strategies can be illustrated by considering the source of pollutants present in stormwater runoff and the effect of each strategy on reducing those loads.

The majority of waterbodies draining watersheds with greater than 11% IC are located in urbanized areas that are subject to the requirements of Connecticut's MS4 General Permit

(Figure 5). The MS4 General Permit will provide legally enforceable reasonable assurance that stormwater issues will be addressed for TMDLs completed in MS4 Urbanized Areas. Areas that are outside of the jurisdiction of the MS4 General Permit that have Impaired Waters caused by stormwater identified by a Stressor Identification conducted by the Department may be good candidates to include in the program in the future.

An ongoing biological monitoring program is critical to assess the effectiveness of implementation efforts. Implementation is expected to continue until biological monitoring shows attainment of aquatic life use goals. The Department will also be encouraging implementation efforts to also include an in-stream and riparian habitat enhancement component since it is likely that restoration of physical habitat will enable a more rapid and complete recovery of the aquatic biological community as IC% approaches the TMDL target threshold of 11%.

Benefits of Using IC as a Surrogate for Aquatic Life Impairments caused by Stormwater

- Quantifiable relationship linking IC and aquatic life use support
- IC is an appropriate surrogate measure of the probable cause of the impairment (mixture of pollutants transported by stormwater)
- Consistent with Bureau of Water Protection and Land Reuse's strategy to address stormwater impacts
- IC is easily understood by public
- TMDLs can be developed with readily available information

Limitations of Using IC as a Surrogate for Aquatic Life Impairments caused by Stormwater

- Habitat degradation may preclude achieving aquatic life goals
- Additional TMDLs for specific pollutants may be required in areas where groundwater contamination or point sources are contributing to the impairment
- Site specific information will be required to identify the most cost effective BMPs to achieve TMDL goals

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Table 1. Strength of evidence: A review of current stream studies and the effects on IC (adapted from *Center for Watershed Protection Research Monograph Number 1* [1].).

Parameter	**Number of Studies showing a progressive change in parameter as IC increases**
Increased Runoff Volume	2
Increased Peak Discharge	7
Stream channel enlargement	8
Decline in stream habitat quality	11
Changes in pool/riffle structure	4
Increased stream temperature	5
Increased nutrient load	30 +
Increases sediment load	30 +
Increased metals and hydrocarbons	20 +
Increased pesticide levels	7
Increased chloride levels	5
Decline in aquatic insect diversity	33
Decline in fish diversity	19
Loss of coldwater fish species	6
Reduced fish spawning	3

Table 2. Benthic monitoring sites selected for analysis (Applicable Streams).

Sample Date	Stream Name	Drainage Area Upstream (square miles)	Percent IC upstream of site	Percent of Reference D
10/17/2002	Ekonk Brook	5.3	2.9	67
10/28/1998	Pocotopaug Creek	5.4	3.7	29
10/13/1998	Stony Brook	5.7	2.7	52
11/2/2000	Hewitt Brook (Poquetanuck Brook)	5.8	3.4	72
10/30/2002	Lake Waramaug Brook	5.8	3.3	90
10/15/2002	Latimer Brook	5.9	3.8	67
11/13/1997	Pequonnock River	5.9	8.6	60
10/20/1998	Burlington Brook	5.9	4.5	62
10/26/1999	Tenmile River	6.0	3.5	95
10/6/1999	Myron Kinney Brook	6.1	2.3	53
10/19/2000	Seth Williams Brook	6.2	4.3	50
10/16/2000	Farm River	6.3	4.1	47
10/9/2002	Pond Meadow Brook	6.4	3.5	85
11/5/1996	Naugatuck River	6.7	7.3	40
11/5/1997	Norwalk River	6.8	7.9	65
10/29/1997	Norwalk River	6.8	7.9	70
10/3/2002	Norwalk River	6.8	8.0	47
10/4/2000	Transylvania Brook	6.9	4.3	33
10/23/1997	West River	7.2	3.0	94
10/21/1997	West River	7.2	3.0	100
10/17/2000	Sympaug Brook	7.2	13.1	29
10/2/1997	Salmon Creek	7.4	3.6	95
11/9/1999	Factory Brook	7.5	3.9	67
10/14/1997	Mill River	7.7	8.2	100
10/17/1997	Branford River	8.3	5.7	71
11/13/1997	Mill River	8.4	7.0	90
10/24/2000	Still River	8.5	9.4	38
10/23/1998	Salmon Brook	8.8	10.1	67
10/6/2000	Willow Brook	9.2	18.6	29
11/3/2000	Oxoboxo Brook	10.2	5.6	29
11/2/2000	Oxoboxo Brook	10.2	5.6	38
11/2/2000	Trading Cove Brook	10.2	4.6	95
10/22/1999	Whetstone Brook	10.3	3.4	58
10/20/2000	Gardner Brook	10.5	3.4	71
10/20/1998	Nepaug River	10.7	3.7	90
10/16/2000	Bladdens River	10.7	6.2	48

D Percent of Reference is calculated as described in Plafkin et al [6]. In general, sites > 54 % of reference community meet Connecticut's narrative aquatic life use in wadeable streams, although others factors are involved in the assessment. See Connecticut's CALM [7] for further information.

