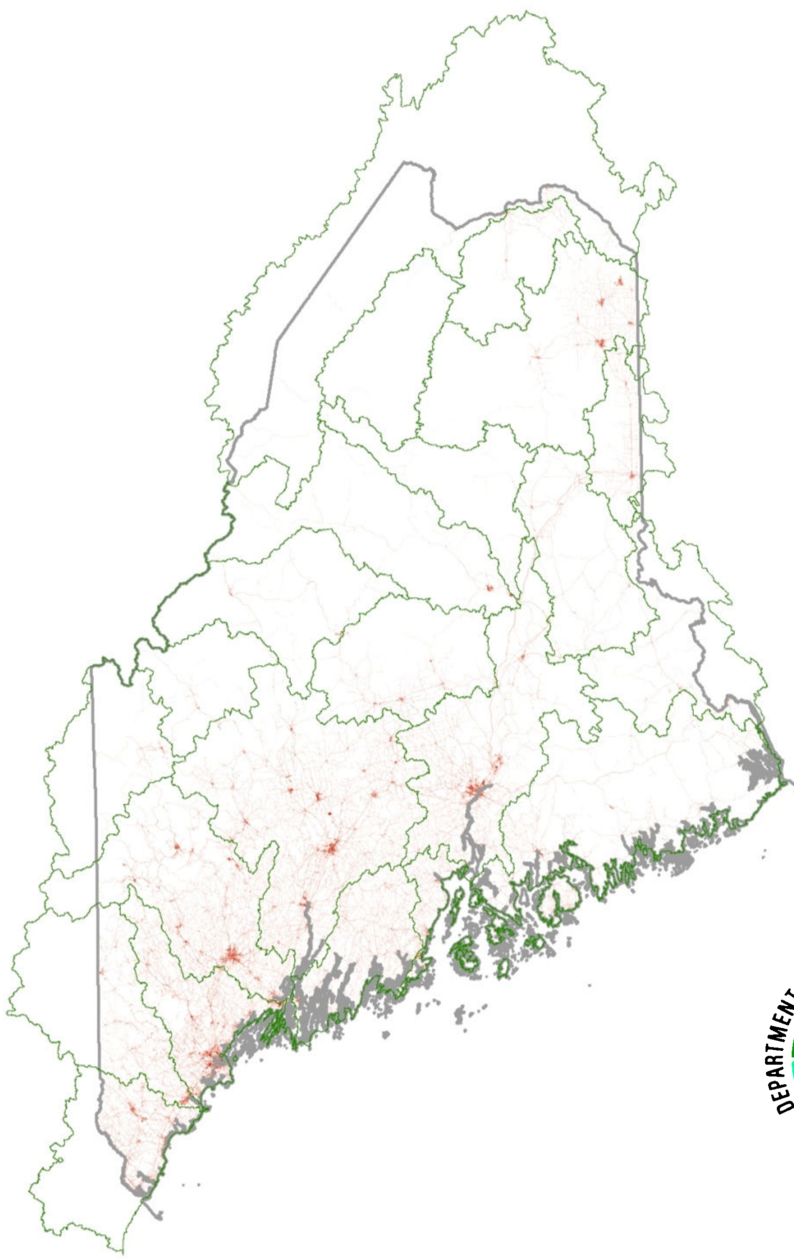
Maine Impervious Cover Total Maximum Daily Load Assessment (TMDL)

for Impaired Streams



DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE

Maine Impervious Cover
Total Maximum Daily Load Assessment
(TMDL)

for Impaired Streams

DEPLW-1239

First Draft Prepared by FB Environmental, Portland, Maine

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Maine Statewide Impervious Cover TMDL

Executive Summary

Why is a TMDL Assessment Needed?

Section 303(d) of the Federal Clean Water Act (CWA) and Federal Water Quality Planning and Management Regulations require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies, commonly referred to as the "**303(d) list**". In Maine, the Department of Environmental Protection (DEP) is responsible for the 303(d) listing process. The list is updated and issued for public comment every two years, with the final list submitted to the United States Environmental Protection Agency (EPA) on April 1st of each even numbered year.

This report is issued to satisfy the requirements of Section 303(d) of the Clean Water Act and of 40 CFR § 130.2 that the State of Maine provide an estimate of the total maximum daily load of pollutants for those impaired waters previously identified in the State. Because the results of the estimates may be subsequently considered and/or utilized in regulatory programs such as the MS4 program, the Department includes in the appendices examples of ways to utilize the information in the report, and recommendations regarding addressing the impaired waterbodies. This report does not impose any regulatory requirements.

The waterbodies included in this *Maine Statewide Impervious Cover Total Maximum Daily Load (TMDL) Assessment, for Impaired Streams* document have been assessed by DEP as not meeting Maine's water quality standards for aquatic life use, and have been listed on the 303(d) list of impaired waters. The Clean Water Act requires that all 303(d)-listed waters undergo a **TMDL** assessment that describes the impairments and estimates a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards. Given the number of waters listed for impairment of aquatic life use, addressing the TMDL assessments in a combined Statewide TMDL report is the most appropriate and efficient use of resources. The Statewide TMDL approach makes the TMDL process more efficient and allows the implementation and restoration process to begin sooner.

Impervious Cover and Stormwater

This *Maine Statewide Impervious Cover TMDL* report provides a framework for addressing aquatic life and habitat impairments in streams. Developed areas and associated **impervious cover (IC)** result in increased stormwater volume and pollutant loads to receiving waterbodies. Impervious cover refers to surfaces such as roads,

Sediment and other pollutants are carried into streams during a rain storm.

driveways, parking lots, and building rooftops that change the natural dynamics of the hydrologic cycle. When rain falls in developed areas, it flows quickly off these impervious surfaces, carrying dirt, oils, metals, nutrients, and other pollutants to the nearest stream. A combination of pollutants found in stormwater, including sediment and nutrients, contribute to aquatic life impairments in streams, along with habitat loss and unstable stream banks caused by excessive amounts of runoff.

Increasing the percentage of total impervious cover (% IC) in a watershed is linked to decreasing stream health (CWP, 2003). Because aquatic life impairment associated with stormwater is not always caused by a single pollutant, % IC has been selected and applied as a representative measure of the mix of pollutants and other impacts associated with excessive stormwater runoff and urban development. This TMDL report estimates the effective % IC target for the sub-watershed of each impaired surface water addressed by the TMDL, and, for informational purposes, estimates the reductions in stormwater runoff volume and associated pollutants that may be needed to meet water quality standards. The Load Allocation & Waste Load Allocation (WLA & LA) target is intended to guide the development of a **Watershed Management Plan (WMP)** that will apply **Best Management Practices (BMP)** and **Low Impact Development (LID)** techniques to achieve water quality standards.

Elements of a TMDL

TMDL Element	Definitions	Stream Goals
Goal (End Point)	Achieve water quality consistent with Maine's Class A, B or C standards	A biological community consistent with Maine's Class A, B or C standards
TMDL Target (Loading Capacity)	Maximum loading of pollutants that attains the goal	Analysis of Maine's biomonitoring data indicate that a watershed with characteristics of X% IC would achieve the goal
Margin of Safety (MOS)	The MOS accounts for uncertainty in target-setting and adds a safety factor to increase the likelihood of attainment	A 1% or 2% IC reduction is reserved from the target as a MOS
Load Allocation (LA) & Waste Load Allocation (WLA) Target	Maximum allowable pollutant load that can be allocated to various watershed sources and still achieve the water quality target and goal	X – MOS % IC, which represents an approximate % reduction in stormwater runoff volume and associated pollutants when compared to existing pollutant loads
Future Actions or Watershed Management Plan	Actions or engineered BMPs that are designed to achieve water quality standards	A Watershed Management Plan and/or BMP implementation plan may be developed to determine the relative contributions and the best approach to solutions

Sampling Results & Pollutant Sources

DEP's Biological Monitoring Program uses benthic **macroinvertebrate** data to determine if streams and rivers are attaining the aquatic life goals assigned to them. Aquatic macroinvertebrate communities integrate the effects of multiple environmental stressors and provide reliable indicators of stream health. The number of different kinds of organisms and the abundance of different groups provide information about a waterbody's health. The Program uses a statistical model that incorporates 30 variables of data collected from rivers and streams, including the richness and abundance of streambed organisms, to determine the probability of a sample attaining Class A, B, or C conditions. Biologists use the model results and supporting information to determine if samples attain conditions of the class assigned to the stream or river (Davies and Tsomides, 2002; State of Maine 2003 Rule Chapter 579).

The impairments identified in this report are based on data collected by DEP, indicating the waterbodies are not meeting their assigned classification. DEP will evaluate progress towards attainment of Maine's water quality standards by monitoring the benthic macroinvertebrate communities in the impaired streams under the Biological Monitoring Program's existing rotating basin sampling schedule. Success will be measured based on attainment of Maine's water quality standards.

Waters with Aquatic Life Impairments

This *Maine Statewide Impervious Cover TMDL* report serves as TMDL documentation for 30 aquatic life-impaired waters in Maine. Watershed-specific TMDL summaries containing descriptions, maps and calculations to support the TMDL for each of these impaired streams are included in Appendices 3 through 31 of this report. The waterbodies included in this document are located within 6 of the 21 major watersheds in the state (known as Hydrologic Unit Code 8 (HUC 8) watersheds), as shown in Figure ES-1.

The impaired waters are generally located in the southern half of the state, in or near developed areas from Bangor in the north to Biddeford in the south. Much of Maine's population is concentrated along the coastline and in the southern portion of Maine. It is these populated areas that generally correspond with the aquatic life-impaired waterbodies listed on Maine's 303(d) list.

Recommended Next Steps

This TMDL document provides the initial step in watershed assessment for the impaired waterbodies by establishing the watershed target % IC and providing guidance for efforts to improve water quality in the watersheds. This report contains information to support communities, watershed groups, and other stakeholders in developing a WMP in a phased, community-based manner that will ultimately result in attainment of water quality standards. In the WMP municipal official, landowners and other stakeholders will systematically identify, evaluate, and prioritize sites for stormwater mitigation in the next phase of the assessment and implementation process. This iterative watershed restoration approach includes stakeholder involvement through a series of cooperative, iterative steps to:

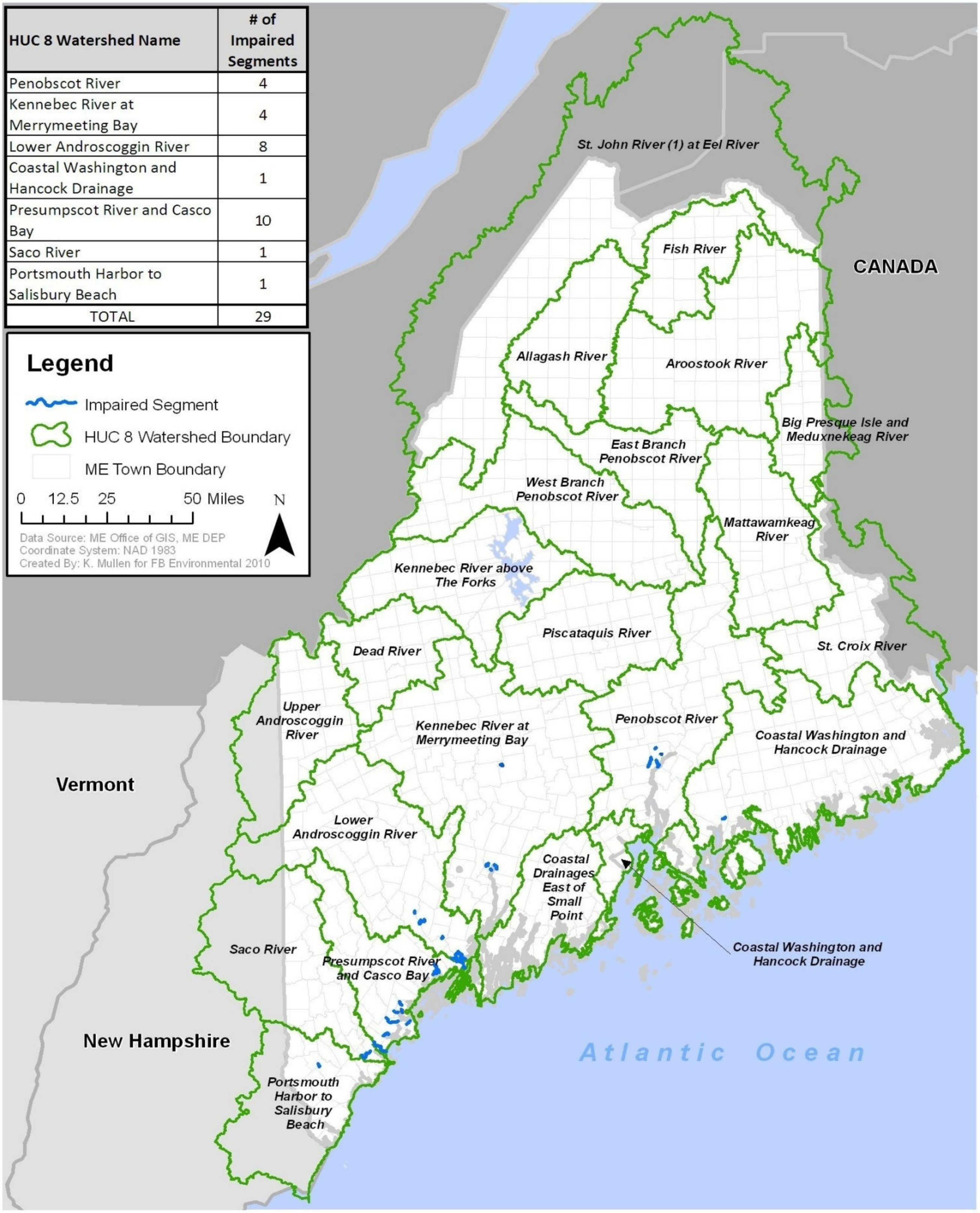
1. Characterize existing conditions;
2. Identify and prioritize problems;
3. Define management objectives;
4. Develop protection or remediation strategies; and
5. Implement and adapt selected actions as necessary.

A WMP serves as a guide to protect and improve water quality in a defined watershed and includes analyses, actions, participants, and resources related to developing and implementing the plan. Examples of such plans developed in Maine are provided in appendices of this report.

Definitions

- **303(d) list** *identifies waters impaired by one or more pollutants that require a TMDL, describes the causes and potential sources of impairment, and specifies a timetable for the development of TMDLs.*
- **TMDL** *is an acronym for* ***Total Maximum Daily Load****, representing the total amount of a pollutant that a water body can receive and still meet water quality standards, also called loading capacity.*
- **Impervious cover** *refers to landscape surfaces (covered by pavement or buildings) that no longer absorb rain and may direct large volumes of stormwater runoff into the stream.*
- **WMPs or Watershed Mangement Plans** *are comprehensive assessments of current watershed conditions and the engineering solutions to apply to the goal of meeting water quality standards.*
- **BMPs or Best Management Practices** *are techniques designed to reduce the impacts of impervious cover, including excess pollutant loads and altered flow associated with stormwater runoff.*
- **LIDs or Low Impact Development** *strategies integrate green space, native landscaping, natural hydrologic functions, and various other techniques to generate less runoff from developed land.*
- ***Benthic macroinvertebrates*** *are aquatic animals without backbones that can be seen by the unaided eye and typically dwell on the stream bed (e.g., rocks, logs, sediment, plants). Examples include aquatic insects (such as mayfly, dragonfly and caddis fly larvae), aquatic worms,*

Figure ES- 1: Figure ES-1: Locations of impaired waterbodies included in this TMDL.



Note: One stream has two listed segments, increasing the overall total to 30 segments

1. Introduction and Pollutants of Concern

The Maine Department of Environmental Protection has developed this *Maine Statewide Impervious Cover Total Maximum Daily Load (TMDL)* report to address water quality impairments in multiple small urban/suburban streams in Maine that are affected by excessive stormwater runoff and accompanying pollutants. The 30 stream segments in this report are listed[1] for impairments of aquatic life and/or habitat use, (in accordance with Maine's water quality standards and classification system), as required under Section 303(d) of the federal Clean Water Act. The two main purposes of this TMDL report are to comply with Maine's responsibilities under the Clean Water Act (and EPA's implementing regulations), and to provide information, watershed-specific geographic data, and examples of different stages of "next steps" to help stakeholders prepare watershed management plans (WMP) for improving stream water quality.

This report is issued to satisfy the requirements of Section 303(d) of the Clean Water Act and of 40 CFR § 130.2 that the State of Maine provide an estimate of the total maximum daily load of pollutants for those impaired waters previously identified in the State. Because the results of the estimates may be subsequently considered and/or utilized in regulatory programs such as the MS4 program, the Department includes in the appendices examples of ways to utilize the information in the report, and recommendations regarding addressing the impaired waterbodies. This report does not impose any regulatory requirements.

Developed areas and associated **impervious cover (IC)** may result in increased stormwater volume and pollutant loads to receiving waterbodies. Developed area runoff can alter stream stability and causes in-stream habitat degradation including bank erosion, siltation, scour, and over-widening of stream channels. Impervious surfaces also prevent seepage of rainfall to groundwater which in turn may reduce summer base flow and habitat availability.

