FUSS & O'NEILL

Appendix A

Quality Assurance Project Plan

Pomperaug River Watershed Based Plan

Quality Assurance Project Plan
Field Assessments, Modeling, and Analysis

In support of:

Pomperaug River Watershed Based Plan
CTDEEP No. 13-04b

Pomperaug River Watershed Coalition
Woodbury, Connecticut

May 3, 2017

FUSS & O'NEILL
146 Hartford Road
Manchester, CT 06040

Project No. 20160005.A10

Title and Approval Sheet (A1)

Carol Haskins, PRWC, Project Manager — May 2, 2017 — Date

Steven Winnett, EPA Project Manager — 5/3/17 — Date

Bryan Hogan, EPA QA Manager — 5/3/2017 — Date

Charles Lee, CTDEEP, Project Manager — 5/2/17 — Date

Susan Peterson, CTDEEP, Project Manager — 5-2-17 — Date

Christopher Bellucci, CTDEEP, QA Manager — 5 - 3 - 17 — Date

Erik Mas, Fuss & O'Neill, Project Manager — May 2, 2017 — Date

William Guenther, Fuss & O'Neill, QA Manager — May 2, 2017 — Date

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Distribution List (A3) – Quality Assurance Project Plan – Pomperaug River Watershed Based Plan

The approved Quality Assurance Project Plan (QAPP), and any subsequent updates, will be distributed to the following individuals by electronic mail:

PRWC	**Carol Haskins** 39 Sherman Hill Road Suite C103 Woodbury, CT 06798 (203) 263-0076	**Project Manager**	chaskins@pomperaug.org
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CTDEEP	**Charles Lee** Supervising Environmental Analyst 79 Elm Street Hartford, CT 06106 (860) 424-3716	**Project Manager**	Charles.Lee@ct.gov
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CTDEEP	**Christopher Bellucci** Supervising Environmental Analyst 79 Elm Street Hartford, CT 06106 (860) 424-3735	**Quality Assurance Manager**	Christopher.Belucci@ct.gov
Fuss & O'Neill, Inc.	**Erik Mas, PE,** 146 Hartford Road Manchester, CT (800) 286-2469 x4433	**Project Manager**	emas@fando.com
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1 Section A – Project Management

1.1 Project Task Organization (A4)

The project that is the subject of this Quality Assurance Project Plan (QAPP) is being led by the Pomperaug River Watershed Coalition (PRWC). Fuss & O'Neill (F&O) is assisting with the development of a QAPP and the execution of the project. Key individuals and an organizational chart are presented in **Table 1** and **Figure 1**. All references to "Project Staff", "Project Managers", and "Project QA Managers" are associated with Fuss & O'Neil staff throughout the document.

Table 1. Project Team Responsibilities

Person/Entity	Project Title/Responsibility
Carol Haskins Pomperaug River Watershed Coalition	Project Manager – Overall manager leading the project for the Pomperaug River Watershed Coalition (PRWC), review/approval of final work products.
Steven Winnett US EPA – Region 1	EPA Project Manager– General project oversight.
Bryan Hogan US EPA – Region 1	EPA QA Manager – Reviews and approves QAPP and subsequent revisions.
Charles Lee CTDEEP	CTDEEP Project Manager – General oversight, final review/approval of all final work products.
Susan Peterson CTDEEP	CTDEEP Project Manager – General oversight, final review/approval of all final work products.
Christopher Bellucci CTDEEP	CTDEEP QA Manager – Reviews and approves QAPP and subsequent revisions.
Erik Mas Fuss & O'Neill	Project Manager/Principal-In-Charge – Project management, oversight of all visual assessments, modeling, and reporting activities. Maintains the official QAPP.
William Guenther Fuss & O'Neill	QA Manager – Quality assurance, data evaluation to ensure compliance with this QAPP.

Staff members within each organization will report to their project manager for technical and administrative direction. Each staff member is responsible for the performance of any assigned duties in the course of completing identified sub-tasks within the overall project. Quality control duties include:

- Completing assigned tasks on or before schedule.
- Completing assigned tasks in accordance with established procedures.
- Assuring that the work performed is technically correct and conforms to the applicable requirements of this QAPP.

