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

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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 land cover 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 CT DEEP 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 land cover 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 affect 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 DEEP 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, DEEP will assign responsibilities to storm water dischargers as necessary to meet instream water quality standards.

TMDL Implementation

Implementation of 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

References

(1) Center for Watershed Protection. 2003. *Impacts of impervious cover on aquatic ecosystems.* Watershed Protection Research Monograph Number 1.

(2) Arnold, C.L. and C.J Gibbons. 1996. Impervious surface coverage. The emergence of a key environmental variable. Journal of the American Planning Association 62:243-258.

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

(4) Connecticut Department of Environmental Protection. In press. *Connecticut Department of Environmental Protection ambient water quality monitoring: rotating approach data summary.* 79 Elm Street, Hartford, CT 06106.

(5) United States Environmental Protection Agency. In press. *New England wadeable streams.*

(6) Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish.* EPA 440/4-89/001. USEPA, Washington, DC.

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

(8) Schuler, T.R. 1994. *The Importance of Imperviousness.* Watershed Protection Techniques1(3) 100-111.

(9) Maine Department of Environmental Protection. 2005. *Percent Impervious Cover TMDL Guidance for Attainment of Tiered Aquatic Life Uses.*

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 A
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

A 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.

10/2/1997	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
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

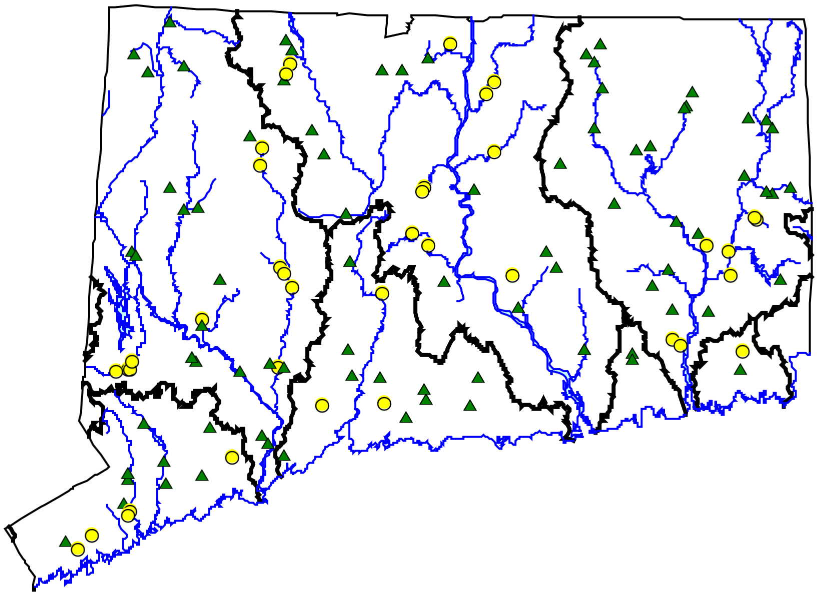

Figure 1. *Applicable streams. Benthic monitoring sites considered for this analysis. Thick black lines show major drainage basin divides. Green triangles are sites that met Connecticut's aquatic life criteria (n=86) and yellow circles are sites that did not meet Connecticut's aquatic life criteria (n=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