Impervious Cover (IC): *landscape surfaces (e.g. roads, sidewalks, driveways, parking lots, and rooftops) that no longer absorb rain and may direct large volumes of stormwater runoff into a stream or other waterbody.*

Impervious cover is often used as a measure of human disturbance as it relates to aquatic communities in streams, and to the overall health of watersheds. At higher levels of IC, studies have documented that streams become degraded and are unable to support sensitive species of fish and aquatic macroinvertebrates. Typically, sensitive species of fish decline in watersheds with 4-6% IC or less. Watersheds exceeding 12% IC often fail to meet aquatic life criteria and narrative standards (Stanfield and Kilgore, 2006).

A combination of pollutants found in stormwater, including sediment and nutrients, contributes to aquatic life impairments in streams, along with habitat destruction by flash floods and bank erosion. Often, there is not a direct link to a specific source that is causing or contributing to exceedances of a pollutant-

[1] 27 segments are listed in the 2010 303d list; 3others are listed in the draft 2012 303d list (Goodall Brook, Goosefare Brook and Nasons Brook in Westbrook)

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 impervious cover. Because aquatic life impairments associated with stormwater are not always caused by a single pollutant, and are most often due to a complex array of pollutants transported by stormwater and other impacts of urban development, % IC is used for this TMDL is a surrogate to represent the mix of pollutants and other impacts associated with excessive stormwater runoff.

This TMDL report estimates the target % IC for the watersheds of impaired surface waters (Section 4), provides documentation of impairment, and outlines the approaches recommended to meet water quality standards (Section 5). The overall goal is to reduce adverse impacts from stormwater, and reduction of actual impervious cover (e.g. removing pavement) is not necessary if water quality standards can otherwise be achieved. In the absence of actual IC reduction, stormwater management techniques that otherwise improve water quality can be implemented in the impaired watersheds. Aquatic life assessments conducted by the Maine Department of Environmental Protection (DEP) Biological Monitoring Program will be used to measure the progress of water quality improvements.

Every stream has a unique watershed configuration and is affected differently by various pollutant sources and volumes of runoff and not every pollutant is a problem in every stream. The TMDL uses IC as a surrogate for the many potential pollutants and urban environmental characteristics influencing the streams. This approach does not identify specific pollutants in any given watershed, but recommends communities undertake watershed management that may include a ‘hot spot’ survey to identify problem sources. In some watersheds, the volume of runoff may be the object of watershed management rather than specific sources because greater quantities of stormwater flows destabilize, alter structure, and impair habitat for aquatic life, and less base flow is available to aquatic life in streams during low flow periods.

WMPs developed to improve water quality may use a watershed-based approach. The watershed approach includes stakeholder involvement and uses a series of cooperative, iterative steps to assess watershed conditions, identify problems and develop solutions. Participation by local governments and citizens, individuals most likely to be knowledgeable of watershed conditions, is the key to successful implementation efforts.

The total estimated watershed percent IC has been calculated for all of the impaired streams included in this report. This basic level of assessment information is sufficient for TMDL target-setting, which can be referenced in subsequent WMPs. Impervious cover targets represent the estimated level of imperviousness (in the contributing watershed), absent other water quality improvement measures, at which the waterbody is capable of supporting a benthic macroinvertebrate community that meets aquatic life use goals and criteria in Maine’s water quality standards. Impervious cover TMDL targets are discussed in Section 4 of this report.

Directly Connected Impervious Area (DCIA): *impervious cover that is directly connected to the stream via hard surfaces or in close proximity, and from which runoff enters a waterbody untreated.*

Many of these watersheds have development that incorporates some LID techniques that reduce the negative impacts of stormwater runoff on receiving streams, but not to a level that results in water quality attainment. This means the effective %IC in a given watershed is not always the same as the total %IC, used as a surrogate in the TMDL. Delineating the relative contributions of engineered structures to reduce the effectiveness of IC is an important step in the watershed assessment that will be undertaken by watershed municipalities and stakeholders. While this TMDL report focuses on IC as an appropriate surrogate for individual pollutant loading, future WMPs may consider implementation of all water quality improvement measures. The assessments may also include conducting watershed reconnaissance surveys to identify locations of **directly connected impervious area (DCIA)**. DCIA refers to impervious areas that are directly connected to stormwater conveyance systems, such as stream channels and storm sewers. A basic goal for stormwater management is to minimize or "disconnect" these DCIAs, if and where appropriate. This can be done by limiting overall impervious land coverage and directing runoff from impervious areas to pervious areas such as small depressions.

A watershed reconnaissance survey was completed for an impaired waterbody and included in this report. A summary of the survey and examples of potential mitigation sites are included in Appendix 28. This summary demonstrates the initial steps in identifying and prioritizing sites for stormwater mitigation as part of an overall watershed restoration process.

Best Management Practices (BMPs): *techniques designed to reduce the impacts of impervious cover, including excess pollutant loads and altered flow associated with stormwater runoff.*

A more comprehensive level of watershed assessment may include stream corridor habitat assessments and/or conducting a complete watershed survey. These types of assessments support development of prioritized lists of potential stormwater mitigation sites in a watershed. Detailed site engineering surveys are needed for designing specific **best management practices (BMPs)** to address stream restoration actions. One example of these more detailed levels of effort is the *Whitten Brook Restoration Plan*. The plan provides detailed description of stormwater issues and the initial steps necessary to move forward toward solutions [http://www.fbenvironmental.com/projectPostings.html].

More information on the above assessment options is included in Appendix 1 of this report (Recommended Future Actions). One goal of the Maine TMDL process is to promote, encourage, and inform local community action for water quality improvement and protection of public health by addressing sources of water quality impairment caused by stormwater. This report provides information to help communities, watershed groups, and other stakeholders to implement water quality improvements in a phased, community-based manner that will ultimately result in attainment of water quality standards.

1.1. Report Format

This document contains the following sections:

- ***Aquatic Life Impaired Waters (Section 2)*** – Provides a brief introduction to the aquatic life impaired waters in Maine addressed in this TMDL (based on the *2010 303(d) List*). This section also includes a description of the TMDL listing and prioritization process.
- ***Applicable Water Quality Standards (Section 3)*** – Provides a summary of applicable Maine Quality Standards.
- ***TMDL Target (Section 4)*** – Identifies and discusses development of % IC TMDL targets for Maine waters.
- ***TMDL Allocations (Section 5)*** – Provides a description of the TMDL calculation process and incorporates key required elements for TMDL development.
- ***Water Quality Monitoring Plan (Section 6)*** – Describes information regarding long term monitoring plans for impaired waters.
- ***Reasonable Assurance (Section 7)*** – Describes reasonable assurances that WMPs and BMPs will be implemented, where non-point source pollution reductions take the place of reductions from permitted sources.
- ***Public Participation (Appendix 1)*** **–** Outlines the public participation process and response to public comments specific to this TMDL.
- ***Appendices*** – Contains: recommended future actions, management plan examples and actions to reduce the effects of impervious cover, including coordination with local stakeholders, development of watershed based plans, responses to public comments, technical guidance for setting IC TMDL targets, and watershed-specific TMDL summaries.

2. Aquatic Life-Impaired Waters

This *Maine Statewide Impervious Cover TMDL* report serves as TMDL documentation for 30 aquatic life-impaired waters in Maine. Some of these waterbodies are also impaired due to low dissolved oxygen (DO) levels that are linked to aquatic life violations. In these cases, this TMDL report also addresses dissolved oxygen impairments. Watershed-specific TMDL summaries containing descriptions, maps and calculations to support the TMDL for each of these impaired streams are included in Appendices 4 through 32 of this report.

2.1. Waters with Aquatic Life Impairments

The waterbodies included in this document are small urban/suburban streams, located within 6 of the 21 major watersheds in the state (known as Hydrologic Unit Code 8 (HUC 8) watersheds): Penobscot River; Kennebec River at Merrymeeting Bay; Lower Androscoggin River; Coastal Washington and Hancock Drainage; Presumpscot River and Casco Bay; and Saco River (Figure 2-1, Table 2-1).

The urban-impaired waters are generally located in the southern half of the state, in or near the population centers between Bangor in the north to Biddeford in the south. Much of Maine's population is concentrated along the coastline and in the southern portion of Maine. It is these populated areas that generally correspond with the aquatic life-impaired waterbodies listed on Maine's 303(d) list.

Table 2-1: TMDL watershed and waterbody information, with Urban Impaired Streams & MS4 Communities indicated.

Segment Name	Towns	Location	Assessment Unit ID[4]	Cause	Segment Size (mi.)[4]	Segment Class
Arctic Brook (Valley Avenue)[1]	Bangor[3]		ME0102000510_224R06	Benthic-Macroinvertebrate Bioassessments (Streams), Habitat Assessment (Streams)	1	Class B
Capehart, a.k.a Unnamed (Pushaw) Stream[1]	Bangor[3]		ME0102000510_224R05	Habitat Assessment (Streams)	0.46	Class B
Capisic Brook[1]	Portland[3], Westbrook[3]		ME0106000105_610R01 ME0106000105_610R01_W 023	Benthic-Macroinvertebrate Bioassessments (Streams & Wetlands), Habitat Assessment (Streams), Periphyton Bioassessment[2]	4.1	Class C
Card Brook	Ellsworth		ME0105000213_514R_01	Dissolved Oxygen, Macroinvertebrate Bioassessments (Streams)	1.2	Class B
Concord Gully[1]	Freeport[3]		ME0106000106_602R03	Dissolved Oxygen, Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams), Periphyton Bioassessment[2]	2.47	Class B
Dole Brook	Portland[3]	Tributary to Presumpscot R. entering east of Rt. 302	ME0106000105_609R01 ME0106000105_609R01_W 026	Benthic-Macroinvertebrate Bioassessments (Streams & Wetlands)[2]	1.6	Class B
Frost Gully Brook[1]	Freeport[3]		ME0106000106_602R01	Benthic-Macroinvertebrate Bioassessments (Streams), Habitat Assessment (Streams)	3.2	Class A

[1] Chapter 502 Urban Impaired Stream *[3] MS4 Community*

[2] Consistent with the 2012 303 (d) List in DEP's Intergrated Report

Table 2-1, continued: TMDL watershed and waterbody information, with Urban Impaired Streams & MS4 communities indicated.

Segment Name	Towns	Location	Assessment Unit ID[4]	Cause	Segment Size (mi.)[4]	Segment Class
Goodall Brook[2]	Sanford	Upstream of Berwick Rd	ME0106000304_625R04	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	2.5	Class B
Goosefare Brook[1,2]	Saco[3,] Old Orchard Beach[3]		ME0106000106_612R01_01	Benthic-Macroinvertebrate Bioassessments (Streams)	5.54	Class B
Hart Brook[1], a.k.a Dill Brook including Goff Bk	Lewiston[3]		ME0104000210_419R02	Habitat Assessment (Streams), Dissolved Oxygen, and Benthic-Macroinvertebrate Bioassessments (Streams), Periphyton Bioassessment[2]	4.15	Class B
Kennedy Brook[1]	Augusta[3]		ME0103000312_333R03	Benthic-Macroinvertebrate Bioassessments (Streams), Periphyton Bioassessment[2]	0.87	Class B
Kimball Brook	South Portland[3]		ME0106000105_610R06	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	1.55	Class C
Logan Brook[1]	Auburn[3]		ME0104000208_413R04	Habitat Assessment (Streams), Dissolved Oxygen	0.96	Class B
Mere Brook[1], a.k.a. Mare Brook	Brunswick		ME0106000106_602R02	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	8	Class B
Nasons Brook[1]	Portland[3]	South of Rt 25, trib to Fore River	ME0106000105_607R11_01 ME0106000105_607R11_01_W127	Benthic-Macroinvertebrate Bioassessments (Streams & Wetlands), Dissolved Oxygen, Periphyton Bioassessment2	2	Class C
Nasons Brook[1]	Westbrook[3]	South of Rt 25, trib to Fore River	ME0106000105_607R11_02 ME0106000105_607R11_02_W172	Benthic-Macroinvertebrate Bioassessments (Streams & Wetlands), Dissolved Oxygen, Periphyton Bioassessment[2]	0.8	Class B
Phillips Brook	Scarborough[3]		ME0106000104_611R02	Habitat Assessment (Streams), Dissolved Oxygen	2.77	Class C
Red Brook[1]	Scarborough[3], South Portland[3]		ME0106000105_610R07	Habitat Assessment (Streams)	5.4	Class C
Shaw Brook[1]	Hermon, Bangor[3], Hampden[3]		ME0102000511_225R01_02	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams), Periphyton Bioassessment[2]	3.91	Class B
Sucker Brook	Bangor[3], Hampden[3]	Tributary to Penobscot R. entering from the west, in Hampden	ME0102000511_225R02	Dissolved Oxygen, Benthic-Macroinvertebrate Bioassessments (Streams)	2.5	Class B
Thatcher Brook	Biddeford[3] Arundel		ME0106000211_616R05 ME0106000211_616R05_W043	Benthic-Macroinvertebrate Bioassessments (Streams & Wetlands)	5.67	Class B
Unnamed Stream (Route 196)[1]	Lisbon Falls		ME0104000210_419R01	Habitat Assessment (Streams)	1.36	Class B
Unnamed tributary to Bond Brook[1]	Augusta	Entering below I-95	ME0103000312_333R04	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams), Periphyton Bioassessment[2]	1.34	Class B
Unnamed Tributary to the Androscoggin River (draining Topsam Fair Mall)[1]	Topsham	Drains Topsham Fair Mall; Biomon Sta 634	ME0104000210_420R05	Benthic-Macroinvertebrate Bioassessments (Streams)	1.4	Class B
Unnamed Tributary to the Androscoggin River (near Jordan Avenue)[1]	Brunswick	Near Jordan Ave., Brunswick	ME0104000210_420R03	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	1.73	Class B
Unnamed Tributary to the Androscoggin River (near River Road)[1]	Brunswick	Near River Rd. Brunswick	ME0104000210_420R01	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	1.85	Class B
Unnamed Tributary to the Androscoggin River (near Topsham Fairgrounds)[1]	Topsham	Near Rt. 196, Topsham	ME0104000210_420R04	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	1.77	Class B
Unnamed Tributary to the Androscoggin River (near Water Street)[1]	Brunswick	Near Water St. Brunswick	ME0104000210_420R02	Habitat Assessment (Streams), Benthic-Macroinvertebrate Bioassessments (Streams)	0.56	Class B
Whitney Brook[1,2]	Augusta		ME0103000312_333R02	Benthic-Macroinvertebrate Bioassessments (Streams), Nutrients, Periphyton Bioassessment[2]	1.86	Class B
Whitten Brook[1]	Skowhegan		ME0103000306_320R03	Benthic-Macroinvertebrate Bioassessments (Streams), Habitat Assessment (Streams)	1.12	Class B

[1] *Chapter 502 Urban Impaired Stream*
[3] *MS4 Community*
[2] *Consistent with the 2012 303 (d) List in DEP's Intergrated Report*

Figure 2-1: Map of impaired waterbodies included in this TMDL.

2.2. Data Collection

Benthic Macroinvertebrates: *Aquatic animals without backbones that can be seen by the unaided eye and typically dwell on the bottom surfaces of a waterbody (e.g., rocks, logs, sediment, plants). Examples include aquatic insects (such as mayfly, dragonfly and caddis fly larvae), aquatic worms, amphipods (scuds), leeches, clams and snails.*

Stream data collection in Maine is accomplished via biomonitoring, and chemical and physical parameters for stressor identification. River and stream **benthic macroinvertebrate** and algal samples are collected in accordance with the Biomonitoring Program Quality Assurance Project Plan. Stream macroinvertebrate and algal assessments are based on a statistical model that predicts attainment of tiered aquatic life uses (Classes AA/A, Class B, and Class C). Class A shows near natural biological conditions, Class B waters must support all indigenous species with “no detrimental changes”, and Class C waters must support all indigenous fish and maintain the “structure and function” of the biological community.

Maine’s stream macroinvertebrate model uses 30 variables of taxonomic and numeric data collected from rivers and streams, including macroinvertebrate richness and abundance, to determine the probability of a sample attaining Class A, B, or C conditions. The model and numeric criteria are described in DEP Rule Chapter 579: Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams (see also Section 6). For streams and rivers, attainment of aquatic life criteria are based on meeting established protocols and statistically-based threshold and protocols (DEP, 2010).

2.3. Priority Ranking and TMDL Schedules

Section 303(d) of the Clean Water Act requires that waters on the 303(d) list be ranked in order of TMDL development priority. A TMDL schedule date shown on the 303(d) list indicates when the TMDL is expected to be completed.

According to Maine’s 2010 303(d) list, development of TMDLs for aquatic life-impaired waters has been given a medium to high priority, with most TMDLs scheduled to be completed between 2010 and 2012. Given the number of waters scheduled for near-term development, addressing TMDL development with a Statewide TMDL report is the most appropriate and efficient use of resources, makes the TMDL process more efficient, allows the water quality improvements and restoration process to begin sooner.