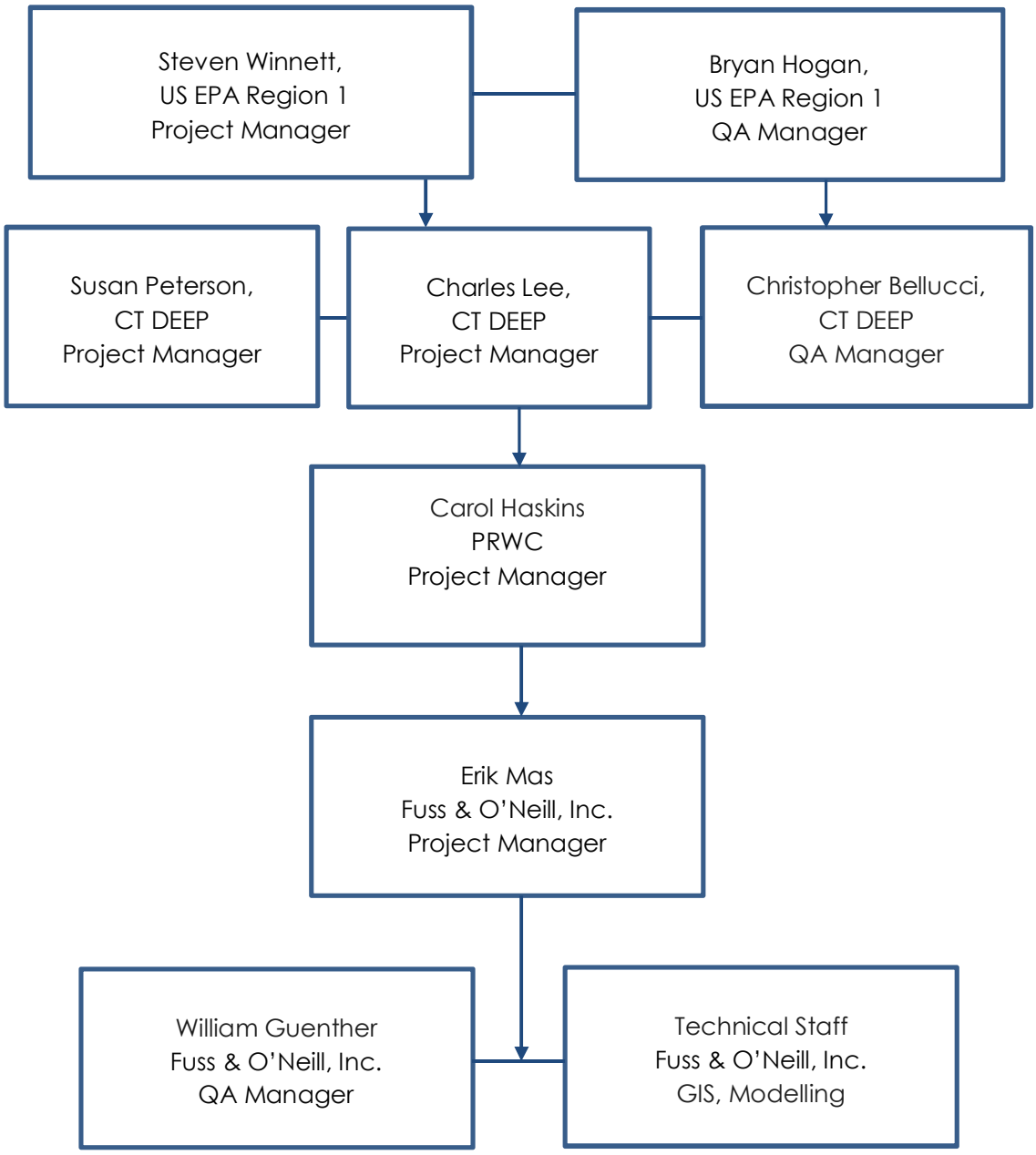

Figure 1. Project Organizational Chart

1.2 Problem Definition/Background (A5)

This QAPP provides a framework for assessing the quality of data obtained from visual assessment surveys and manipulation of existing data (i.e., secondary data/mapping and modeling) in support of the development of a watershed based plan for the Pomperaug River watershed consistent with the Connecticut Department of Energy and Environmental Protection (CTDEEP) and United States Environmental Protection Agency (EPA) criteria for a Nine-Element Watershed Based Plan. The plan will incorporate historical water quality data and statewide bacteria Total Maximum Daily Load (TMDL) information for the Pomperaug River and prioritize implementation projects to reduce pollutant loads. The ultimate goal of the watershed plan is to delist impaired segments of the Pomperaug River and its tributaries from the Impaired Water List. The watershed plan is funded in part by the CTDEEP and EPA through an EPA Clean Water Act Section 319 Nonpoint Source Grant.