10/31/1996	Bladdens River	10.7	6.2	105
10/13/1999	Middle River	10.9	4.4	68
10/10/2000	Noroton River	11.0	19.5	25
10/13/1998	Muddy Brook	11.1	4.0	24
10/25/1999	Mill Brook	11.2	3.9	32
10/25/1999	Mill Brook	11.2	3.9	47
10/27/1998	Jeremy River	11.4	4.0	67
10/13/1999	Furnace Brook	11.6	3.3	53
10/4/2000	Shepaug River	11.8	2.4	90
10/6/1999	Pachaug River	11.9	3.3	37
10/3/2000	Middle River	12.0	4.4	53
11/4/1997	Harbor Brook	12.1	18.8	35
10/28/1998	Pine Brook	12.3	3.8	67
10/31/2000	Latimer Brook	12.4	4.2	90
10/24/2002	Whitford Brook	12.5	4.1	100
10/25/1999	Quanduck Brook	12.9	3.0	68
10/7/1999	Merrick Brook	13.0	3.0	74
10/17/2003	Eightmile River	13.1	10.6	100
10/12/1999	Eightmile River	13.1	10.1	95
10/14/1999	Willimantic River	13.5	3.8	79
10/20/1997	Mianus River	13.6	10.5	55
11/9/2000	Silvermine River	13.8	10.9	65
10/19/1999	Bungee Brook	14.2	2.9	74
10/21/1998	Still River	14.5	6.2	43
10/5/2000	Still River	14.5	6.2	38
11/14/1996	Farmill River	14.7	12.0	65
10/14/2003	Saugatuck River	14.8	4.4	100
10/6/1998	Trout Brook	15.1	22.7	24
11/7/1996	Farmill River	15.1	11.9	80
10/6/1999	Broad Brook	15.2	2.9	32
10/29/1998	East Branch Eightmile River	15.3	3.3	71
10/20/2000	Susquetonscut Brook	15.3	3.5	90
11/1/1996	Little River	15.5	5.1	90
10/22/1998	Broad Brook	15.8	4.8	24
10/28/1999	Moosup River	15.8	4.4	84
10/19/1999	Still River	16.0	3.0	74
10/6/1998	Piper Brook	16.3	28.0	19
10/12/2000	Steele Brook	17.0	13.5	38
10/12/2000	Steele Brook	17.0	13.5	33
10/1/1998	Coppermine Brook	17.4	11.5	62
11/7/1996	Eightmile Brook	17.4	4.5	105
11/6/1996	Hollenbeck River	17.6	2.5	105
10/14/1997	Mill River	18.4	8.3	100
11/13/1996	East Aspetuck River	18.7	4.7	95
11/4/1998	Pootatuck River	18.9	5.3	90
10/10/2000	Rippowam River	19.1	17.2	12