2.4. Future TMDL Applicability

Under appropriate circumstances in the future, DEP may submit additional TMDLs to EPA for specific waterbodies to be added for IC TMDL coverage, but without resubmitting the approved Core document at such times. The future submittals will provide detailed information on the impaired waterbodies and their TMDLs. Maine will provide public notice for review of the additional TMDLs either alone, or as part of the public notice process associated with the biannual review of the State’s Section 303(d) list in its Integrated Water Quality Report. If previously unlisted waterbodies are involved, DEP will clearly state its intent to list the newly assessed waterbodies as impaired, and to apply the appropriate waterbody-specific IC TMDLs.

2.5. Maine's Stormwater Program and Urban Impaired Streams

Maine's stormwater program works toward protecting and restoring surface and groundwater impaired by pollutants carried by stormwater as well as the rates and volumes of stormwater flows from developed areas that may cause damage if discharged to natural waterbodies. Chapter 500 and 502 provide rules for developments that need to be reviewed and licensed under Maine's "Site Law"[2] and Maine's Stormwater Management Law. Chapter 500 provides standards for erosion and sedimentation control, inspection and maintenance, and housekeeping at development sites. Chapter 502 provides additional stormwater treatment controls for development in urban watersheds of impaired streams where proposed development may contribute to the further degradation of stream water quality.

Urban impaired streams are ones that do not meet water quality standards because of the effects of stormwater runoff from developed land. DEP identifies and lists these streams in Appendix B of Chapter 502 [http://maine.gov/dep/blwq/docstand/stormwater/storm.htm], and includes all streams listed under Category 4-A or Category 5-A in the Maine Integrated Water Quality Monitoring and Assessment Report that have urban non-point source (NPS) pollution indicated as a potential source.

Under the Maine stormwater management rules, a proposed development project located in the direct watershed of an urban impaired stream is required to meet appropriate standards to prevent and control the release of pollutants to waterbodies, wetlands, and groundwater, and reduce impacts associated with increases and changes in flow. The urban impaired stream standard must be met if a project located within the direct watershed of an urban impaired stream meets one of the following criteria:

(1) Results in 3 acres or more of impervious area or 20 acres or more of developed area;

(2) May substantially affect the environment and requires a site location of development (Site Law) permit; or

(3) Is a Site Law modification.

Standards require that owners of projects in the direct watershed of an urban impaired stream must pay a compensation fee, or mitigate project impacts by treating, reducing or eliminating an off-site or on-site pre-development impervious stormwater source. Urban impaired streams included in this report are noted on Table 2-1 (above).

Under Maine's Waste Discharge Law (MEPDES), DEP regulates the discharge of stormwater from construction projects, from municipal separate storm sewer systems (MS4s), from selected industrial sectors, and from post construction discharges of stormwater in the Long Creek watershed (see case study in Appendix 1). The DEP uses both general permits and individual permits to control these stormwater

[2] The Site Location of Development Law

discharges. Municipalities with designated MS4 areas are noted on Table 2-1 (above), and designated area maps are provided on DEP's website (http://www.maine.gov/dep/land/stormwater/stream_map_1.html).

3. Applicable Water Quality Standards

Maine's water quality standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts: classification and designated uses, criteria, and antidegradation regulations. Each of these parts is described below as they pertain to the impaired waters included in this report.

Under Maine's Water Classification Program, as designated by the Maine Legislature (Title 38 MRSA 464-468), the State of Maine has four tiers of water quality classifications for freshwater rivers and streams (AA, A, B, C), each with varying designated uses and water quality criteria providing different levels of protection. Classifications range from the highest quality (AA, "free flowing and natural"; A, "natural") to classification allowing some discharges as long as the water quality remains "unimpaired" (B) and classification allowing discharges with some impact as long as aquatic life habitat is maintained (C). The highest quality classes have the most stringent water quality criteria.

According to State statute the designated uses for each classification of freshwater rivers and streams include the following:

Table 3-1: Designated uses for each classification of Maine's freshwater rivers and streams.

Water Class	Designated Uses
Class AA	Drinking water supply after disinfection, recreation in and on the water, fishing, agriculture, navigation and habitat for fish and other aquatic life.
Class A	Drinking water supply after disinfection, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.
Class B	Drinking water supply after treatment, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.
Class C	Drinking water supply after treatment, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.

Maine's water quality criteria are designed to protect the legislative designated uses for each classification. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use. Maine has a *Tiered Aquatic Life Use* system that describes, in water quality standards, multiple levels or goals for aquatic life conditions. Table 3-2 (below) summarizes the narrative and numeric water quality standards applicable to the waterbodies included in this report.

Table 3-2: Applicable narrative and numeric water quality standards for Maine's rivers and streams.

Water Class	Dissolved Oxygen Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria[1]
Class AA	As naturally occurs	Free flowing and natural	No direct discharge of pollutants; as naturally occurs
Class A	7 ppm; 75% saturation	Natural	As naturally occurs
Class B	7 ppm; 75% saturation	Unimpaired	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community.
Class C	5 ppm; 60% saturation; 6.5 ppm (monthly average) at 22° and 24°F	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

[1] Numeric biocriteria in Maine rule Chapter 579; Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams.

In addition, Maine water quality standards have an antidegradation provision designed to protect and maintain all water uses and water quality whether or not stated in the waterbody's classification as of November 28, 1975 [38 MRSA Ch. 3 §464]. Uses include aquatic life, wildlife that use the waterbody, habitat, recreation, water supply, commercial activity, and ecological, historical or social significance. The antidegradation provision ensures that waste discharge licenses or a water quality certification are issued only when there will be no significant impact on the existing use or result in failure of the waterbody to meet standards of classification.

4. Loading Capacity and TMDL Target Development

This *Maine Impervious Cover Total Maximum Daily Load (TMDL)* report uses %IC as a surrogate for a complex array of pollutants transported by stormwater runoff. As mentioned earlier, there is a strong correlation between increasing watershed %IC, increasing stormwater runoff volumes, increasing pollutant loads, and decreasing stream quality. Therefore, surrogate measure of % IC is used to represent the loading capacity, or combination of pollutants that contribute to aquatic life impairments (CWP, 2003).

A guidance document developed by DEP in 2011 outlines the methods used to determine the % IC values adequate to support aquatic life use in Maine's waterbodies. The full %IC guidance document, which links watershed impervious cover to stream quality, can be found in Appendix 1of this report. The % IC guidelines are based on analyses of data collected in Maine streams at 148 sample locations across the state, representing the full range of impervious cover expected in Maine. The relationship between % IC and aquatic macroinvertebrate communities was evaluated using three methods: attainment of aquatic life criteria, change points associated with three community metrics, and community threshold response.

Of 24 streams with watershed IC above 17%, only 3 samples (12.5%) attained Class C aquatic life criteria and the remaining 21 samples (87.5%) did not attain Class A, B or C. Based on the combined information obtained in the study, the % IC guideline ranges specified in Table 4-1 represent the % IC values found sufficient to support water quality classes in Maine (DEP, 2011).

Table 4-1: Percent impervious cover (% IC) guidance for expected attainment of Maine's designated aquatic life uses (DEP, 2011)*.

Analysis	Class AA/A	Class B	Class C
1. Percentiles (75^{th}-90^{th}) of % IC values for samples grouped by attained class	3.6-6.1%	7.1-10.2%	17%**
2. EPT richness changepoint analysis	--	9.30%	--
3. Hilsenhoff Biotic Index (HBI) changepoint analysis	--	9.30%	--
4. Perlidae abundance changepoint analysis	3.20%	--	--
5. TITAN z- thresholds	1-3.5%	9-10%	18-19%
6. TITAN z+ thresholds	4-5%	9%	14%, 18%
IC TMDL TARGETS	**≤5%**	**≤9%**	**≤16%**

** A 1% MOS is applied to Class AA, A, and B waters; a 2% MOS is applied to Class C waters. Waterbody-specific MOSs are shown in Table 5-1 below.*

*** DEP used only the 75th percentile of % IC values for Class C because of the small number of samples.*

[1] Load allocation (LA) is included in the WLA because it is not feasible to calculate separately.

[2] For attainment determination, Classes AA and A are combined.

[3] Because of the high-priority, sensitive nature of Class AA streams, application of a generalized method such as the % IC method is not advised.

[4] Stream-specific targets will be chosen for each TMDL.

Waterbody-specific %IC targets for the TMDLs in this report are determined based on the range of values provided in Table 4-1. For each impaired stream, DEP staff employ best professional judgment to set a single % IC TMDL target value, based on knowledge of site-specific conditions and aquatic life goals for the waterbody. Site-specific conditions may either diminish or worsen the effects of % IC, leading to a % IC recommendation near the upper or lower end of the range shown in Table 4-1, respectively. Diminishing conditions may include the existence of an adequate riparian buffer, demonstrated cold water input to the stream, an intact flood plain, or a highly permeable soil group. Worsening conditions may include the absence of an adequate riparian buffer, loss of the flood plain, an impermeable soil group, naturally stressful in-stream conditions (e.g. naturally low dissolved oxygen levels).

The IC TMDL measures success by attainment of aquatic life criteria. The % IC targets in this report are provided as a guide for development of WMPs and must not be used as a surrogate or substitute for the full list of measures taken to implement water quality improvements (DEP, 2011).

The current watershed %IC for the impaired streams is derived first by delineating the watershed boundary and then by estimating the impervious surface within the watershed. Watershed boundaries are determined by either a field assessment (described below), estimation based on contours and digital elevation models. The IC within the watershed are characterized by anthropogenic features such as buildings, roads, parking lots, etc. The %IC calculation is based on either a field assessments using aerial photos or a GIS coverage that uses a satellite derived raster data set of impervious areas. Two different GIS coverages were available; a 5 meter SPOT imagery collected in 2004 over the State of Maine and a 1 meter SPOT imagery collected in 2007 over select areas of Maine. The %IC calculations are based on the most recent, accurate and detailed data set available and this information is described for each watershed in their individual summaries, Appendices 4-32.

For many of the impaired streams, whose existing watershed delineations and associated IC estimate based on contour maps were thought to be inaccurate, field assessments were performed to better determine the actual watershed perimeter and obtain a more accurate total % IC value. These assessments were performed by walking from the outlet point of the impaired stream to the top of the watershed and observing the slope of the ground and impervious areas, gutters, catch basins, drainage networks, and combined sewer networks. This method of drainage area assessment uses a hand level to determine the direction of water flow for any specific spot within the stream watershed. Special attention was paid to combined sewer networks as water flowing into these pipes would be taken across watershed boundaries, contrary to the original topographical watershed delineation. A corrected watershed boundary was then drawn using ArcMap. Finally, using an orthophoto image layer in ArcMap, data layers were created delineating all of the impervious area within the corrected watershed boundary. Figure 4-1 shows the difference between the original watershed delineation and associated IC (based on topography) and the revised watershed delineation and IC (based on field assessments) for Whitten Brook. As time and resources permit, ME DEP continues to perform field assessments for improved watershed delineations in watersheds not yet updated. Refer to Waterbody-Specific TMDL Summaries, Appenidx 4-32, for the current watershed delineation status of each watershed.

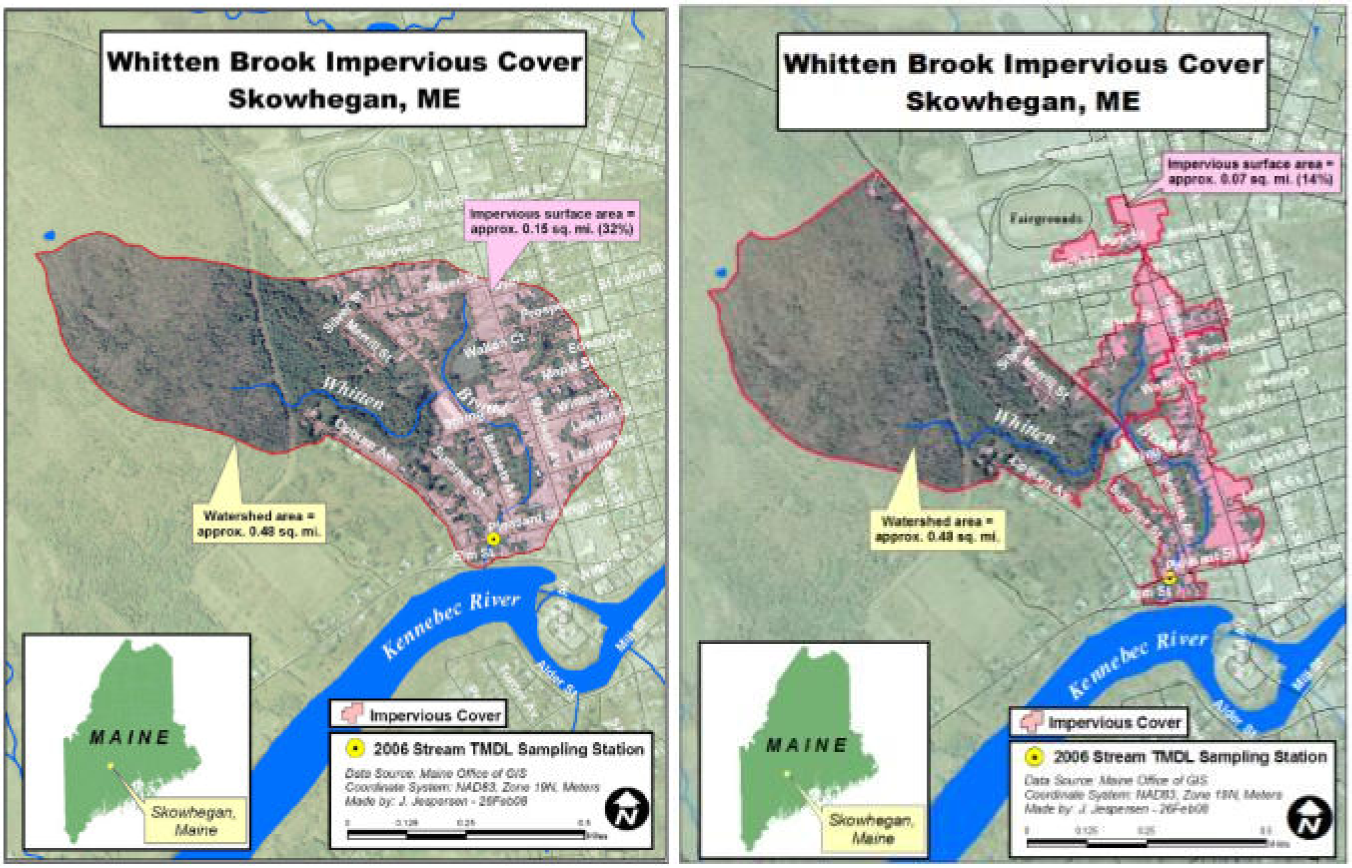


Figure 4-1: Map of Whitten Brook watershed delineation and % IC based on contour maps (left), and field assessment (right).

The waterbody-specific targets set for this TMDL report are presented in Section 5 (Table 5-1).

5. TMDL Allocations and Margins of Safety

> *The* **National Pollutant Discharge Elimination System (NPDES)** *permit program controls water pollution by regulating point sources that discharge pollutants into surface waters. (**Point sources** are any single identifiable source of pollution from which pollutants are discharged.)*

According to the Federal Code of Regulations that govern water quality and management [40 CFR Part 130.2], the TMDL for a waterbody is equal to the sum of the individual loads from point or **NPDES** regulated sources (i.e., waste load allocations or **WLAs**), and load allocations (**LAs**) from non-point or non-NPDES regulated sources (including natural background conditions). Section 303(d) of the Clean Water Act also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (**MOS**) which takes into account any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality.

In equation form, a TMDL is expressed as follows:

$$TMDL = WLA + LA + MOS$$

where:

WLA	=	Waste Load Allocation (i.e. loadings from point sources or NPDES regulated sources)
LA	=	Load Allocation (i.e., loadings from non-point sources or non-NPDES regulated stormwater sources, including natural background)
MOS	=	Margin of Safety

TMDLs may be expressed in terms of either mass per time, concentration or other appropriate measure [40 CFR Part 130.2 (i)].

5.1. Margins of Safety

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 can either be *explicit* or *implicit*. If an *explicit* MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is *implicit*, a specific value is not assigned to the MOS. Use of an *implicit* MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they are sufficient to account for the MOS.

Maine's % IC TMDL provides an explicit MOS in the contributing watersheds, which is reserved from the total loading capacity. A 1% MOS is applied to Class AA, A, and B waters; a 2% MOS is applied to

Class C waters to account for the greater variability in the range % IC associated with Class C streams (see Appendix 2). Waterbody-specific MOSs are shown in Table 5-1 below.

5.2. Wasteload Allocation (WLA) and Load Allocation (LA)

For each impaired stream addressed in this TMDL, a Load Allocation (LA) (for background sources, nonpoint sources and non-regulated stormwater) is given the same % IC allocation as the Waste Load Allocation (WLA) (in these cases, regulated stormwater). This approach is used because LAs must be accounted for, but it is not feasible to separate the loading contributions from nonpoint sources, background, and stormwater. Since the streams addressed by this TMDL are small and do not have point source wastewater discharges upstream in the watershed, source-specific WLAs are not needed, and gross allocations for the WLAs can be used.