The Pomperaug River Watershed is located in Western Connecticut in Litchfield and New Haven Counties. The 90-square mile regional basin includes parts of eight Connecticut towns in the lower central Housatonic Valley (**Figure 2**). Three segments of the Pomperaug River and two segments of other tributaries within the watershed (Weekeepeemee River and Transylvania Brook) are listed as impaired for recreation in the CTDEEP 2014 Integrated Water Quality Report. These impairments are the result of elevated bacteria levels. Specific sources of bacteria have not been identified, but are expected to include permitted discharges, illicit discharges, agriculture, failing septic systems, nuisance wildlife and pets, and stormwater runoff. Additional segments within the watershed have not been assessed, but may have similar water quality issues as the assessed segments, especially those with similar land uses.

Due to the documented bacterial impairments within the watershed, the CTDEEP has included the Pomperaug and Weekeepeemee Rivers in its statewide bacteria Total Maximum Daily Load (TMDL). The watershed has also been impacted by physical alterations to streamflow and alteration of the river floodplain. Potential future flow alterations, including permitted water withdrawals, may potentially impact habitat and interrupt other uses of the river.

In 2006, the PRWC prepared a Watershed Management Plan. Fuss & O'Neill will use the 2006 plan along with studies and models previously developed in the watershed to develop a new watershed plan that conforms to the EPA 9-element requirements. The effort will include collection and review of existing studies to characterize non-point source pollution in the watershed and identify load reduction goals. The plan will also identify potential sites for water quality Best Management Practices (BMPs) and develop implementation strategies for up to 15 priority projects.