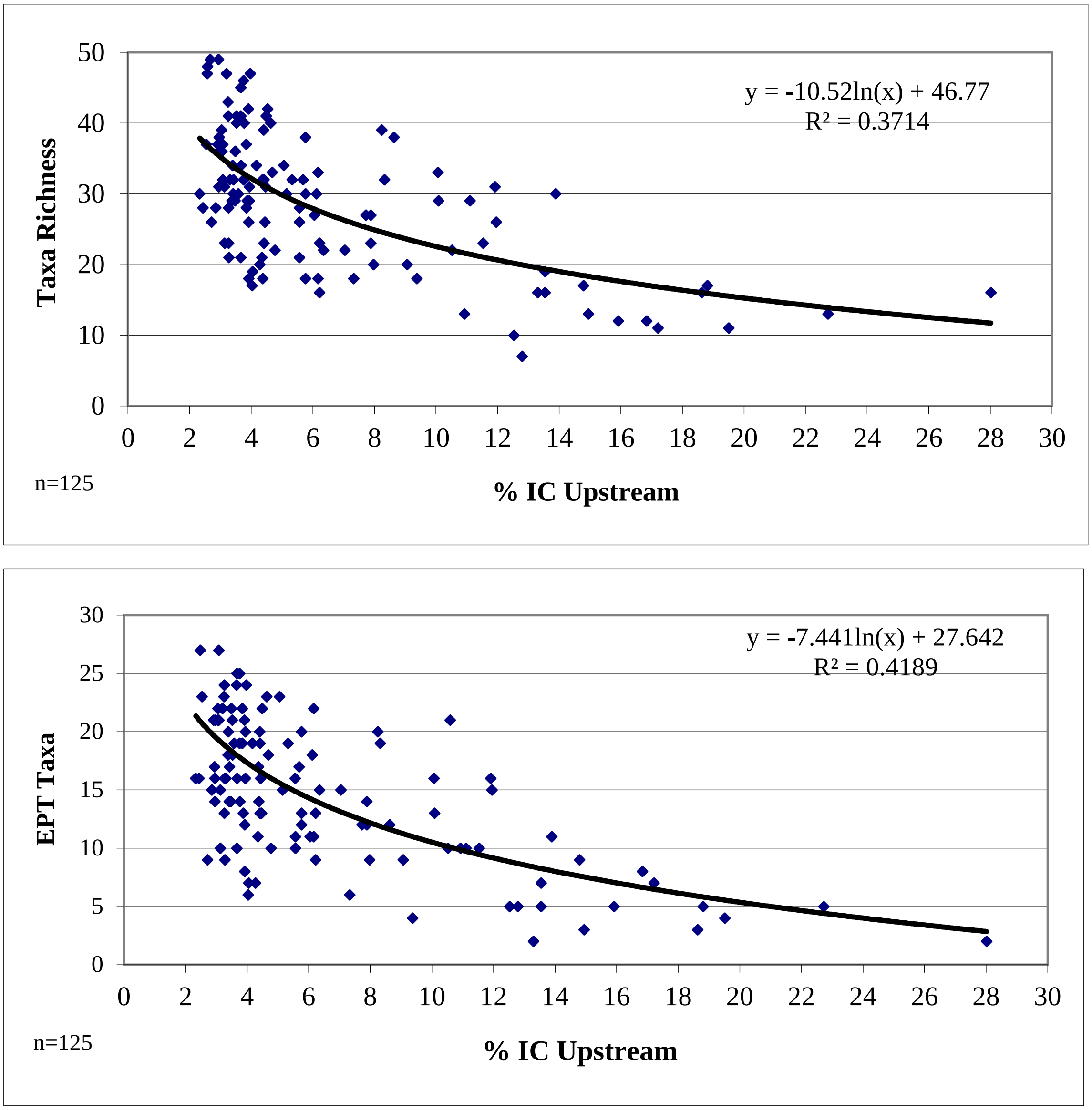

Figure 2. *Scatter plot of taxa richness (upper) and EPT taxa (lower) and percent impervious cover upstream of macroinvertebrate monitoring locations from applicable streams in Connecticut.*

	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

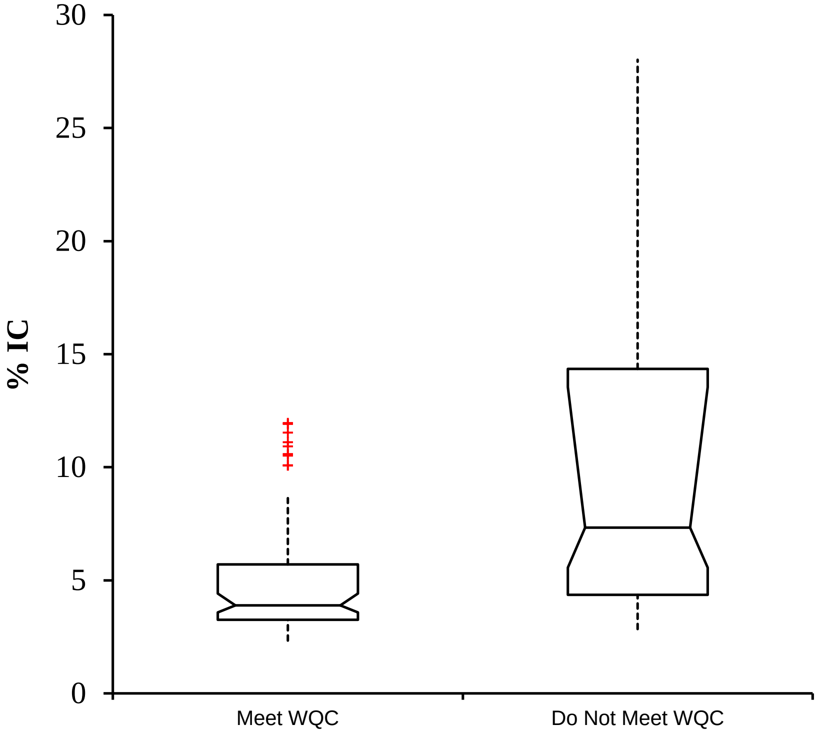

Figure 3. *Box and whiskers plot and summary statistics of sites that meet Connecticut's Water Quality Criteria (WQC) for aquatic life (n=86) and sites that do not meet Connecticut's aquatic life criteria (n=39). The notched box shows the median and lower and upper quartiles. The dotted line extending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