Different streams addressed by this TMDL have different portions of their watershed classified as a "regulated area" under Maine's Phase II Stormwater Program. Under the stormwater program, municipal separate storm sewer system (MS4), construction, and industrial stormwater discharges are considered as point sources and must be allocated as waste loads. In this TMDL, the total extent of impervious cover (% IC) in each watershed is used as a surrogate for the complex mixture of pollutant and non-pollutant stressors attributable to stormwater runoff from developed areas. The total loading capacity, or TMDL, is established at a level intended to meet Maine's water quality standards. Then, as described above, the appropriate margin of safety (MOS) is reserved from the loading capacity, and the resulting calculation is the % IC allocated as an implementation target for all discharges (WLAs and LAs).

CSO discharges are also permitted under the MEPDES Program. In the event that CSOs are present in the watershed, a separate WLA must be identified. Maine would typically allocate a waste load of zero ("0") because CSOs in Maine either have controls in place, or are in the process of implementing facility plans to achieve water quality standards.

Table 5-1: Current IC condition, TMDL, WLA & LA for the impaired waterbodies.

Waterbody Name	Town	Water Class	Percent Impervious Cover			
			WLA & LA	MOS	TMDL Target[1]	Current Condition
Arctic Brook (Valley Avenue) *(ME0102000510_224R06)*	Bangor	Class B	8%	1%	9%	23%
Capehart, a.k.a Unnamed (Pushaw) Stream *(ME0102000510_224R05)*	Bangor	Class B	8%	1%	9%	15%
Capisic Brook *(ME0106000105_610R01)*	Portland, Westbrook	Class C	14%	2%	16%	31%

[1]Except as noted, TMDL targets are set at the recommended %IC level for the apporpriate stream classification.
[2]Refer to stream-specific appendix for TMDL target-setting explanation.

Table 5-1, continued: Current IC condition, TMDL, WLA & LA for the impaired waterbodies.

Waterbody Name	Town	Water Class	Percent Impervious Cover			
			WLA & LA	MOS	TMDL Target[1]	Current Condition
Card Brook *(ME0105000213_514R_01)*	Ellsworth	Class B	5%	1%	6%[2]	7%
Concord Gully *(ME0106000106_602R03)*	Freeport	Class B	8%	1%	9%	22%
Dole Brook *(ME0106000105_609R01)*	Portland	Class B	8%	1%	9%	25%
Frost Gully Brook *(ME0106000106_602R01)*	Freeport	Class A	4%	1%	5%	9%
Goodall Brook *(ME0106000304_625R04)*	Sanford	Class B	8%	1%	9%	37%
Goosefare Brook *(ME0106000106_612R01_01)*	Saco, Old Orchard Beach	Class B	8%	1%	9%	17%
Hart Brook, a.k.a Dill Brook including Goff Bk *(ME0104000210_419R02)*	Lewiston	Class B	8%	1%	9%	20%
Kennedy Brook *(ME0103000312_333R03)*	Augusta	Class B	8%	1%	9%	29%
Kimball Brook *(ME0106000105_610R06)*	South Portland	Class C	4%	2%	6%[2]	7%
Logan Brook *(ME0104000208_413R04)*	Auburn	Class B	8%	1%	9%	38%
Mere Brook *(ME0106000106_602R02)*	Brunswick	Class B	8%	1%	9%	21%
Nasons Brook *(ME0106000105_607R11_01)*	Portland	Class C	14%	2%	16%	29%
Nasons Brook *(ME0106000105_607R11_02)*	Westbrook	Class B	8%	1%	9%	29%
Phillips Brook *(ME0106000104_611R02)*	Scarborough	Class C	6%	2%	8%[2]	9%
Red Brook *(ME0106000105_610R07)*	Scarborough, South Portland	Class C	8%	2%	10%[2]	11%
Shaw Brook *(ME0102000511_225R01_02)*	Hermon, Bangor, Hampden	Class B	8%	1%	9%	15%
Sucker Brook *(ME0102000511_225R02)*	Hampden, Bang	Class B	8%	1%	9%	25%
Thatcher Brook *(ME0106000211_616R05)*	Biddeford	Class B	8%	1%	9%	13%
Unnamed Stream (Route 196) *(ME0104000210_419R01)*	Lisbon Falls	Class B	8%	1%	9%	18%
Unnamed Tributary to Bond Brook (entering below I-95) *(ME0103000312_333R04)*	Augusta	Class B	8%	1%	9%	20%
Unnamed Tributary to the Androscoggin River (draining Topsam Fair Mall) *(ME0104000210_420R05)*	Topsham	Class B	8%	1%	9%	30%
Unnamed Tributary to the Androscoggin River (near Jordan Avenue) *(ME0104000210_420R03)*	Brunswick	Class B	8%	1%	9%	19%
Unnamed Tributary to the Androscoggin River (near River Road) *(ME0104000210_420R01)*	Brunswick	Class B	8%	1%	9%	23%
Unnamed Tributary to the Androscoggin River (near Topsham Fairgrounds) *(ME0104000210_420R04)*	Topsham	Class B	8%	1%	9%	20%
Unnamed Tributary to the Androscoggin River (near Water Street) *(ME0104000210_420R02)*	Brunswick	Class B	8%	1%	9%	50%
Whitney Brook *(ME0103000312_333R02)*	Augusta	Class B	8%	1%	9%	18%
Whitten Brook *(ME0103000306_320R03)*	Skowhegan	Class B	8%	1%	9%	14%

[1]Except as noted, TMDL targets are set at the recommended %IC level for the apporpriate stream classification.
[2]Refer to stream-specific appendix for TMDL target-setting explanation.

5.3. Percent Reductions

Calculating a % reduction in impervious cover, or the effects of IC, compared to current conditions, can provide a benchmark for implementation of best management practices (BMPs) designed to reduce the *impacts* of impervious cover on aquatic biota living in the stream.

To calculate the % impervious cover reductions estimated to achieve the TMDL target:

$$\% \text{ IC}_{\text{reduction}} = [(\% \text{ IC}_{\text{Current Condition}} - \% \text{ "WLA \& LA" value}) / \% \text{ IC}_{\text{Current Condition}}] \times 100$$

The "WLA & LA" %IC value in Table 5-1 is used to calculate the estimated percent reduction because the larger TMDL value includes a margin of safety which must be preserved in order to ensure attainment of water quality standards. For this reason, the WLA & LA %IC value is the number used to guide TMDL implementation. The calculated percent reductions in IC, based on estimates of current IC conditions in the watersheds, are provided for informational purposes only in each waterbody-specific appendix.

Seasonal Analysis

Stormwater events that occur over the entire year contribute to the aquatic life impairments documented in the impaired streams. Therefore, the percent IC targets are applicable year round. There is no need to apply different targets on a seasonal basis because the stormwater controls to be implemented to meet water quality standards should 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.

Daily Loads

EPA's guidance recommends that TMDL submittals express allocations in terms of daily time increments (USEPA, 2006). 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.

Benefits of Using IC as a Surrogate for Aquatic Life Impairments related to Stormwater

- This method uses 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).
- This method is consistent with DEP's strategy to address stormwater impacts.
- IC is easily understood by the public.
- TMDLs can be developed with readily available information.

Limitations of the Impervious Cover Method

Two limitations that potentially affect the use of the IC method in this TMDL are as follows (ENSR, 2005):

- ***Limitation #1:*** This method is not intended to account for non-stormwater sources of pollutant loadings.
- ***Effect:*** The method is only appropriate for use in small watersheds with no wastewater treatment facility discharges located upstream in the watershed.

- ***Limitation #2:*** Additional site specific information is required for identification and specification of BMPs to achieve TMDL goals.
- ***Effect:*** As with any TMDL development method that addresses stormwater, a reduction of the IC (or its effects) will require additional site-specific information for optimal planning and implementation of BMPs.

The benefits and limitations of the IC Method strongly support the use of this method which is uniquely suited for small urban/suburban streams with water quality impairments related to excessive stormwater runoff. The calculations of % IC reductions may change over time, as watershed delineations are refined, or as there are development changes in the watershed, but the water quality-based TMDL or loading capacity will not change, and compliance will be measured by the attainment of Maine's water quality standards.

6. Reasonable Assurance

DEP will work with watershed partners, including local watershed groups, towns and watershed residents to implement better stormwater management in the impaired watersheds. Technical assistance by DEP is available to mitigate export from existing stormwater and nonpoint source pollution sources and to prevent excess loading from future sources. A teamwork approach, using adaptive management techniques, will result in an eventual and overall improvement in the impaired watersheds through stormwater BMP implementation and increased public involvement and awareness. Successful reduction in stormwater runoff and non-point sources, however, depends on the willingness and motivation of stakeholders to get involved. The pace of progress will depend on the availability of federal, state, and local funds. (See Appendix 3 for a brief summary of DEP's overarching regulatory and non-regulatory mechanisms to address water quality and stormwater management.)

7. Public Participation

EPA regulations [40 C.F.R. § 130.7(c)(1)(ii)] require that calculations to establish TMDLs be subject to public review. A description of the ongoing public participation process and response to public comments will be provided after the public comment period for this TMDL has ended. The final TMDL and response to all comments will be sent to U.S. EPA Region 1 in Boston for approval. Electronic forms of the report are available for public review at DEP's Public Comment website, (http://www.maine.gov/dep/water/comment.htm#tmdl) and notice will be sent out via email to all interested parties. The following is an example of the public notification that will be used for this TMDL:

PUBLIC NOTICE FOR MAINE STATEWIDE IMPERVIOUS COVER TMDL – In accordance with Section 303(d) of the Clean Water Act, and regulations in 40 CFR Part 130, the Maine Department of Environmental Protection (DEP) has prepared a Total Maximum Daily Load (TMDL) report for waters in the State of Maine with impairments associated with developed area stormwater runoff. The TMDL report establishes the target % impervious cover for watersheds with impaired surface waters, provides documentation of impairment, and outlines the measures which may be needed to meet water quality standards. The report also outlines measures for reducing the impacts from impervious cover and stormwater. The report is posted at the DEP website: http://www.maine.gov/dep/water/comment.htm#tmdl. To receive hard copies, please contact Melissa Evers at 207-215-3879 or melissa.evers@maine.gov.

Send all written comments by July 19, 2012 to Melissa Evers, DEP, State House Station #17, Augusta, ME 04333, or email: melissa.evers@maine.gov.

All public comments received in July 2012 are presented in Appendix 3, along with DEP's response to those comments.

Public Outreach Activities

DEP has undertaken a series of IC TMDL outreach efforts to inform, educate and engage interested parties beginning in the spring of 2011. As part of this effort, a draft version of the TMDL and Stream Specific Appendices has been available on DEP's Public Comment webpage beginning in mid 2011. Table 9-1 contains a list of IC TMDL meetings with presentations that were well attended by a variety interested people. The first five presentations were given by FB Environmental and DEP and the remainder by DEP staff.

Table 7-1. List of Public Outreach Meetings

Sponsor or Venue	*Audience*	*Location*	*Date*
Maine Water Conference	Statewide Draw	Augusta	March 16, 2011
Bangor Area Stormwater Group (BASWG)	Regional Municipalities & Consultants	Bangor	April 14, 2011
Interlocal Stormwater Group (ISWG)	Regional Municipalities, Consultants & Interested Parties	Portland	April 21, 2011
Topsham Town Hall	Regional Municipalities, Consultants & Citizens	Topsham	April 26, 2011
Augusta City Hall	Local Municipal Officials & Consultants	Augusta	May 16, 2011
ISWG	Regional Municipalities, Consultants & Interested Parties	Portland	July 21, 2011
Ellsworth City Hall	Local Municipal Officials	Ellsworth	July 27, 2011
ISWG, DEP, EPA @ Augusta Armory	Statewide Draw Municipalities, Consultants & Interested Parties	Augusta	December 15, 2011
Interlocal Stormwater Group (ISWG)	Regional Municipalities, Consultants & Interested Parties	Portland	January 19, 2012
Ellsworth City Hall	Local Municipal Officials, Consultants & Citizens	Ellsworth	January 25, 2012
Maine DEP	Statewide Draw Municipalities, Consultants & Interested Parties	Augusta	July 17, 2012

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Appendix 1: Water Quality Monitoring Plan & Recommended Future Actions

Water Quality Monitoring Plan

DEP will evaluate progress towards attainment of Maine's water quality standards by monitoring the benthic macroinvertebrate communities in the impaired streams under the Biological Monitoring Program's existing rotating basin sampling schedule. An ongoing biological monitoring program is critical to assess the effectiveness of implementation efforts. While benthic macroinvertebrates will provide the primary metric to determine water quality attainment, interim progress can be measured with other water quality metrics. A water quality monitoring plan can incorporate a variety of parameters, depending on the implementation questions stakeholders are trying to answer. Potential parameters include: temperature, sediment, flow, dissolved oxygen, conductivity and bacteria, which can be measured by stakeholders with some training and an investment of time. These parameters are capable of characterizing existing conditions and detecting changes over time. Watershed improvement work is expected to continue until DEP's biological monitoring shows attainment of aquatic life use goals.

Recommended Future Actions

Next steps for taking action aims at achieving water quality in stormwater-impaired watersheds is to develop and implement a **watershed-specific management plan**, along with an adaptive management approach to the use and installation of BMPs (and by using infiltration BMPs, wherever appropriate, to reduce the volulme of stormwater runoff). Stakeholder involvement is essential to this more detailed level of planning, and some communities may need contractor assistance for more comprehensive site assessments and the evaluation of appropriate stormwater BMPs and stream restoration techniques needed. Stakeholders would also benefit by pursuing BMP cost-optimization techniques, and need to establish fair and equitable ways of funding the costs of stormwater management.

The following information on DEP's programs, suggested next steps and examples (case studies) are provided as general guidance for stakeholders on how to get started in a local planning and stream restoration process.

Maine DEP's Regulatory and Non-regulatory mechanisms to address water quality and stormwater management:

Maine Stormwater Program - The Maine Stormwater Program works toward protecting and restoring surface and groundwater impacted by stormwater flows. The program includes the regulation of stormwater under three core laws: The Site Location of Development law (Site Law), Stormwater Management Law, and Waste Discharge Law (MEPDES). Aspects of stormwater are also addressed under industry specific laws such as the borrow pit and solid waste laws.

Online at: *http://www.maine.gov/dep/land/stormwater/index.html*

Maine Non-point Source Management Program - The overall objective of the Maine Non-point Source Management Program is to prevent, control, or abate non-point source pollution to lakes, streams, rivers and coastal waters so that beneficial uses of those waters are maintained or improved. The program uses Section 319 funds and state funds to support a variety of NPS projects to help achieve this objective. Annually, DEP issues a 'Request for Proposals for NPS Water Pollution Control Projects' and awards these '319 grants' to Maine public organizations to implement actions help restore or protect waters impaired or considered threatened by polluted runoff.

Online at: http://www.maine.gov/dep/water/grants/319.html

Maine Water Classification Program (Title 38 MRSA 464-468) - Maine's Water Classification Program assigns designated uses and water quality criteria to meet those uses. Water body classifications (Maine's river and stream classes include AA, A, B, C) are established to protect each class of designated uses. In addition, aquatic life criteria are established for each individual classification.

Online at: *http://www.maine.gov/dep/water/monitoring/305b/*

The TMDL targets identified in this report may be used as a point of reference when developing Best Management Practices (BMPs) and **Low Impact Development (LID)** techniques to reduce the impact of impervious surfaces or otherwise improve water quality. Development of BMPs and other water quality improvement techniques will be provided in a comprehensive and detailed WMP.

As discussed below, it is recommended that detailed watershed management plans (WMP) be developed, where appropriate, to focus and prioritize appropriate restoration measures. For the impaired waterbodies in this report, the next steps toward water quality improvement should include the identification and detailed assessments of problem areas, including directly connected impervious areas

LIDs or Low Impact Development: *strategies integrate green space, native landscaping, natural hydrologic functions, and various other techniques to generate less runoff from developed land.*

In 1978, Congress amended the Clean Water Act to establish the ***Section 319 Non-point Source Management Program****. Under section 319, State, Territories, and Indian Tribes receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects.*

(DCIA). Watershed stakeholders can then take management actions to iteratively move toward attaining target conditions in the impaired waterbodies through prioritized watershed management planning, stream corridor restoration, and stormwater BMP design – using a phased, adaptive management approach.

Addressing funding options for BMP execution is an important aspect of the implementation process. To get started, a limited number of grants are available from DEP's Nonpoint Source Program. Development and implementation of detailed watershed plans may be eligible for federal funding under the ***Section 319*** grant program. The goal of these grants is to prevent or reduce non-point source pollutant loadings entering water resources so that beneficial uses of the water resources are maintained or restored (More information: ***http://www.maine.gov/dep/water/grants/319.html***).

1. Developing a Watershed Management Plan

Using a watershed-based approach is an effective way to manage water quality within specified drainage areas, or watersheds. Watershed-based planning offers a promising approach to protect and restore Maine's water resources. The watershed approach includes stakeholder involvement and uses a series of cooperative, iterative steps to:

- Characterize existing conditions;
- Identify and prioritize problems, define management objectives;
- Develop protection or remediation strategies; and
- Implement and adapt selected actions as necessary.

The outcomes of this process are normally documented in a watershed management plan (WMP). A WMP serves as a guide to protect and improve water quality in a defined watershed and includes the analyses, actions, participants, and resources related to developing and implementing the plan (USEPA, 2008).