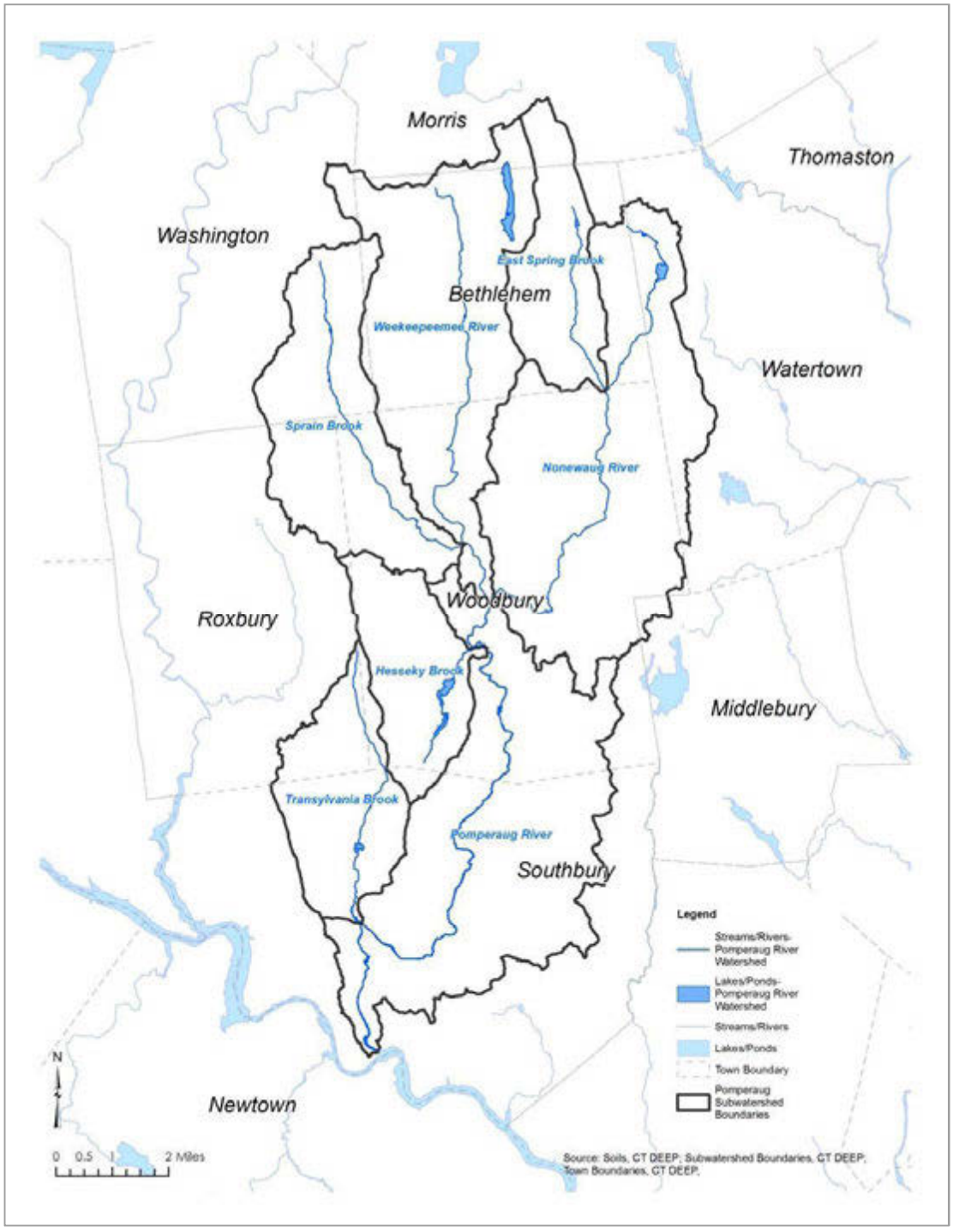

Figure 2. Pomperaug River Watershed

To effectively use the limited project funds available for the updated Pomperaug River Watershed Plan, Fuss & O'Neill will be focusing the watershed assessment and identification of BMPs on the impaired segments of the Pomperaug River and its tributaries, as well as the primary pollutant of concern for the watershed- indicator bacteria. The objective of the watershed plan update is to identify specific sources of bacteria within the subwatershed areas of the impaired stream segments of the Pomperaug River, Transylvania Brook, and Weekeepeemee River and develop management actions to address these sources. Recommended actions will include both structural and non-structural BMPs. In addition, the plan will emphasize the use of green stormwater infrastructure which has significant potential to address water quality and related issues in the Pomperaug River Watershed. Fuss & O'Neill will prioritize recommended actions to develop cost-effective implementation strategies, get early buy-in from watershed municipalities, identify short- and long-term funding sources for plan implementation, and produce a high quality finished product that is understandable to the general public. The data collection efforts described in this QAPP is needed to support this study and incorporate direct data collection (visual assessments) and secondary data collection, including modeling.

1.3 Project/Task Description (A6)

This QAPP addresses field assessments (collection of direct measurements), manipulation of existing data (secondary data), and pollutant load modeling to identify causes of water quality impairments and assist in targeting best management practices in the Pomperaug River watershed. A schedule for these tasks is provided in **Table 2**. Data collection efforts would begin following approval of the QAPP. Note that this schedule may be adjusted as the project progresses.

Table 2. Project Implementation Schedule

Task	Responsible Party	Estimated Start Date	Deliverables	Est. Completion Date
Field Assessments (See Section 1.3.3)	Fuss & O'Neill	June 2017	Field assessment forms and supporting maps/graphics – included in draft plan	July 2017
Manipulation of Secondary Data (See Section 1.3.2)	Fuss & O'Neill	May 2017	Prioritized locations for field assessments - included in draft plan	June 2017
Pollutant Load Modeling (See Section 1.3.3)	Fuss & O'Neill	May 2017	Pollutant loading by subwatershed - included in draft plan	June 2017

1.3.1 Field Assessments

Screening-level field investigations of the Pomperaug River watershed will be conducted by a two-person team using the Center for Watershed Protection (CWP) Unified Stream Assessment (USA) Unified Subwatershed and Site Reconnaissance (USSR) methods (Kitchell & Schueler, 2005; Wright et al., 2005). Areas to be assessed include stream corridors and upland areas that are known or suspected of contributing to the water quality impairments in the watershed. Areas to be assessed will be selected by the project team based on review of existing data and information on watershed land use, water quality impairments, and pollutant sources including the findings of previous volunteer streamwalk assessments in the watershed. The following CWP field assessment forms/procedures will be used (see the field data forms provided in **Appendix A** of this QAPP):

- Reach Level Assessment (stream corridor).
- Neighborhood Source Assessment (residential areas).
- Hotspot Site Investigation (commercial, industrial, agricultural, institutional land use).
- Pervious Area Assessment (schools, parks, vacant land).
- Streets and Storm Drains (drainage systems).