10/16/1997	Muddy River	19.3	7.7	71
10/30/1996	West Aspetuck River	19.6	3.3	85
11/6/1997	Wepawaug River	19.9	11.1	76
11/4/1998	Pootatuck River	20.8	5.8	80
11/4/1998	Pootatuck River	20.8	5.8	85
11/13/1996	Nonewaug River	21.3	3.8	90
10/29/1996	Pomperaug River	21.4	6.3	65
10/2/2003	Roaring Brook	22.0	3.0	100
11/19/1997	Aspetuck River	23.1	5.1	90
10/22/1999	Blackwell Brook	23.4	3.3	79
10/27/1998	Blackledge River	23.8	4.5	67
10/8/2002	Sandy Brook	24.2	2.6	100
11/14/1996	Mad River	24.3	15.9	18
10/29/1998	Eightmile River	24.4	2.7	95
10/30/1997	Norwalk River	25.2	14.8	35
10/19/1999	Bigelow Brook	25.2	2.5	95
10/24/2000	Still River	26.3	12.5	29
10/21/1997	Hammonasset River	26.4	3.7	106
10/19/1998	West Branch Salmon Brook	26.6	3.1	90
11/12/2003	Sandy Brook	26.8	2.6	100
11/6/1996	Blackberry River	26.9	3.5	75
10/14/1999	Fenton River	27.3	3.9	68
10/21/1998	Mad River	27.6	3.4	57
10/10/2000	Pequonnock River	27.9	16.8	18
10/26/1999	Mount Hope River	28.1	3.1	68
10/2/1998	Coginchaug River	28.3	6.1	67
10/22/2002	Mashamoquet Brook	28.5	3.2	100
11/5/1996	West Branch Naugatuck River	28.8	3.8	70
11/1/1999	Skungamaug River	30.7	3.9	74
10/17/1997	West River	31.7	14.9	18
10/22/1998	Scantic River	32.0	6.0	38
10/19/1998	Salmon Brook	34.5	3.9	62
11/19/1997	Saugatuck River	34.7	5.6	65
10/7/1999	Little River	36.7	3.1	63
10/16/1996	Mattabesset River	36.9	13.3	24
10/28/1999	Fivemile River	38.2	4.4	53
10/9/1997	Bantam River	38.7	3.7	100
10/24/2000	Still River	39.5	12.8	17
10/26/1998	Hockanum River	41.7	9.1	29
10/5/2000	Still River	41.7	4.4	50
11/1/2000	Little River	41.9	3.1	38
11/5/1996	East Branch Naugatuck River	43.8	5.8	50
10/29/1997	Norwalk River	46.4	13.9	45

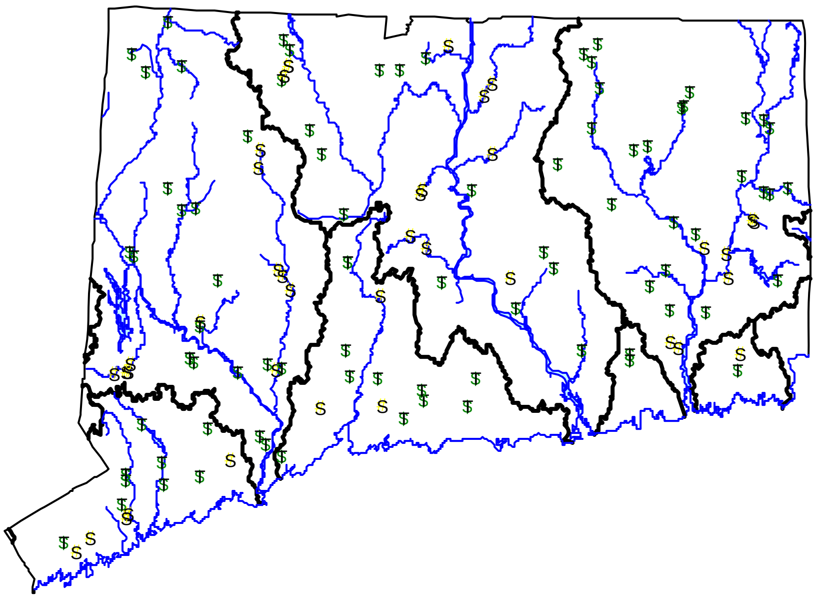
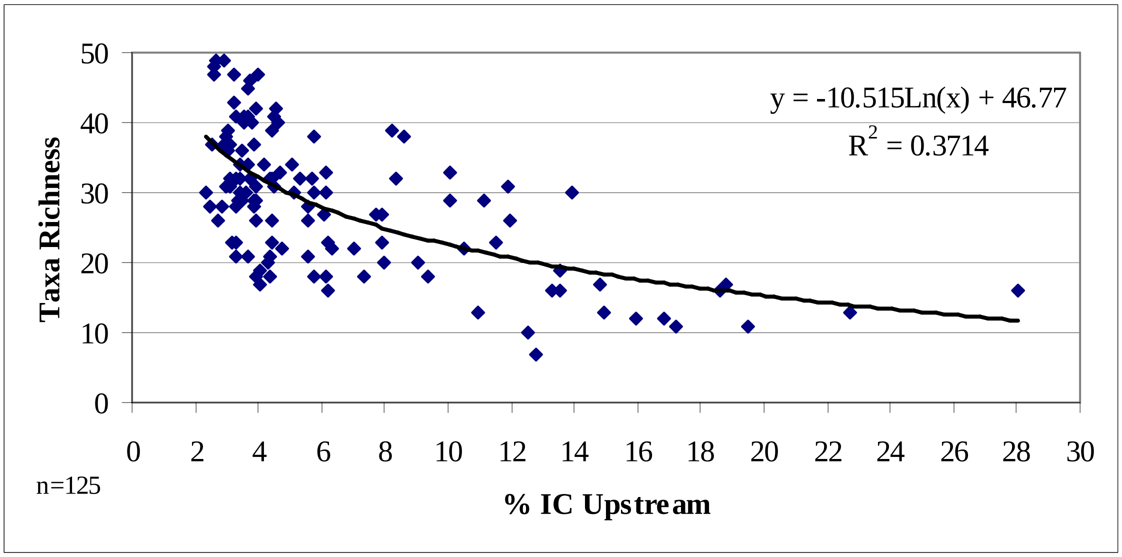