It is particularly important to develop and implement WMPs for waters that are impaired in whole or in part by non-point sources of pollution. For these waterbodies, plans should incorporate on-the-ground mitigation measures and practices that will reduce pollutant loads and contribute in measurable ways to reducing impairments and to meeting water quality standards (USEPA, 2008). For Maine's aquatic life-impaired waters where TMDLs for the affected waters have already been developed, watershed management plans should be designed to take into account information provided in the TMDLs.

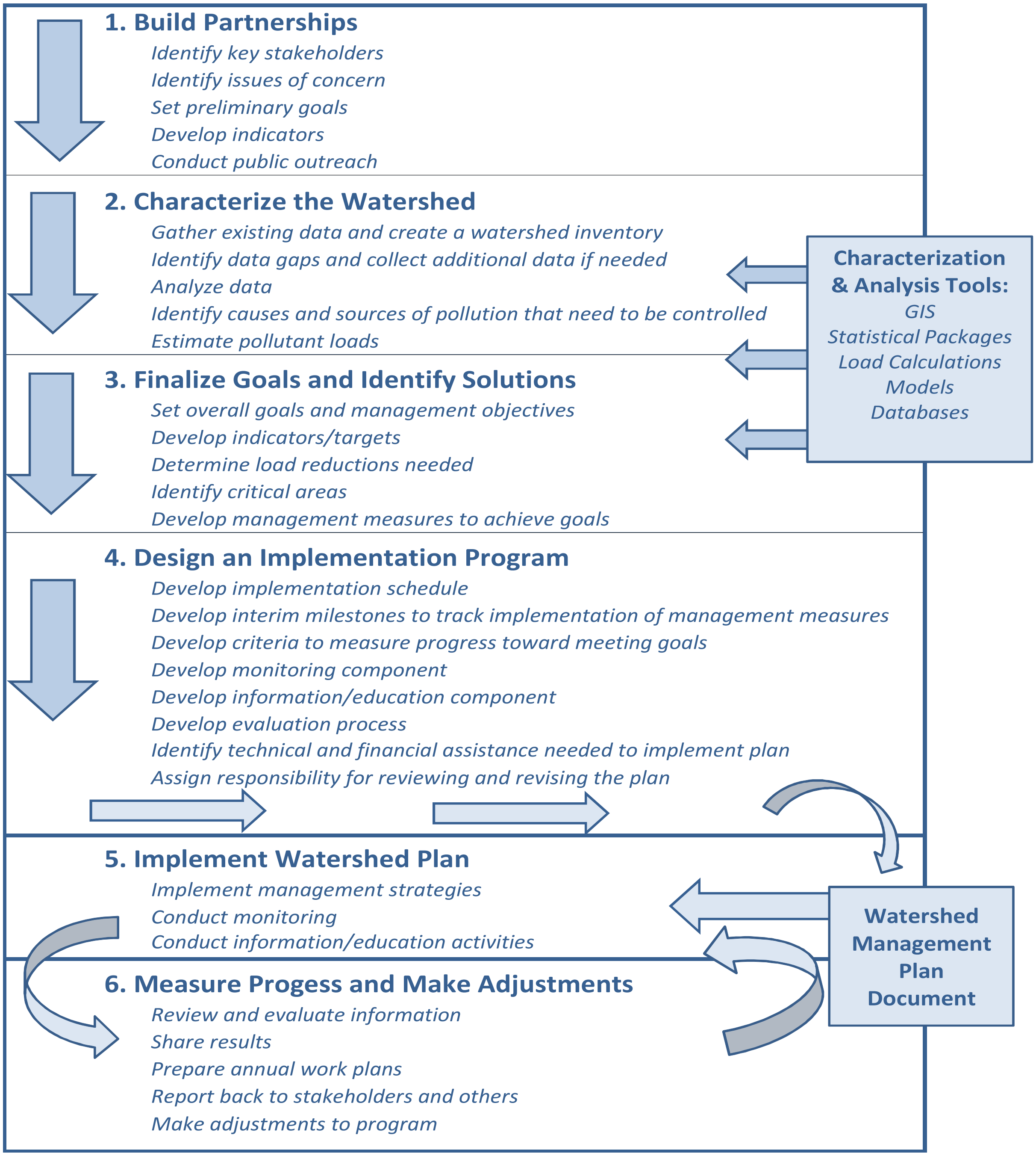
Watershed management plans should consider all impairments and threats in the watershed. While TMDLs focus on specific waterbody segments and specific pollutant sources, watershed management plans should be holistic incorporating the pollutant- and site-specific TMDLs into the larger context of the watershed, including additional water quality threats, pollutants, and sources (USEPA, 2008).

A WMP should address a watershed area large enough to ensure that implementing the plan will address all the major sources and causes of impairments and threats to the waterbody of interest. Plans that bundle subwatersheds with similar sets of problems or address a common stressor (e.g., impervious cover) across multiple related watersheds can be particularly useful in terms of planning and implementation efficiency and the strategic use of administrative resources (USEPA, 2008). Therefore, it is possible for multiple impaired segments within a watershed to be addressed in the same WMP.

Although many different components may be included in a WMP, EPA has identified nine key elements that are critical for achieving improvements in water quality. EPA requires that these nine elements be addressed in watershed plans funded with Clean Water Act section 319 funds. Meeting the nine minimum requirements will help ensure that when work towards plan implementation begins, funding support can be found under the section 319 program.

EPA's nine required elements for 319-funded watershed management plans are (USEPA, 2008):

1. ***Identification of causes of impairment and pollutant sources*** or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed management plan.
2. ***An estimate of the load reductions expected*** from management measures.
3. ***A description of the non-point source management measures that will need to be implemented*** to achieve load reductions in number 2, and a description of the critical areas in which those measures will be needed to implement this plan.
4. ***Estimate of the amounts of technical and financial assistance needed,*** associated costs, and/or the sources and authorities that will be relied upon to implement this plan.
5. ***An information and education component*** used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the non-point source management measures that will be implemented.
6. ***Schedule for implementing the non-point source management measures*** identified in this plan that is reasonably expeditious.
7. ***A description of interim measurable milestones*** for determining whether non-point source management measures or other control actions are being implemented.
8. ***A set of criteria that can be used to determine whether loading reductions are being achieved over time*** and substantial progress is being made toward attaining water quality standards.
9. ***A monitoring component*** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 above.



Steps in the watershed planning process. (USEPA, 2008)

References:

USEPA. 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. March, 2008. United States Environmental Protection Agency. EPA 841-B-08-002. Available at: http://www.epa.gov/owow/nps/watershed_handbook

2. Water Quality Improvements and Restoration Process

The following is a suggested phased water quality improvement and restoration approach adapted from the EPA Region 1 *Stormwater TMDL Implementation Support Manual* (ENSR, 2006). The method below is a process of identifying problem areas and taking management actions to iteratively move toward attaining target conditions in the impaired waterbodies. As an example of the first steps of assessment and implementation, preliminary reconnaissance has been conducted for waterbodies addressed in Appendix 28. Additional investigation is necessary for all of watersheds in order to fully document problem areas and begin the restoration process.

a) Investigate

Investigating current conditions in the watershed is the first step. This TMDL report sets a WLA/LA % IC target which can guide implementation efforts. For practical purposes, the %IC calculations in this TMDL do not distinguish between total IC and effective IC. In any watershed, the runoff from IC reaches the stream through both direct and indirect conduits that represent varying levels of stormwater treatment. A comprehensive sub-watershed survey of outlet structures and storm drainages is required to determine the amount of directly connected impervious area (DCIA). One of the water quality improvement approaches focuses on identifying, disconnecting, and treating IC.

Municipalities and entities that own extensive impervious surfaces are encouraged to conduct such sub-watershed surveys of outlet structures and storm drainages (see Section 4 for more information). Because effective IC presents the greatest pollution risk, efforts to disconnect or convert impervious surfaces should be directed primarily at these areas to ensure maximum benefit. This approach of "disconnecting" directly connected IC is likely to accelerate stream recovery and reaching the ultimate goal of attaining aquatic life criteria in-stream. If all water quality criteria are attained before the target % IC is reached, the need for further reductions in in the effects of impervious cover would be eliminated. Disconnecting "hot spots" and installing BMPs that infiltrate, promote plant uptake or reuse stormwater may move the streams closer to the water quality target than documenting the current extent of IC.

b) Prioritize

After current conditions in the watershed have been inventoried, the next step is to identify and prioritize specific "hot-spot" areas, or areas of greatest stormwater impact, for stormwater mitigation actions. Subwatersheds and specific locations may be ranked and prioritized based on factors such as the extent, proximity, and connectedness of IC to the impaired stream. DCIAs contribute to stream impairment more significantly than areas that are not directly connected. Additionally, subwatersheds or areas higher up in the watershed should be of higher priority because areas near the headwater may influence the entire downstream portion of the stream

Other areas of high stormwater impact may include stream sections with inadequate riparian buffers or with IC connected to, or within close proximity to the stream. Field reconnaissance to verify riparian areas of concern is suggested. Areas with lower IC should be prioritized for stormwater planning strategies to help reduce the influence of these sites on future water quality.

c) Mitigate

Once high priority areas have been identified, specific management options may be determined. Beginning with highest priority areas, develop detailed site specific mitigation plans and obtain funding to implement mitigation. Abatement measures generally take one of three forms: general stream restoration techniques (including flood plain and habitat restoration), disconnection of impervious surfaces from the stream and conversion of impervious surfaces to pervious surfaces. Any of these measures can assist in reducing the effects of IC on a stream. Implementation of any BMPs will require coordination among local authorities, industry and businesses, and the public. Stormwater mitigation requires detailed site-specific information and cannot be prescribed in general terms. Advice on the selection, design, and implementation of any remedial measures can be obtained from DEP and through numerous guidance documents.

d) Monitor

Monitoring shall continue until water quality standards are achieved. The water quality monitoring plan for these waterbodies is described above.

e) Assess and Repeat

Implementation of remedial measures will occur under an adaptive management approach in which certain measures are implemented, their outcome evaluated, and future measures selected so as to achieve maximum benefit based on new insights gained. After monitoring, if water quality standards have not been achieved, return to the prioritized list of sites and implement the next series of corrective actions. Repeat the process until applicable water quality standards are met.

The order in which measures are implemented should be determined with input from all concerned parties (e.g., city, businesses, industry, residents, regulatory agencies, watershed protection groups).

3. Measures to Restore Impaired Waters

Best Management Practices (BMPs) to help mitigate the effects of impervious cover on Maine's surface waters generally take two forms: non-structural and structural. Restoration of stormwater impaired watersheds typically requires a combination of both types of BMPs.

Non-structural BMPs are a broad group of practices that prevent pollution through maintenance and management measures. They are typically related to the improvement of operational techniques or the performance of necessary stewardship tasks that are of an ongoing nature. These include institutional and pollution-prevention practices designed to control pollutants at their source and to prevent pollutants from entering stormwater runoff. Non-structural measures can be very effective at controlling pollution generation at the source, thereby reducing the need for costly "end-of-pipe" treatment by structural BMPs. Examples of non-structural BMPs may include maintenance practices to help reduce pollutant contributions from various land uses and human operations, such as street and parking lot sweeping, road and ditch maintenance, or specifications regarding the spreading of winter road salt.

Structural BMPs are generally engineered, constructed systems that can be designed to provide water quality and water quantity control benefits. Structural BMPs are used to address both existing watershed impairments as well as the impacts of new development. A few examples of structural BMPs include: infiltration systems designed to capture a volume of stormwater runoff, retain it and infiltrate that volume into the ground; detention systems designed to temporarily store runoff and release it at a gradual and controlled rate; retention systems designed to capture a volume of runoff and retain that volume until it is displaced in part or whole by the next runoff event; constructed wetland systems to provide both water quality and water quantity control; and filtration systems, which use a media such as sand, gravel or peat in order to remove particulate pollutants found in stormwater runoff. Ideally, structural BMPs treat and infiltrate stormwater runoff to enable the land surface to mimic the hydrologic characteristics of a natural system.

Structural and non-structural BMPs are often used together. Effective pollution management is best achieved from a management systems approach, as opposed to an approach that focuses on individual practices. Some individual practices may not be very effective alone but, in combination with others, may provide a key function in highly effective systems.

Effective BMP implementation should focus not only on reducing existing pollutant loads, but on preventing new pollution. Once pollutants are present in a waterbody, or after it reaches a receiving waterbody, it is much more difficult and expensive to restore to an unimpaired condition. Therefore, management systems that rely first on preventing degradation of receiving waters are recommended.

The following websites provide additional information on low impact development strategies and stormwater BMPs:

- ***Maine Stormwater Best Management Practices Manual -*** The purpose of this manual, which consists of three volumes, is to provide communities, developers, designers and regulatory personnel with a reference guide for the selection, design and application of measures to manage stormwater from newly developed and redeveloped properties, while meeting environmental objectives in the Maine regulatory setting.
  Online at: http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm
- ***LID Manual for Maine Communities -*** The purpose of this guidance manual is to help municipalities implement LID practices on small, locally permitted development projects. This manual provides a recommended set of LID standards and guidance on implementing LID practices to comply with those standards.
  Online at: http://www.maine.gov/dep/blwq/docwatershed/materials/LID_guidance/index.htm
- ***Center for Watershed Protection (CWP) -*** The Center for Watershed Protection works to protect, restore, and enhance our streams, rivers, lakes, wetlands, and bays. CWP creates viable solutions and partnerships for responsible land and water management so that every community has clean water and healthy natural resources to sustain diverse life. The CWP website contains an extensive resource library with information on watershed shed planning, stormwater and BMPs.
  Online at: http://www.cwp.org/
- ***University of New Hampshire Stormwater Center -*** The UNH Stormwater Center serves as a unique technical resource for stormwater practitioners by studying a range of issues for specific stormwater management strategies including design, water quality and quantity, cost, maintenance, and operations. The field research facility serves as a site for testing stormwater treatment processes, for technology demonstrations and workshops. The testing results and technology demonstrations are meant to assist in the planning, design, and implementation of effective stormwater management strategies for resource managers.
  Online at: http://www.unh.edu/erg/cstev/
- ***National Menu of Stormwater Best Management Practices -*** The National Menu of Best Management Practices for Stormwater Phase II was first released in October 2000. EPA has renamed, reorganized, updated, and enhanced the features of the website. These revisions include the addition of new fact sheets and revisions of existing fact sheets. Because the field of stormwater is constantly changing, EPA expects to update this menu as new information and technologies become available.
  Online at: http://cfpub1.epa.gov/npdes/stormwater/menuofbmps/index.cfm

4. Watershed Case Studies

The following pages contain a set of case studies of successful watershed improvement projects in different areas of Maine. Each of these summaries represents a different stage in the process of implementation.

1. **Whitten Brook, Skowhegan, Maine:** The *Whitten Brook Watershed Restoration Plan* [http://www.fbenvironmental.com/projectPostings.html] is an example of a watershed restoration/planning project in the early phases of completion. This project includes the development of a Watershed Restoration Plan for Whitten Brook, stakeholders meetings, a stream corridor survey, rapid geomorphic assessment, and a parcel-by parcel survey of impervious surfaces in the watershed. The final product is a community-driven Management Plan that identifies ways to reduce the effects of impervious area so the stream can once again meet Class B water quality standards.

   Having such a plan can increase chances of competing for DEP 319-grant funds. In general, state water quality or natural resource agencies and EPA will review watershed plans that provide the basis for section 319-funded projects. A plan, such as the *Whitten Brook Watershed Restoration Plan,* that meets EPA's nine minimum requirements will help ensure that when work towards plan implementation begins, funding support can be found under the section 319 program.

2. **Penjajawoc Stream, Bangor, Maine:** The *Penjajawoc Stream Watershed Management Plan* [http://www.gulfofmaine.org/kb/files/9426/Arter_2008_Penjajwoc%20stream%20management%20plan.pdf] is an example of a completed watershed management plan with implementation projects underway. The WMP for Penjajawoc Stream provides over 75 recommendations designed to help business owners, government, conservation organizations, and citizens improve the stream. The working group further refined the 2006 list of 37 high priority subcatchments to a final list of 20 projects which were categorized into four tiers for implementation based largely on their overall impact, estimated load reduction or cost per acre of impervious area. Implementation of these projects is expected to reduce pollutant loads by ~ 240 lbs. of phosphorus per year.

3. **Long Creek, South Portland, Maine:** The *Long Creek Watershed Management Plan* was completed in 2009 as part of the Long Creek Restoration Project [http://www.restorelongcreek.org/plan/index.htm]. The goal of the Restoration Project is to develop and implement a cost-effective, environmentally-responsible, and equitable plan for restoring and protecting Long Creek and its watershed. To this end, some BMP/LID projects are currently underway in the watershed and a Watershed Management District has been created to provide a funding mechanism. Additionally, the Watershed Management Plan created the opportunity to give landowners the option of participating in a coordinated program under a Maine Pollutant Discharge Elimination System (MPDES) permit general permit in lieu of obtaining an individual permit. A watershed-based stormwater general permit has been issued by DEP.

Case Study: Whitten Brook

Watershed Restoration Plan

Waterbody:

Whitten Brook drains a small (0.48 square mile) watershed in the Town of Skowhegan, Maine. The stream flows approximately 0.6 miles through relatively undeveloped forestland north-west of downtown where it joins an unnamed tributary flowing in from the north. The stream flows another 0.5 miles south-east through a residential neighborhood, crossing under six roads before flowing into the Kennebec River. Total impervious cover (IC) in the watershed is high (14%), with close to 90% of the total IC located within just 30% of the watershed area.