Locations of potential pollutant sources will be recorded with a Trimble GeoXT Sub-meter GPS receiver ("GPS").

The field assessments will help identify pollutant sources, riparian impairments, and potential corrective actions, such as restoration, pollution prevention, and retrofit opportunities in the stream corridor and upland portions of the watershed to reduce watershed bacteria and pollutant loads to the impaired segments of the Pomperaug River, Transylvania Brook, and Weekeepeemee River.

1.3.2 Secondary Data Manipulation

Existing data and previous studies (i.e., secondary data) will be used as follows in support of this project:

- Baseline watershed conditions as described in the 2001 State of the Watershed Report and the 2006 Pomperaug River Watershed Management Plan will be updated to reflect current water and land use conditions.
- Areas to be investigated through the use of visual field assessments (see Section 1.3.1) will be selected by the project team based upon review of existing data and previous studies on watershed land use, water quality impairments, and pollutant sources, including identified data gaps.
- Inputs to the pollutant loading model described in Section 1.3.3 will be derived from available land use and land cover data and other watershed-specific information.

- The extent of impacted buffers along the impaired stream segments in the watershed will be conducted using existing GIS data from the UConn CLEAR program and land owner information available from the Naugatuck valley Council of Governments (NVCOG).

The secondary data and existing studies that will be used for this project include, but are not necessarily limited to:

- Existing data on water quality in the waterbodies, their tributary streams, and watersheds collected by other agencies including, but not limited to, PRWC, CTDEEP, University sponsored research studies and reports, Non-profit organization reports (Soil & Water Conservation District (SWCD), and Environmental Review Team (ERT), 2010 Streamwalk Assessment- Pomperaug River Watershed Volunteer Streamwalk Program, Monitoring data collected by the USGS, and other studies supported or commissioned by the PRWC, including instream habitat assessment completed by the University of Massachusetts.
- Land use and Land cover data (either parcel-based land use available from the Naugatuck Valley Council of Governments (NVCOG) or University of Connecticut Center for Land Use Education and Research (CLEAR) satellite-derived land cover data).
- Water Quality Monitoring Data – Data for the watershed and impaired segments collected by other agencies, institutions, and companies such as the CTDEEP and the U.S. Geological Survey. Data sources include published reports and databases. The data may be used in its entirety or limited to a specific time period. All data will be assessed for adequate quality prior to being used.
- Pollutant Loading and BMP Effectiveness – Data taken from peer-reviewed literature values will be used to support the modeling of watershed loads, load reductions from BMPs, and BMP cost-effectiveness.
- Watershed Mapping Data – CTDEEP's Environmental GIS Data Set, UConn MAGIC, and UConn CLEAR will serve as the primary sources of data for watershed mapping. The GIS data will be augmented by GIS mapping available from the watershed municipalities and the Naugatuck Valley Council of Governments (NV COG), as necessary.
- Data on the physical characteristics of impaired stream segments from CTDEEP, U.S. Geological Survey, and PRWC.

All data sources will be identified and fully referenced and all metadata, if applicable, will be included in the final report for the project.

1.3.3 Pollutant Load Modeling

A surface runoff pollutant loading model will be developed for the Pomperaug River watershed to help target the sources of impairments in the watershed, guide the selection of bacteria load reduction measures, and quantify the anticipated load reductions associated with the plan recommendations for structural and non-structural controls in the watershed. The model will be used to assist in identifying, prioritizing, and evaluating watershed pollution control strategies. The pollutant loading evaluation will

simulate average annual surface runoff pollutants loads within the watershed by using existing and future loads calculated using the Watershed Treatment Model (WTM), Version 3.1 (or most recent available) developed by the Center for Watershed Protection. Existing pollutant loads will be calculated from available land use and land cover data and other watershed-specific information. Although bacteria is the focus of this study, the WTM also calculates pollutant loads for total phosphorus, total nitrogen, and sediment. Other pollutants can be included as custom additions to the WTM.