Figure 1. Applicable streams. Benthic monitoring sites considered for this analysis. Thick black lines show major drainage basin divides. Green triangles are sites that met Connecticut's aquatic life criteria (n=86) and yellow circles are sites that did not meet Connecticut's aquatic life criteria (n= 39).



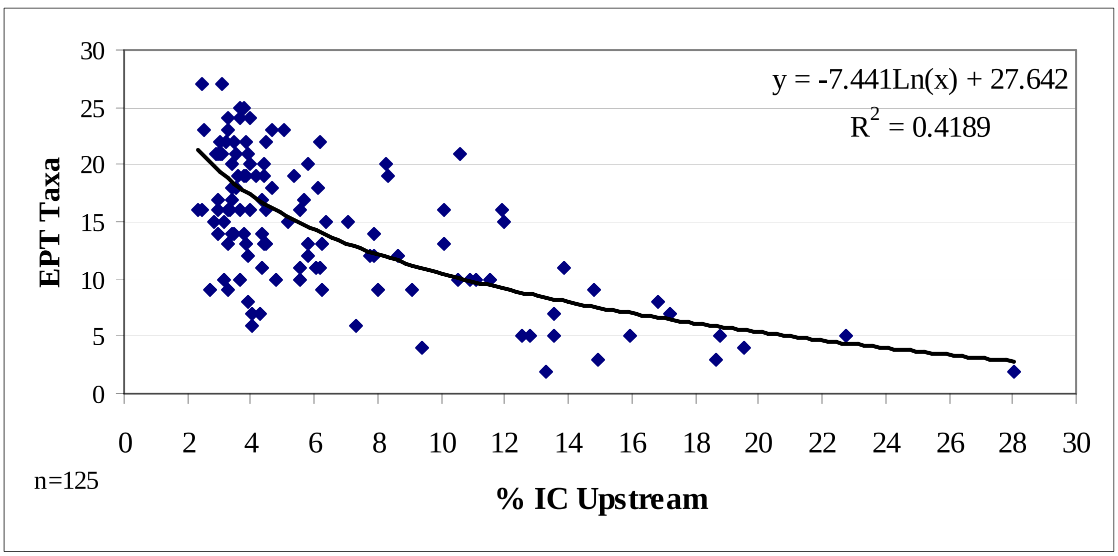


Figure 2. Scatter plot of taxa richness (upper) and EPT taxa (lower) and percent impervious cover upstream of macroinvertebrate monitoring locations from Applicable Streams in Connecticut.

	Sites that Meet WQC	Sites That Do Not Meet WQC
n	86	39
min	2.33	2.85
max	11.96	28.02
average	4.96	10.11
median	3.89	7.33
75%	5.75	14.34
90%	9.35	18.66
95%	10.85	19.83
99%	11.92	26.01

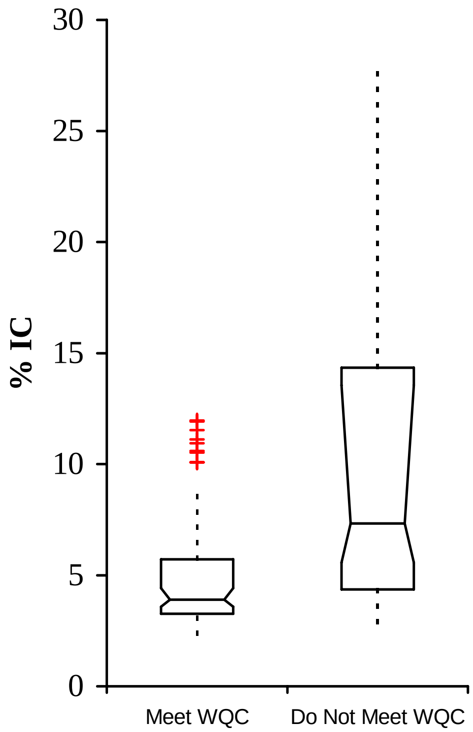


Figure 3. Box and whiskers plot and summary statistics of sites that meet Connecticut's Water Quality Criteria (WQC) for aquatic life (n=86) and sites that do not meet Connecticut's aquatic life criteria (n=39). The notched box shows the median and lower and upper quartiles. The dotted line extending from the quartile boxes shows the nearest observations within 1.5 interquartile ranges (IQR). Crosses indicate observations exceeding 1.5 IQRs.