Location:

Town of Skowhegan in Somerset County, Maine

Sponsor:

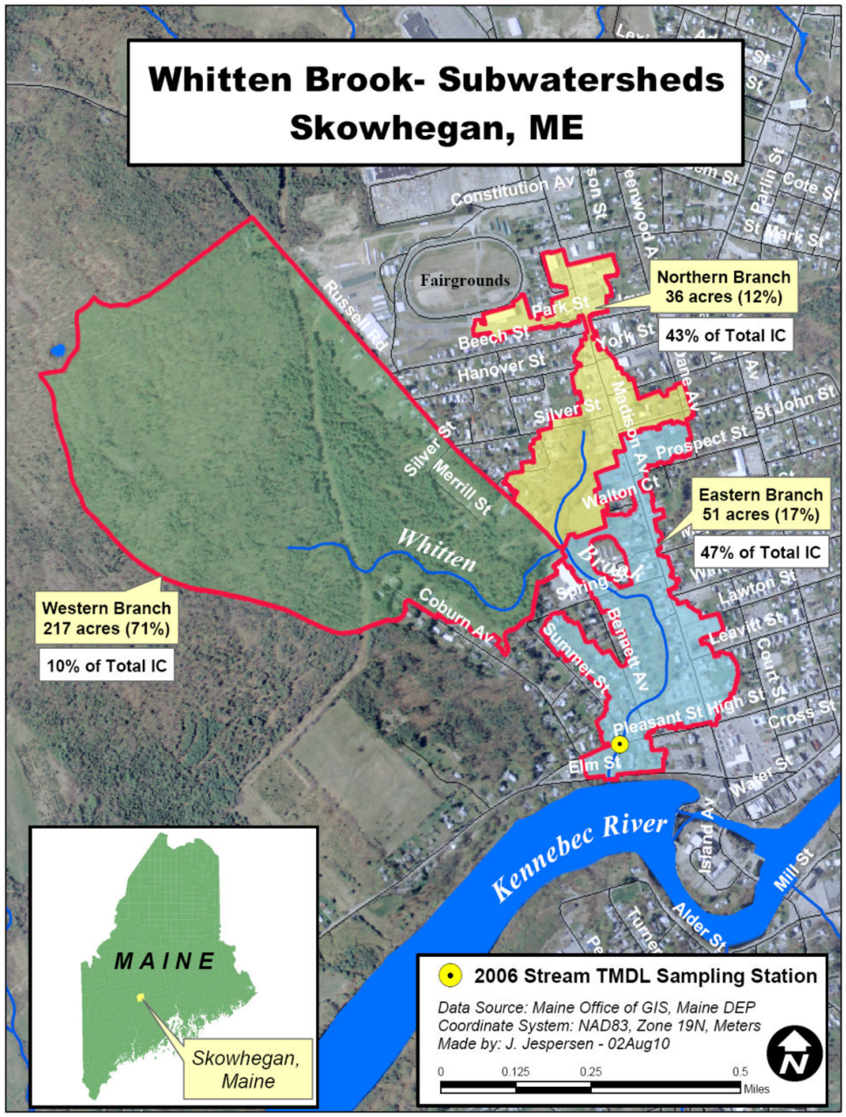
Town of Skowhegan Conservation Commission

Timeframe:

May 2010 through February 2011

Funding Provided by:

U.S. Environmental Protection Agency



Aerial view of the Whitten Brook watershed, its three subwatersheds, and the extent of impervious cover (IC) in each.

Problem:

Conservation Commission volunteer, Peter Whitkop takes a GSP point at one of the four major stormwater outfalls in Whitten Brook.

The Whitten Brook watershed is a small urban drainage that violates Maine's Class B water quality standards based on sampling data collected between 2002 and 2006. This data includes monitoring of the macroinvertebrate community, physical habitat parameters and water chemistry. Sampling results were compared to water quality standards and the stream was listed as impaired on Maine's 303 (d) list of impaired waters due to non-attainment of aquatic life criteria. Whitten Brook is also listed for non-attainment of bacteria standards which has been addressed in a separate Total Maximum Daily Load (TMDL) report. The high percentage of developed land (commercial, industrial and residential land uses) in the Whitten Brook watershed has been identified as the primary culprit to the current aquatic life impairment. Changes in the hydrologic cycle include increased surface flow during storm conditions which carry large volumes of water and attached pollutants to Whitten Brook.

In 2010, the DEP conducted a comprehensive watershed delineation to determine watershed boundaries and to map the extent of impervious cover in the watershed. The study examined the existing stormwater system and its impacts on the stream, and identified four major subcatchments that direct high volumes of stormwater directly to the stream without treatment. These four subcatchments range from 43% IC in the smallest catchment area, to 74% IC in the largest catchment area. Excess stormwater runoff has resulted in an unstable stream environment.

Project Description:

A draft TMDL was developed for Whitten Brook in 2008. The Skowhegan Conservation Commission took an active role in the TMDL process, and in 2009 applied for Section 319(h) grant funds to develop a watershed management plan which was not funded. In 2010, the U.S. EPA identified Whitten Brook as a candidate watershed for a pilot project due to its small size, and actively engaged watershed community.

The watershed restoration/planning project includes the development of a Watershed Restoration Plan for Whitten Brook, including five stakeholders meetings, a stream corridor survey, rapid geomorphic assessment, and a parcel-by parcel survey of impervious surfaces in the watershed. The final product is a Community-Driven Management Plan that identifies ways to reduce the effects of the impervious area so the stream characteristics can respond as if its watershed were only 9% impervious, and so that the stream once again meets Class B standards.

Actions Taken:

Watershed Kick-off Meeting- May 2010

Watershed Stakeholders were invited to attend a meeting to learn about the project. Presentations were given by FB Environmental Associates and DEP. Attendance was high and interest was outstanding.

Level 1 Stream Corridor Survey- August 2010

Volunteers from the Skowhegan Conservation Commission teamed up with DEP and FB Environmental Associates to conduct a Stream Corridor Survey for Whitten Brook. The survey included a Rapid Habitat Assessment and Rapid Geomorphic Assessment of the stream. Survey results are used to assess the overall condition of the stream, including the riparian zone and stream temperature, stream bottom, streambank, stream channel, water quality, potential pollution problems, and geomorphic stability. The survey found that overall, conditions in Whitten Brook are poor, with a few reaches ranking fair.

Stormwater RRI- August 2010

Volunteers from the Skowhegan Conservation Commission teamed up with DEP and FB Environmental Associates to conduct a Watershed Retrofit Reconnaissance Inventory (RRI). The RRI survey includes a rapid field assessment of potential stormwater storage and on-site retrofit sites in the watershed. Typical sites that may be investigated for possible retrofitting include culverts, storm drain outfalls, highway rights-of-way, open spaces, parking lots, and existing detention ponds. The survey identified thirty-three potential stormwater retrofit sites and three demonstration sites that can be implemented right away.

The Whitten Brook RRI survey helped to identify potential stormwater retrofits.

Volunteer Stream Clean-Up- September 2010

Momentum from the Stream Surveys resulted in a volunteer stream clean-up organized by the Skowhegan Conservation Commission. The clean-up utilized 96 hours of volunteer labor by the Charleston Youth Detention Center and the Conservation Commission, as well as four hours of labor from the Town of Skowhegan Highway Department who helped move approximately 20 cubic yards of garbage from the stream using two dump trucks.

Volunteers pulled 20 cubic yards of trash from Whitten Brook in September 2010.

Community Forum- November 2010

Results of the 2010 Watershed Study was presented at a watershed planning forum. Outreach materials included postcards sent to each landowner in the watershed, posters hung at public locations in the town, personal invite letters to municipal officials, and press releases. The forum included a presentation of the 2010 Watershed Study by FB Environmental, an overview of in-stream restoration potential by DEP, a report on the stream clean-up by the Conservation Commission, and a facilitated planning discussion to engage stakeholders in the planning process.

Formation of a Technical Advisory Committee- December 2010

A Technical Advisory Committee (TAC) was developed to help guide the watershed planning process by providing technical expertise for watershed restoration action strategies. The major goals of the TAC include prioritizing retrofit sites, developing action items for the management plan, and providing critical review of the Restoration Plan. The TAC represents the diverse interests of the watershed community including municipal government, conservation groups, business owners, landowners and residents, and state government.

Outcomes:

- Stream Corridor Study and Watershed Stormwater Retrofit Inventory
- Five Community Watershed Planning Meetings
- Formation of a Technical Advisory Committee
- Development of a Watershed Restoration Plan to address Impervious Cover
- Prioritization of retrofit sites for ongoing stream restoration efforts
- Removal of 20 cubic yards of trash from the stream

Future Steps:

- Town of Skowhegan to adopt the Watershed Restoration Plan
- Conservation Commission to apply for funding to implement high priority retrofit sites and/or demonstration sites

References:

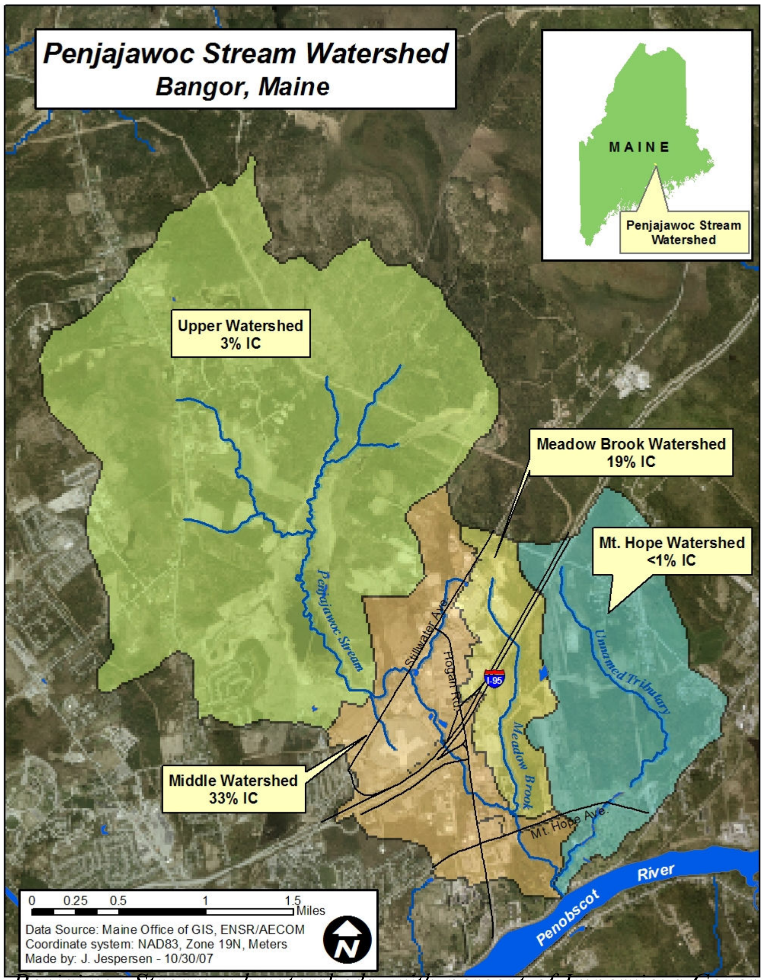
Maine DEP (2008). *Total Maximum Daily Load (TMDL) Report. Whitten Brook, Skowhegan, Maine*. Maine Department of Environmental Protection. Stakeholder Review Draft, March, 2008.

Case Study: Penjajawoc Stream

Watershed Management Plan

Waterbody:

Penjajawoc Stream is a 5.2 mile stream with a watershed area of 8.8 square miles located primarily in the City of Bangor, Maine. The upper watershed, largely undeveloped, is comprised of forestland and wetlands including a 300-acre emergent freshwater marsh. Cultivated land and low-density residential development make up the remaining land uses in the upper watershed. The middle portion of the watershed below the marsh contains the Bangor Mall, and other high-density commercial development, while the lower watershed consists primarily of low-density development. Two tributaries, Meadow Brook and an unnamed stream, flow into the Penjajawoc in the lower watershed. Penjajawoc Stream eventually flows into the tidal portion of the Penobscot River, providing a mild tidal effect on the stream.



Penjajwoc Stream subwatersheds, with percent of Impervious Cover (IC) indicated.

Location:
City of Bangor and Town of Veazie in Penobscot County, Maine

Sponsor:
City of Bangor

Timeframe:
September 2009 - October 2010

Funding Provided by:
American Recovery and Reinvestment Act (ARRA) /State Revolving Loan Fund (SRF), private property owners.

Problem:

Penjajawoc Stream is an urban impaired stream that does not meet the State of Maine Class B water quality standards for dissolved oxygen, aquatic life, and habitat. Aquatic life impairment is likely due to an increase in the amount of impervious surfaces and associated stormwater runoff that has altered stream stability and caused in-stream habitat degradation. Seasonal high temperatures, seasonal low oxygen, high nutrients, high conductivity, toxics (mostly metals and organics from roads), sediment altered hydrology, and impaired biological communities all contribute to the water quality impairment.

Project Description:

Since early 2000, the City of Bangor has been working closely with DEP and various partners to improve water quality in the Penjajawoc Stream watershed. This interest has led to the completion of a fluvial geomorphology study; ongoing water quality analysis (including the formation of a Stream Team in 2007); impervious cover analysis; ordinance review; and structural BMP retrofit recommendations. In 2006 a pollutant load study examined existing stormwater structures in the developed (middle) watershed documenting the absence of stormwater treatment measures or the need to repair or replace older stormwater structures. Stormwater retrofit recommendations were made for 79 subcatchment areas in this middle watershed. Thirty-seven of these (representing 62% of total impervious cover in main stem watershed) were ranked high priority because the impervious cover exceeded 2.5 acres, stormwater treatment was limited or did not meet current standards, or they were considered areas with potentially high traffic and high pollutant release. Retrofit recommendations for these 37 subcatchments were estimated to result in a 44% reduction in pollutant loading to Penjajawoc Stream over time.

The Penjajawoc Stakeholder Working Group was formed in 2007. Comprised of municipal, state, residential, commercial, and conservation representatives, the working group met several times between the fall of 2007 and spring of 2008 to provide input, develop recommendations, and review a Watershed Management Plan for Penjajawoc Stream. The Management Plan builds on previous studies, and provides over 75 recommendations designed to help business owners, government, conservation organizations, and citizens improve the stream. The working group further refined the 2006 list of 37 high priority subcatchments to a final list of 20 projects which were categorized into four tiers for implementation based largely on their overall impact, estimated load reduction or cost per acre of impervious area. Implementation of these projects is expected to reduce pollutant loads by ~ 240 lbs. of phosphorus per year.

Actions Taken:

In 2009, the City of Bangor was awarded $867,000 in American Recovery and Reinvestment Act (ARRA) funds to implement stormwater improvement and stream restoration projects identified in the Penjajawoc Stream Watershed Management Plan. Funds were allocated by the State Revolving Loan Fund (SRF) of which 50% will be paid back by the City over the next 20 years. The remaining 50% of funds will be reimbursed by ARRA when the project is complete.

Six of the highest priority projects were implemented including:

<ins>*Lower Hogan Road Stormwater Improvements*</ins>:

Two subsurface stormwater management systems (StormTech systems) were installed underneath part of a large commercial auto sales park. The system treats stormwater from a portion of the adjacent four-lane road as well as part of the auto sales park. The two systems treat stormwater from 3.8 acres of impervious area.

One of six projects included restoration of 1,700 linear feet of Penjajawoc's stream channel. Photo: City of Bangor

<ins>*Upper Hogan Road Stormwater Improvements:*</ins>

An under-drained grass swale was installed on the southern edge of a large commercial property, as well as a StormTech system on the adjacent city-owned right-of-way, and a 10,485 sq. ft. section of porous pavement on the roadway. The vegetated swale was designed to treat 1.3 acres of impervious area and 0.22 acres of lawn. The StormTech system was designed to treat the first flush of stormwater from 2.35 acres of impervious area. This project also includes 10,485 sq. ft. of porous pavement.

<ins>*Bangor Mall/Borders Ground Water Bypass:*</ins>

A new drainage pipe is now diverting approximately 150 gallons per minute of clean cool ground water from underneath the Bangor Mall and Borders directly into the Penjajawoc. Previously the water flowed into a retention pond before flowing into the stream. This improvement increases the stream's base flow and decreases its temperature.

<ins>*Penjajawoc Stream Channel Restoration Project*</ins>:

This project reconstructed the Penjajawoc Stream channel between Bangor Mall Boulevard and I-95, decreasing the cross-sectional area, increasing the stream's velocity and dissolved oxygen content, and restoring the alignment to more closely mimic a natural channel. The project restored 1,700 feet of stream channel.

<ins>*Stillwater Avenue Stormwater Improvement Project:*</ins>

Four Filterra tree box filters were installed to treat stormwater runoff from a large commercial parking area on Stillwater Avenue.

Eastern Maine Community College (EMCC) Stormwater Treatment Project:

A portion of the EMCC parking lot was built using porous pavement, allowing stormwater to filter through the pavement and into the ground. Not only does this project reduce the volume and rate of stormwater runoff, but its public/institutional location serves as a demonstration site allowing design professionals, contractors and developers the opportunity to observe firsthand the effectiveness and aesthetic values of these practices. The project included 8,253 sq. ft. of porous pavement.