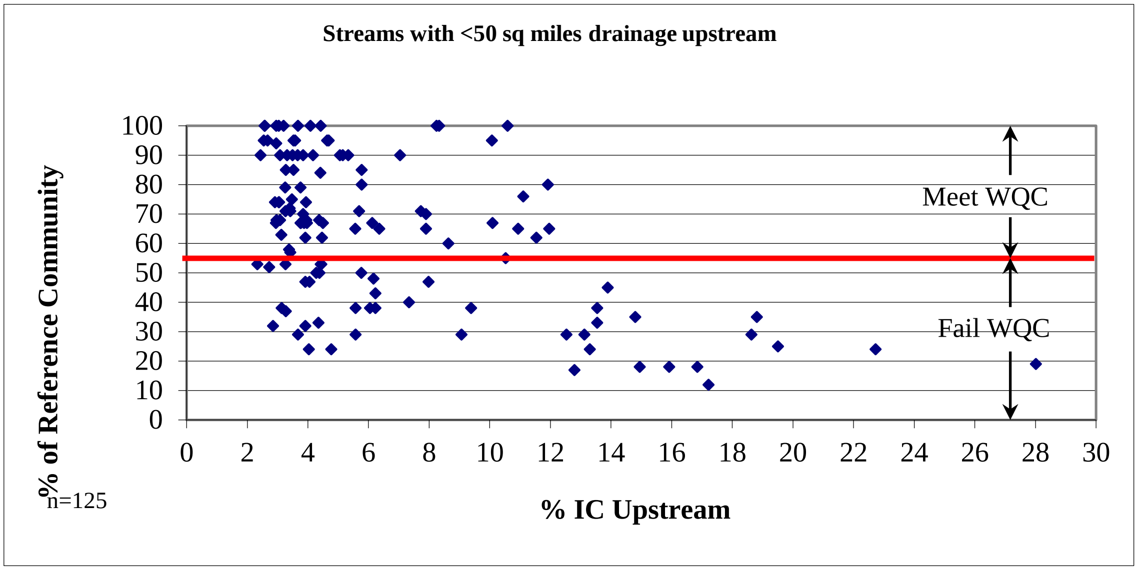

Figure 4. *Scatter plot of percent IC upstream of monitoring locations and % of reference macroinvertebrate community as assessed using Connecticut CALM* [6]*. Points that plot above the horizontal red line meet Connecticut's water quality criteria (WQC) to support aquatic life. Points that plot below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

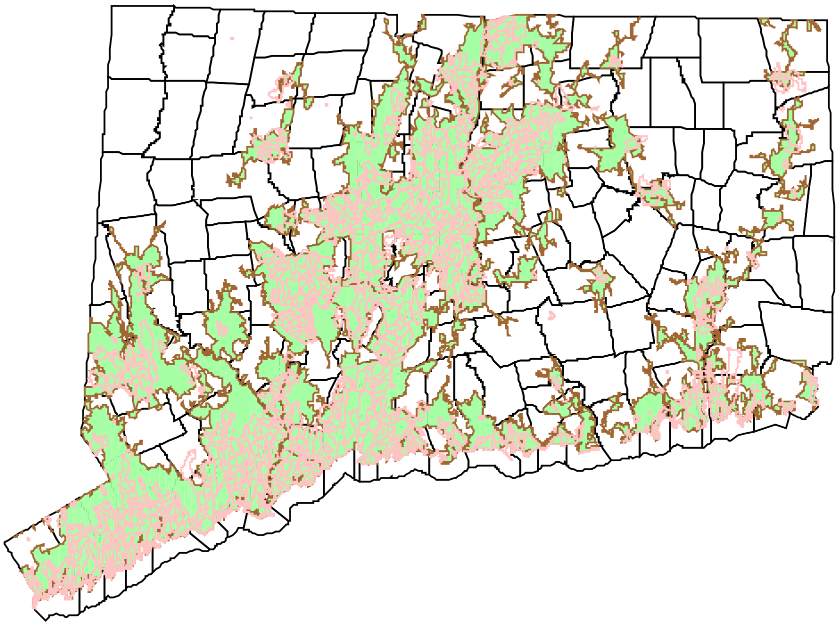

Figure 5. *Relationship between MS4 Urban Areas and IC TMDL threshold. Green solid areas are considered Urban Areas under the Connecticut's MS4 General Permit and pink outlines show watershed locations where IC >= 11%.*