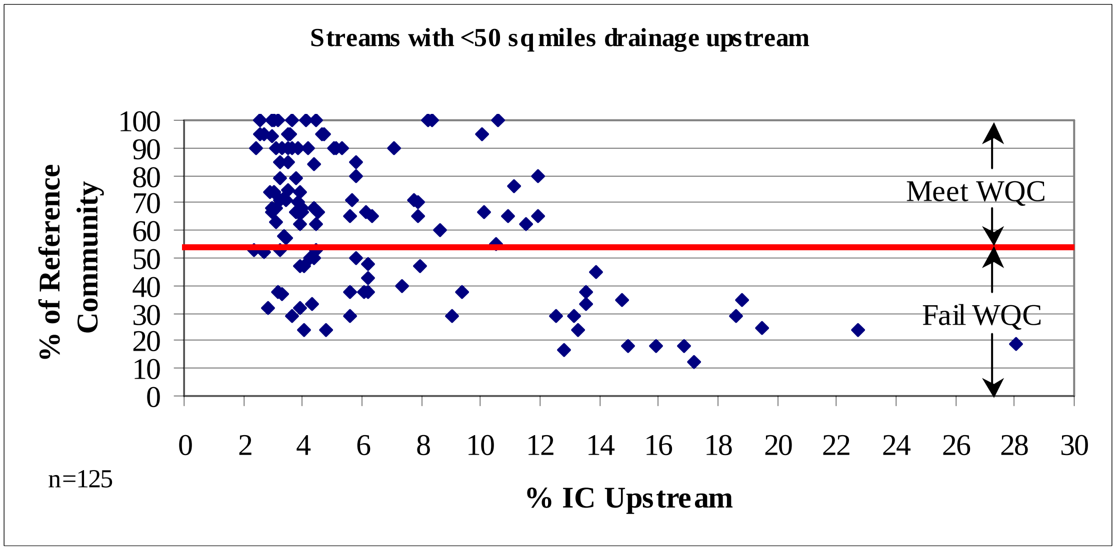


Figure 4. Scatter plot of percent IC upstream of monitoring locations and % of reference macroinvertebrate community as assessed using Connecticut CALM [6]. Points that plot above the horizontal red line meet Connecticut's water quality criteria (WQC) to support aquatic life. Points that plot below the horizontal red line do not meet Connecticut's water quality criteria to support aquatic life.

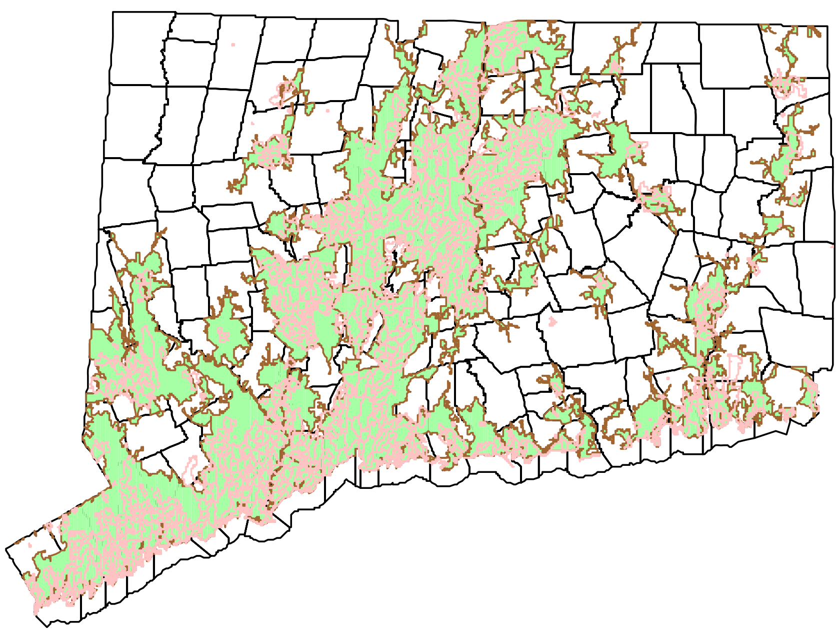


Figure 5. Relationship between MS4 Urban Areas and IC TMDL threshold. Green solid areas are considered Urban Areas under the Connecticut's MS4 General Permit and pink outlines show watershed locations where IC >= 11%.