Outcomes:

- Successful implementation of high priority stormwater retrofits in the Penjajawoc Stream watershed.
- Development of maintenance agreements and easements between the City and private property owners to successfully implement stormwater retrofits on private property.
- New state-of-the-art street sweeper truck to reduce the impacts from excess sand and salt on city streets.
- Improved community awareness of water quality and stormwater issues through use of the sites as demonstration projects.

Future Steps:

The City of Bangor and community groups such as the Bangor Area Stormwater Group continue to move ahead with watershed restoration in the Penjajawoc Stream watershed. Future planning projects that will benefit the stream include:

- Installation of signs at each of the six demonstration sites.
- Detailed GIS mapping of impervious cover and land uses in the watershed.
- A Stormwater Feasibility Study.
- Ongoing water quality monitoring by Stream Team Volunteers.

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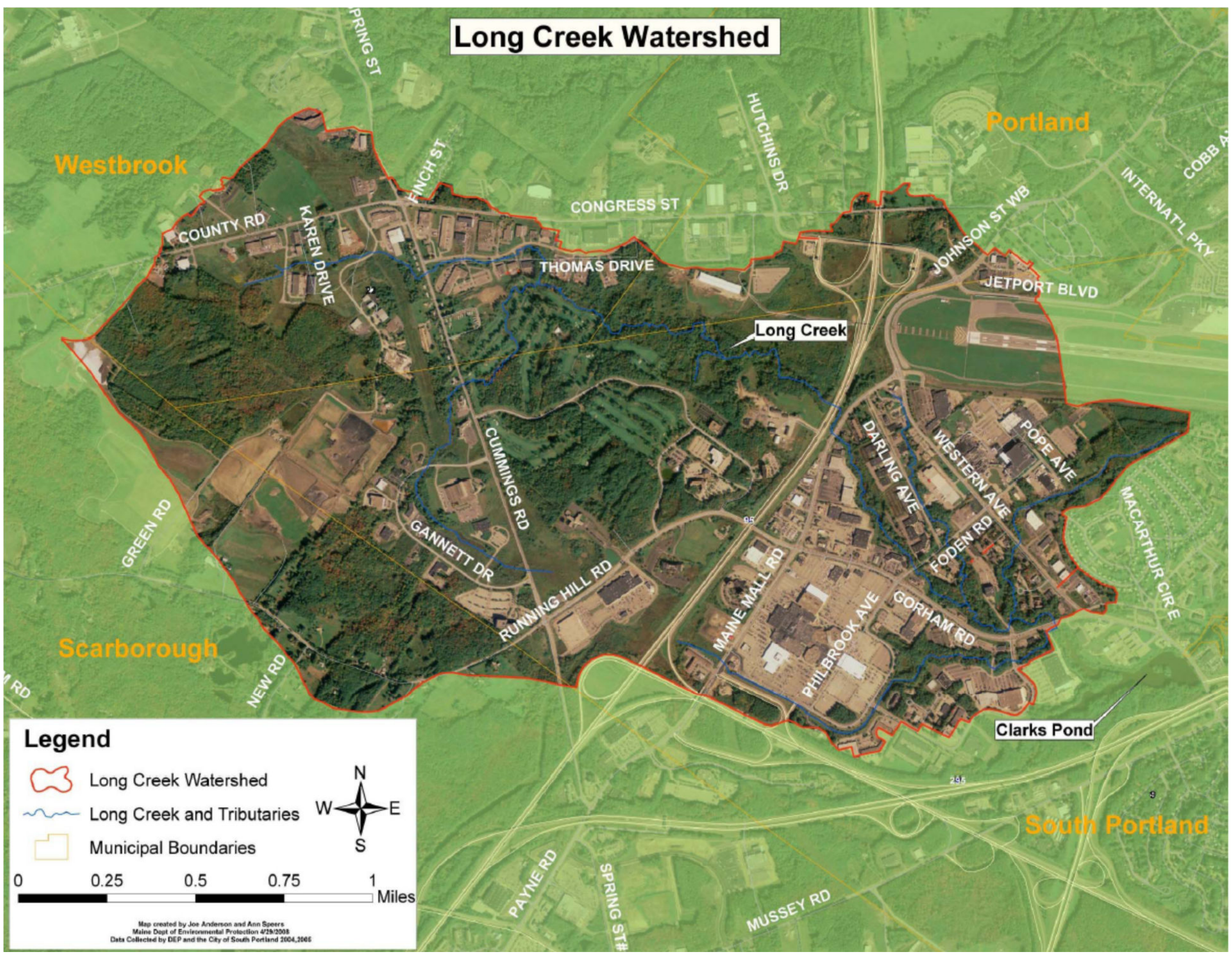
Case Study: Long Creek

Stormwater Treatment Retrofit Projects

Waterbody:

Long Creek is an urban stream located in southern coastal Maine. Its watershed drains 3.45 square miles, most of which is highly developed. The receiving water body is Clarks Pond, a semi-impounded reach of the tidal Fore River, which drains to Casco Bay. The Maine Mall and a large golf course occupy the lower and middle portions of the basin, respectively. A 1.6 mile section of the Maine Turnpike traverses the watershed (Exit 45 to 46, approximately). A portion of the Portland Jetport land and runway are also present.



Location:

Cities of South Portland, Westbrook, Portland, and town of Scarborough; in Cumberland County, Maine.

Key Participants:

Municipalities/Quasi-municipal

- City of South Portland
- City of Westbrook
- Town of Scarborough
- City of Portland
- Ecomaine
- Cumberland County Soil & Water Conservation District

State Entities

- Maine Department of Environmental Protection
- Maine Department of Transportation
- Maine Turnpike Authority
- Maine NEMO

Businesses/Business Representatives

- Fairchild Semiconductor
- National Semiconductor
- Marriott at Sable Oaks
- The Maine Mall
- CBRE The Boulos Company
- Ocean Properties Ltd.
- Bramlie Development Corp.
- Maine Wetlands Bank
- Portland Regional Chamber
- SP/CE Chamber of Commerce

Nonprofits

- South Portland Land Trust
- Casco Bay Estuary Partnership
- Conservation Law Foundation

Timeframe:

Development of Restoration Plan: 2007 – 2009
Permitting and Incorporating Watershed District: January 2009 – June 2010
Implementation: June to October 2010

Funding Provided by:

The Long Creek Watershed Management District is primarily self-funded. Grant funding provided a substantial boost early in the project under ARRA Program ($2.1M) via DEP. Additional smaller grants from US EPA and Casco Bay Estuary Partnership also helped early in the process. Landowners holding 1 acre or more of impervious surface pay an annual fee (proportional to impervious surface owned) to the Long Creek Watershed Management District.

Problem:

The Creek suffers from high levels of polluted runoff, or stormwater, causing it to be listed as one of 31 "urban impaired streams" in Maine. Stormwater introduces toxic metals, chloride, and causes reduced dissolved oxygen concentrations in the streams. Many of these pollutants are washed off of parking lots, streets, and other developed surfaces and into Long Creek when it rains. Altered hydrological conditions also are caused by drainage from impervious surfaces, including severe erosion and bank widening because flows are faster and more intense, and increased runoff temperature due to lack of shading in certain areas. Other pollutants of concern for are nutrients, such as phosphorus and nitrogen; and polycyclic aromatic hydrocarbons (PAHs), whose sources include parking lot sealants and fossil fuels. These pollutants are currently being monitored in Long Creek.

Project Description:

The Long Creek restoration effort began in January 2007, with the City of South Portland playing a leading role. Over the course of about two years, a large group of business and landowners, four municipalities, several state agencies, and non-profits generated a Long Creek restoration plan. The restoration plan was informed by extensive field work and analysis conducted by scientists at FB Environmental, Woodard and Curran, and Field Geological Services.

The Long Creek Watershed Management Plan describes the purpose and goals of a restoration effort, describes the existing environment and water quality standards in detail, and lays out proposed steps to accomplish restoration. The steps include specific construction projects, maintenance efforts, and other efforts, with proposed steps grouped and tiered based on cost-benefit analysis. Specific priority catchments are identified, and an "adaptive management" approach is described, in which restoration efforts are evaluated for effectiveness as they are completed. Adaptive management depends on watershed monitoring, which is also addressed in the plan.

In 2009, as the Long Creek Watershed Management Plan was being developed, EPA indicated that additional stormwater discharges associated with 455 acres of developed land with impervious area would be designated as regulated sources, requiring all landowners with one acre or more of impervious surfaces in the Long Creek watershed to obtain a Maine Pollutant Discharge Elimination System (MPDES) permit.

Maine DEP offered permit applicants a choice between coverage under a watershed-based general permit, or an individual permit. Under the general permit, landowners are required to participate in the Long Creek Watershed Management Plan by agreeing to its terms and paying an appropriate permit fee to support stream restoration, BMP implementation, maintenance activities and stream monitoring on a watershed basis. By contrast, an individual permit requires the landowners to submit for DEP review a detailed plan of restoration activities and maintenance monitoring requirements specific to their property alone, and pay a permit fee. Costs of implementation were projected to be significantly reduced through support of the watershed plan, and participation has been vigorous: so far, remediation efforts for 93% of affected landowners will be guided by the LC Watershed Management Plan.

The Long Creek Watershed Management District was formed in 2010 as an administrative, legal, and financial vehicle to support the general permit approach in the Long Creek watershed. Fees are paid into the district based on the number of acres of impervious surface owned. The District then implements the restoration efforts outlined in the Watershed Based Plan, beginning with highest priority projects, where projected water quality benefits are highest relative to cost. The District also manages the maintenance of stormwater infrastructure, achieving an economy of scale relative to individual landowners. Participation in the District is optional, so landowners who want to pursue an individual permit are free to do so. The collaborative, watershed-scale approach in Long Creek has resulted in large-scale construction projects at key locations. The new stormwater infrastructure projects outlined below improve water quality by increasing detention, filtration, and infiltration of runoff. The first year of projects addressed more than 15% of the DCIA in the watershed. Ongoing monitoring help gauge the effectiveness of these investments.

Actions Taken:

Darling Avenue Stormwater Retrofit

Soil media filters were integrated into a commercial/light industrial 17-acre stormwater catchment area. Collaborating with adjacent landowners, contractors identified and installed DEP specified stormwater treatment technologies. The stormwater features have a minimal footprint, and are placed within a complex network of utilities.

Pervious Pavement on Maine Mall Road

The Maine Department of Transportation developed and installed a pervious pavement system for Maine Mall Road, one of the busiest urban roads in the state. The system consists of two pavement layers atop a 15 inch layer of reservoir stone, in turn above a 6-18 inch layer of sand filter material. The bottom layer of sand filter is expected to provide most of the system's water quality benefits. This project received funding under the American Recovery and Reinvestment Act of 2009 (Stimulus Bill), and was allowed under the Long Creek Watershed Management Plan's adaptive management strategies. The 0.33 length of road equates to a surface area of 3.05 acres, which is 21% of its 14.4 acre catchment area.

Mall Plaza Phase I

A commercial 14-acre stormwater catchment area that was well over 95% impervious previously had no stormwater treatment. A large, 5-cell soil media filter was installed to treat runoff from a 1 inch storm from a large portion of the catchment.

Mall Plaza Phase II

In the same catchment as above, two stormwater installations were constructed. First, a large (10' x 40', excavated to 6') runoff storage chamber were installed underneath a parking lot, via easement. These storage chambers are piped into the second installation, a series of stormwater treatment cells containing washed stone and plantings. These two units combined treat the first inch of runoff to provide channel protection volume.

Installation of soil media filter during Mall Plaza Phase. I

<u>*Philbrook Avenue Stormwater Retrofits*</u>

Stormwater storage and filtration is being installed along one of the major access roads to the Maine Mall, Philbrook Avenue. The retrofits consist of tree filter boxes, below grade storage units, and native riparian vegetation.

<u>*General Growth Properties Wet Pond Repair and Planning*</u>

A wet pond had been constructed to treat this 66-acre commercial site decades ago, but had failed shortly after construction when the impoundment berm was punctured. That berm has been repaired, so that the pond is now retaining some water. Future work will focus on increasing the volumetric capacity of the pond, and removing vegetation from the original retention area, and installation of a soil filter.

What We Found:

- Forming a watershed district is more cost effective to most permit applicants than an individual permit approach.
- Although the collaborative stakeholder process requires a substantial effort, it is well worth the investment.
- High level of participation in the General Permit has been attained during 2010, including 93% of the designated parcels in the watershed. A few landowners still opted for an individual permit.
- A small number of landowners who have slightly more than 1 acre of impervious surface are working to reduce that area to less than an acre, thereby avoiding permit obligations.
- Many permittees object to the 1-acre threshold because permit coverage of all impervious areas with stormwater discharges would be more equitable and fair for cost sharing.
- Taking a watershed-wide approach offers many economies of scale. For example, a fast-food restaurant chose to participate in Mall Plaza Phase 1 as it was getting underway. The additional impervious area treated simply required a slightly taller retaining wall, which resulted in zero additional cost.
- Many commercial property owners insist that their signage and building remain highly visible from the roadway, which affects retrofit design.

Future Steps:

The Long Creek Watershed Management District will continue to direct restoration efforts. Its powerful self-funding mechanism, watershed-wide perspective, and collaborative permit approach appears more cost-efficient than a parcel-by-parcel, individual permit approach.

Selected stormwater improvements planned for the future:

- General Growth Properties will continue to improve the wet pond facility, removing vegetation and adding a soil filter.
- Vegetation will be planted to shade Blanchette Brook, a tributary currently flowing through bare lawn in the upper watershed.
- A dry detention basin will be upgraded into gravel wetland to provide much greater stormwater treatment with the Blanchette Brook drainage.
- Watershed-scale hydrology and water quality monitoring is providing a professional and economical assessment of stream response. Monitoring costs are approximately 60-80% less than those predicted for an individual permit (Pinard, 2010).

References:

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Appendix 2: Percent Impervious Cover Targets for Stream Restoration and Watershed Management (DEPLW July 2011)

INTRODUCTION

Impervious cover (IC) includes hard surfaces that block the infiltration of water into the ground, such as roofs, pavement, and cement. Many impervious surfaces are designed to rapidly shed water into nearby storm drains that often empty into nearby streams. Runoff from IC can cause larger floods and greater bank erosion than normal. Streams with large amounts of impervious cover in their watersheds often suffer from "urban stream syndrome" with degraded habitat and polluted, warm water. Species of fish, macroinvertebrates, and algae that require cold, clean water, intact riparian zones, and good quality habitat are unable to survive in these streams. As a result, many urban streams support poor quality aquatic life communities consisting primarily of tolerant species.

The purpose of this project was to determine impervious cover (IC) targets for watershed management plans designed to maintain and restore water quality in Maine streams, especially total maximum daily load (TMDL) restoration plans. TMDL restoration plans are necessary when streams do not attain water quality standards and criteria of their assigned class. Maine's Water Classification System has four classes for streams and rivers, including AA, A, B, and C, with different environmental goals and expectations. Every stream and river segment in the state is assigned to one of those four classes. Each class has a set of water quality standards and criteria, such as dissolved oxygen and aquatic life support. Classes AA and A have the highest environmental expectations and allow the fewest amount of permitted activities, such as dams and wastewater discharges. Class B has lower environmental expectations and allows more permitted activities. Class C has the lowest expectations but the streams must still support all indigenous fish species and maintain the structure and function of resident biological communities. Department of Environmental Protection (DEP) biologists monitor streams to determine if they attain water quality standards of their assigned class. If the streams do not attain water quality standards, then DEP staff develops plans to restore water quality.

METHODS

The Biological Monitoring Unit queried its database to identify macroinvertebrate sample locations with upstream watersheds less than 30,000 acres because smaller streams are more susceptible to negative impacts from impervious cover than large rivers. The Unit also removed samples primarily impacted by stressors not related to impervious surfaces, such as point source discharges, mine drainage, drought, atypical habitat, and impoundments. The search resulted in 148 sample locations located across the state representing the full range of impervious cover expected in Maine. Classes AA and A were grouped for this analysis because they share the same aquatic life expectations. The relationship between % IC and aquatic macroinvertebrate communities was evaluated using three methods: attainment of aquatic life criteria, changepoints associated with three community metrics, and community threshold response.

Attainment of aquatic life criteria

The first method was to evaluate % IC and attainment of aquatic life criteria by grouping samples by their attained class (i.e., AA/A, B, C), computing percentiles, and creating box-and-whisker plots. Of the 148 samples included in the study, 77 attained Class AA/A, 35 attained Class B, 13 attained Class C, and 23 failed to attain Class C and were categorized as non-attainment (NA). For Classes AA/A and B, we decided to define the preliminary % IC target ranges using the 75^{th}-90^{th} percentiles of streams that attain Classes AA/A and B, respectively. We decided to be more conservative and set a preliminary % IC target at the 75^{th} percentile because of the small number of samples that attained Class C.

Changepoints of macroinvertebrate community metrics

The second method was to examine the relationship between % IC and three macroinvertebrate community metrics of the same 148 samples as above. The three metrics included 1) the number of different mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) genera (aka, EPT richness), 2) the Hilsenhoff Biotic Index (HBI), which is an indicator of organic enrichment, and 3) the abundance of stoneflies in the Perlidae family (Davies and Tsomides 2002). Previous studies of impervious cover showed that EPT richness decreased and HBI increased in response to increasing impervious cover (e.g., Morse and Kahl 2003, Morse et al. 2003, Wang and Kanehl 2003). We included Perlidae abundance because this family of stoneflies were common in streams that attain Classes AA/A and B, and we expected that they would have a negative threshold response at a smaller percentage of impervious cover than the other two metrics. We evaluated the relationships of impervious cover and the three metrics by creating scatterplots with locally-weighted regression lines and computing non-parametric changepoints (Qian et al. 2003). The non-parametric changepoint method identifies an amount of impervious cover where there is the greatest difference in the metric means on either side of the changepoint (Figure 1). The statistical significance of the changepoints was analyzed using χ^2 tests (Qian et al. 2003). The ecological importance of the changepoints was evaluated by using different symbols in the scatterplots to represent Class attainment (i.e., AA/A, B, C) and examining patterns with respect to the changepoints.

Community threshold responses

The third method was to identify shifts in macroinvertebrate community structure using Threshold Indicator Taxa Analysis (TITAN) (Baker and King 2010, King and Baker 2010). The data included 348 kinds of macroinvertebrates in the 148 samples, most of which were identified to the genus or species level. The data did not include macroinvertebrate taxa that occurred in <5 samples. This method identifies a group of macroinvertebrates that have strong decreasing relationships with % IC (z- group) and another group of macroinvertebrates that have strong increasing relationships with % IC (z+ group). TITAN also identifies thresholds along the % IC gradient with great shifts in species composition. In other words, TITAN identifies z- thresholds where there are simultaneous losses of many macroinvertebrates and z+ thresholds where there are simultaneous appearances of more tolerant macroinvertebrates.

RESULTS

Attainment of aquatic life criteria

The preliminary % IC target ranges for Classes AA/A and B were 3.6 - 6.1% and 7.1 – 10.2%, respectively (Table 1, Figure 1). The preliminary % IC target for Class C was 17%. Of the 24 samples with % IC > 17, only 3 samples (12.5%) attained Class C aquatic life criteria and the remaining 21 samples (87.5%) were NA.

Changepoints of macroinvertebrate community metrics

The changepoints for EPT generic richness, HBI, and Perlidae abundance were 9.3, 9.3, and 3.2% IC, respectively (Table 1). The χ^2 tests were all statistically significant ($p<0.001$). We determined that the changepoints were ecologically significant because of the shape of the response curves (Figure 2) and separation of Class AA/A and Class B samples from Class C and NA samples (Table 2).

We used expert judgment to associate the metric changepoints to Class AA/A, B, or C because the metrics changepoints are not direct measures of a particular class and there was only one changepoint per metric. We determined that the changepoints for EPT richness and HBI (both 9.3%) were most appropriately associated with Class B because they fall within the preliminary % IC target ranges for Class B (7-10 %). The response curves (Figure 2) for EPT richness and HBI also show distinct separation of Class AA/A and B samples from Class C and NA samples. We determined that the changepoint for Perlidae abundance (3.2%) was most appropriately associated with Class AA/A because it is slightly lower than the preliminary % IC target range for Class AA/A (4-6%).

Community threshold responses

TITAN identified several peak losses of macroinvertebrate genera, shown as the blue line (z-) in Figure 3. The first peak occurred between 1 and 3.5% IC, which we interpreted as an initial loss of pollution-sensitive taxa. The second and third peaks occurred at 9-10% and 18-19% IC. We interpreted the three peaks to relate to Classes AA/A, B, and C respectively (Table 1). TITAN also identified several peak influxes of more tolerant macroinvertebrate genera, shown as the red line (z+) in Figure 3. The first peak was between 4-5%, which we associated with the transition from Class AA/A to Class B (Table 1). The initial peak was followed by a series of smaller peaks, representing a relatively constant influx of increasingly more tolerant genera. We associated the peak at 9% IC with Class B and the peaks at 14 and 18% IC with Class C (Table 1).

Table 1. Results of % IC analysis and targets for IC TMDLs and watershed planning.

Analysis	Class AA/A	Class B	Class C
1. Percentiles (75^{th}-90^{th}) of % IC values for samples grouped by attained class	3.6-6.1%	7.1-10.2%	17% [a]
2. EPT richness changepoint analysis	--	9.3% [b]	--
3. Hilsenhoff Biotic Index (HBI) changepoint analysis	--	9.3% [b]	--
4. Perlidae abundance changepoint analysis	3.2% [c]	--	--
5. TITAN z- thresholds [d]	1-3.5%	9-10%	18-19%
6. TITAN z+ thresholds [d]	4-5%	9%	14%, 18%
IC TMDL TARGETS	**≤5%**	**≤9%**	**≤16%**

[a] – We used only the 75^{th} percentile of % IC values for Class C because of the small number of samples.

[b] – Although the EPT richness and HBI changepoints are not directly tied to a class, we decided these changepoints were most appropriately associated with Class B.

[c] – Although the Perlidae abundance metric is not directly tied to a class, we decided it was most appropriately associated with Class AA/A.

[d] – We used expert judgment to associate peaks in Figure 3 to appropriate classes.

Figure 1. Box-and-whisker plot of % IC of samples grouped by macroinvertebrate bioassessment results. The non-attainment (NA*) group includes samples that do not attain aquatic life criteria for Classes AA/A, B, or C.

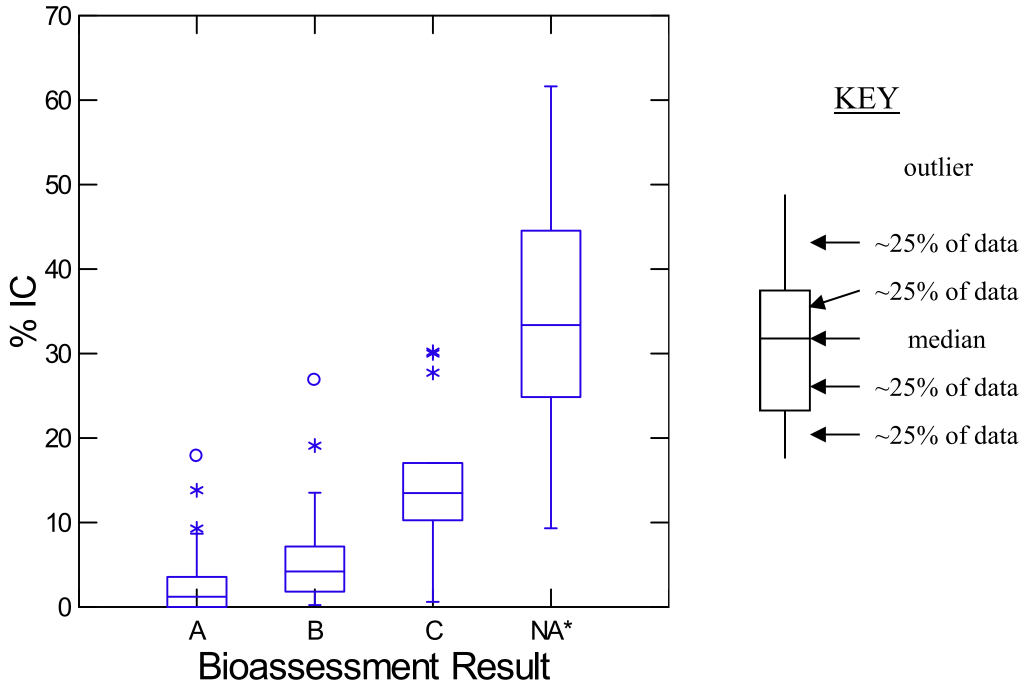

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Figure 2. Scatterplots of % IC with A) number of mayfly, stonefly, and caddisfly genera (EPT richness), B) Hilsenhoff Biotic Index (HBI) of organic enrichment, and C) abundance of stoneflies in the family Perlidae. Black lines are locally-weighted regression lines. Red lines are the changepoints.

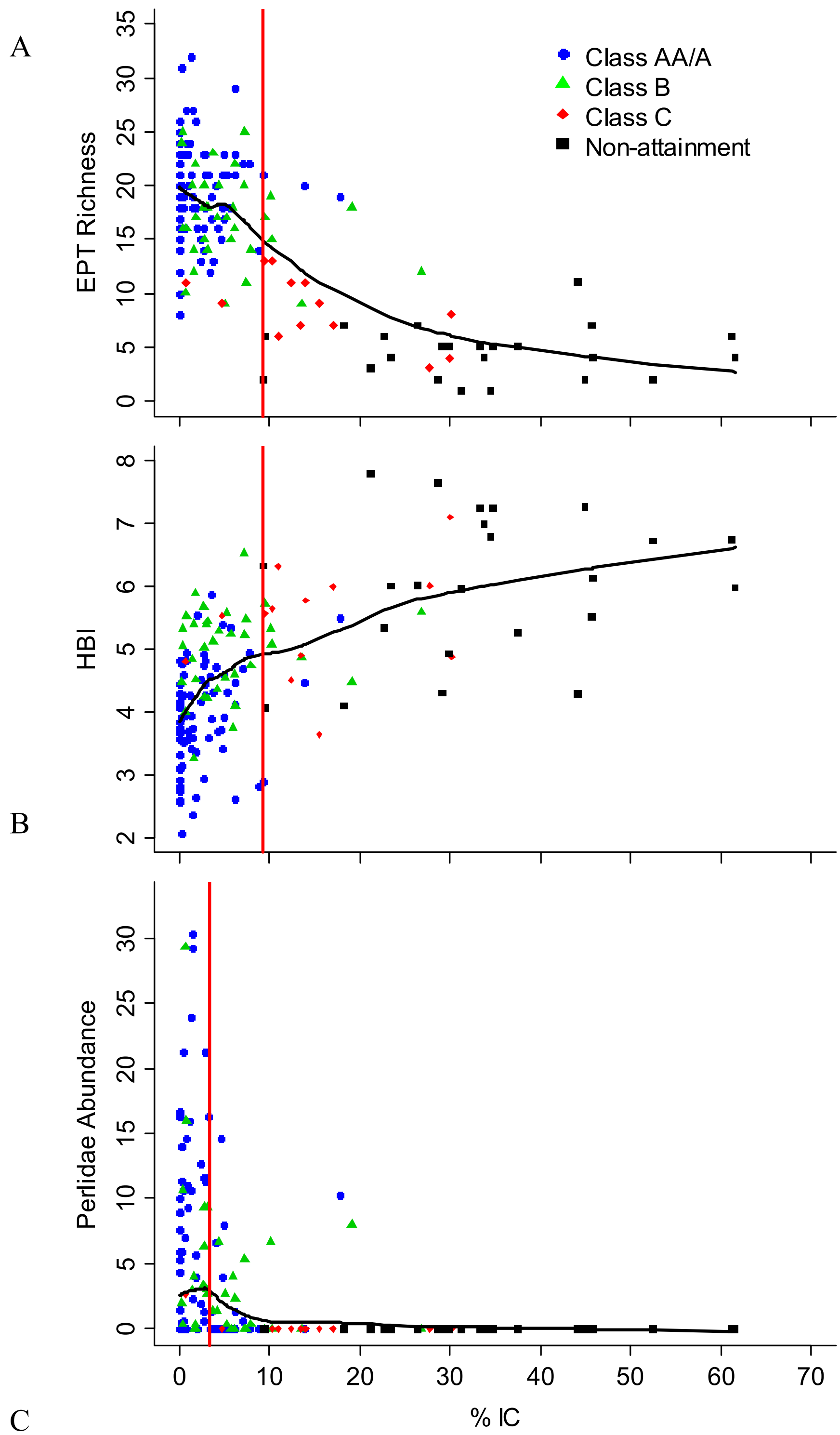
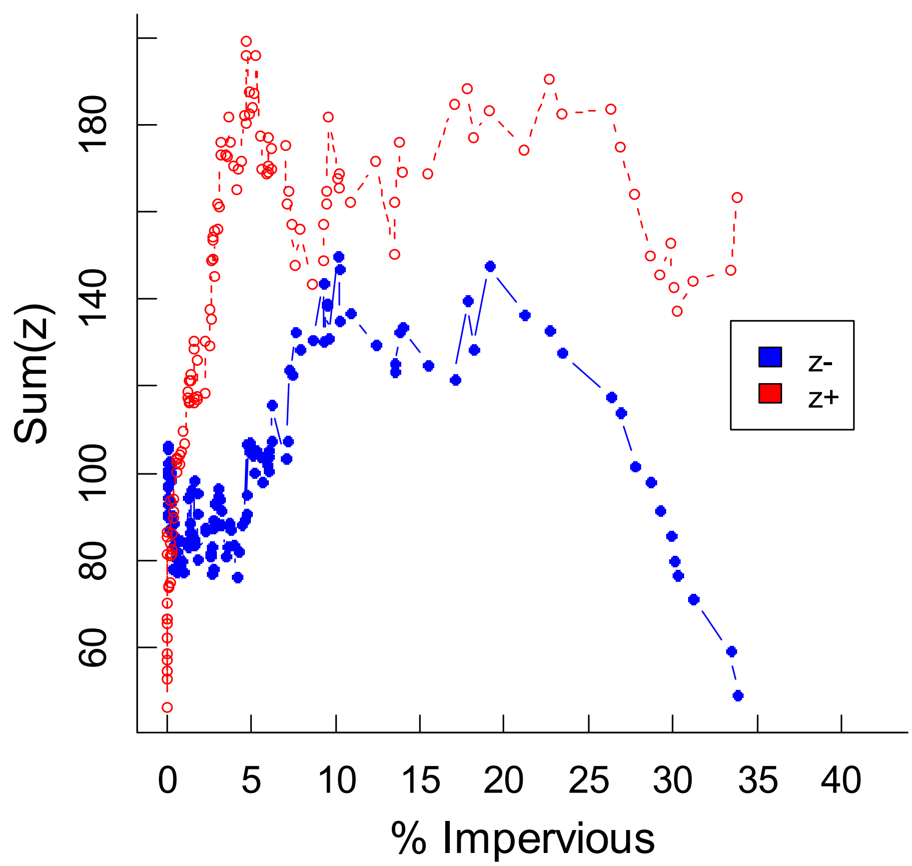


Table 2. % IC changepoints for EPT richness, HBI, and Perlidae abundance with metric means to the left and right of the changepoints.

Metric	% IC changepoint	Metric mean to the left of the changepoint	Metric mean to the right of the changepoint
EPT Richness	9.3%	18.9	7.7
HBI	9.3%	4.2	5.7
Perlidae Abundance	3.2%	6.9	1.1

Figure 3. TITAN graph showing the simultaneous loss of macroinvertebrate genera (z-, blue) and simultaneous influx of more tolerant genera (z+, red) in response to increasing % IC. Large sum(z) values represent greatest losses (z-) and influxes (z+) of macroinvertebrate genera.



MANAGEMENT RECOMMENDATIONS

Setting IC TMDL Targets

The IC TMDL targets were based on best professional judgment and a comparison of the results in Table 1. We used the percentiles of samples that attain Class AA/A, B, and C (Row 1 in Table 1) as the preliminary targets because they are numeric aquatic life criteria and the other results (Rows 2-6 in Table 1) are not directly associated with aquatic life criteria. We used the changepoint and TITAN results (Rows 2-6 in Table 1) to verify and revise the preliminary targets. In general, we recommend that IC TMDL targets for Classes AA/A, B, and C be ≤5%, ≤9%, and ≤16% IC, respectively (Table 1).

The targets assigned to individual streams may vary because of differences in watershed setting, stream gradient, substrate composition, width and quality of riparian zones, canopy cover, groundwater input, water temperature, and other factors. For example, a stream with the goal of Class B may require a lower target (i.e., 7% IC instead of 9% IC) if it has a degraded riparian zone, limited canopy cover, little groundwater input, and warmer water. Card Brook in Ellsworth, for example, has a current IC estimate of 9% but does not attain Class B or C biological criteria. The % IC goal for Card Brook will probably need to be less than 9% because IC is close to the stream and it has degraded riparian zones. It may be more susceptible to the influences of IC because Card Brook drains a wetland complex, the water is somewhat warm, and has low dissolved oxygen concentrations. In contrast, it may be appropriate to set goals for individual streams that are greater than the default targets (i.e., ≤5%, ≤9%, and ≤16%) if the streams have good riparian zones, canopy cover, and cold water. For example, it may be appropriate to set an IC goal for Sucker Brook in Hampden that is greater than the 9% default target for Class B because it attains Class C biological criteria despite having 31% IC in its watershed. If it attains Class C at a % IC almost double the default IC target for Class C (16%), then it may attain Class B at an IC level greater than the 9% target for Class B.

Determining Success

The measure of Watershed Management Plans and BMP success is attainment of water quality standards and criteria, not reaching a % IC target. If the initial IC target is met but a stream still does not attain criteria of the stream's assigned class, then the process of identifying and evaluating watershed stressors should be repeated and the IC target may need to be reduced. Conversely, there is no need to reach a stream's IC target (e.g., 9%) if a stream consistently attains water quality standards of its assigned class at a larger % IC (e.g., 12%).

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