WTM calculates watershed pollutant loads primarily based on nonpoint source (NPS) runoff from various land uses. The model can also be used to estimate pollutant loads from other sources, including:

- Illicit Discharges.
- Septic Systems.
- Sanitary Sewer Overflows.
- Managed Turf.

Reductions in future pollutant loads in the watershed can be estimated using a range of treatment measures, such as structural and nonstructural best management practices, that are included in the WTM.

Other similar screening-level pollutant loading models were considered for use in this project, including the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), the Generalized Watershed Loading Function (GWLF) model, and other similar models. It was determined that the WTM is better suited for use with this project because it provides a larger suite of watershed best management practices. The ArcView GIS version of the GWLF model was also considered for use in the project, but the WTM model was determined to allow for more transparency and simplicity of use for this watershed.

The WTM uses the Simple Method to calculate nutrient, sediment, and bacteria loads from various land uses. The user specifies several model parameters for each land use in the watershed to estimate runoff quantity and pollutant levels. These parameters include Event Mean Concentrations (EMCs), which are literature values for the mean concentration of a pollutant in stormwater runoff for each land use, and an average impervious cover percentage for each land use. The Watershed Treatment Model manual is included in **Appendix C** of this QAPP.

A literature review will be conducted to determine EMC values and impervious percentage values for use in the evaluation. The default impervious cover coefficients in the WTM will be adapted as necessary to better reflect local conditions in the watersheds. All modeling methods will be documented as required in *Section 1.7.2*. Summaries of the specific model input parameters and identified sources of information for those parameters are included in **Appendix D**.

1.4 Quality Objectives and Acceptance Criteria (A7)

1.4.1 Direct Data Measurements

Data Quality Objectives (DQOs) for field assessments of watershed conditions rely on quasi-subjective assessments by field personnel. Accuracy, precision, completeness, representativeness, and comparability of visual assessments of watershed conditions will be assessed through the collaborative consensus of the staff performing those assessments consistent with the methodologies described in the Center for Watershed Protection Urban Subwatershed Restoration Manual Series (2005-2008). The Unified Stream Assessment (USA) and Unified Subwatershed and Site Reconnaissance (USSR) user's manuals and field data sheets are available for download at http://owl.cwp.org/. Field data sheets for visual assessments that are proposed as part of this project are provided in **Appendix A** of this QAPP.

1.4.2 Non-Direct Data (Secondary and Modeling) (A7; B9)

Assessing whether the DQOs have been achieved for secondary data collection and modeling is somewhat different than direct data collection. For indirect/secondary data, important features include documentation that the data meets the needs of the project and that data quality is high and data limitations are known. The usual data quality indicators (e.g., completeness, representativeness, comparability) can be met if metadata is available or data was collected under a QAPP or Standard Operating Procedure (SOP). For modeling, the data quality indicators are often difficult to apply and in many cases do not adequately characterize model output. The ultimate quality test for the model is whether the output sufficiently represents the natural system that is being simulated.

1.4.2.1 Secondary and Modeling Data Acceptance Criteria

The following criteria will be considered for acceptance of secondary data used in the project:

- Data generated by a reliable source, from a data generator that is generally trusted and respected, including federal, state, and local agencies, or research institutions, and data published in peer-reviewed articles or publications.
- All model input and parameterization (calibration) and corroboration (validation and simulation) data for the model will be of a known and documented quality.
- Data for modeling will be collected from as many sources as available, and provide the maximum temporal and spatial coverage of the watershed, if necessary and applicable.
- The data will be comparable with respect to previous studies.
- Modeling data will be representative of the parameters being measured with respect to time, location, and the conditions from which the data are obtained.

- Data have been collected for purposes similar to this project (i.e., to estimate BMP performance, etc.).
- Data was collected using a QAPP or similar plan.
- Data has been widely used and/or trusted by scientists and professionals in the subject area.

The following decision tree (**Figure 3**) will be used to assess the quality of secondary data. In general, the completeness of the data set will be assessed first, either by inspecting the metadata or the dataset itself.

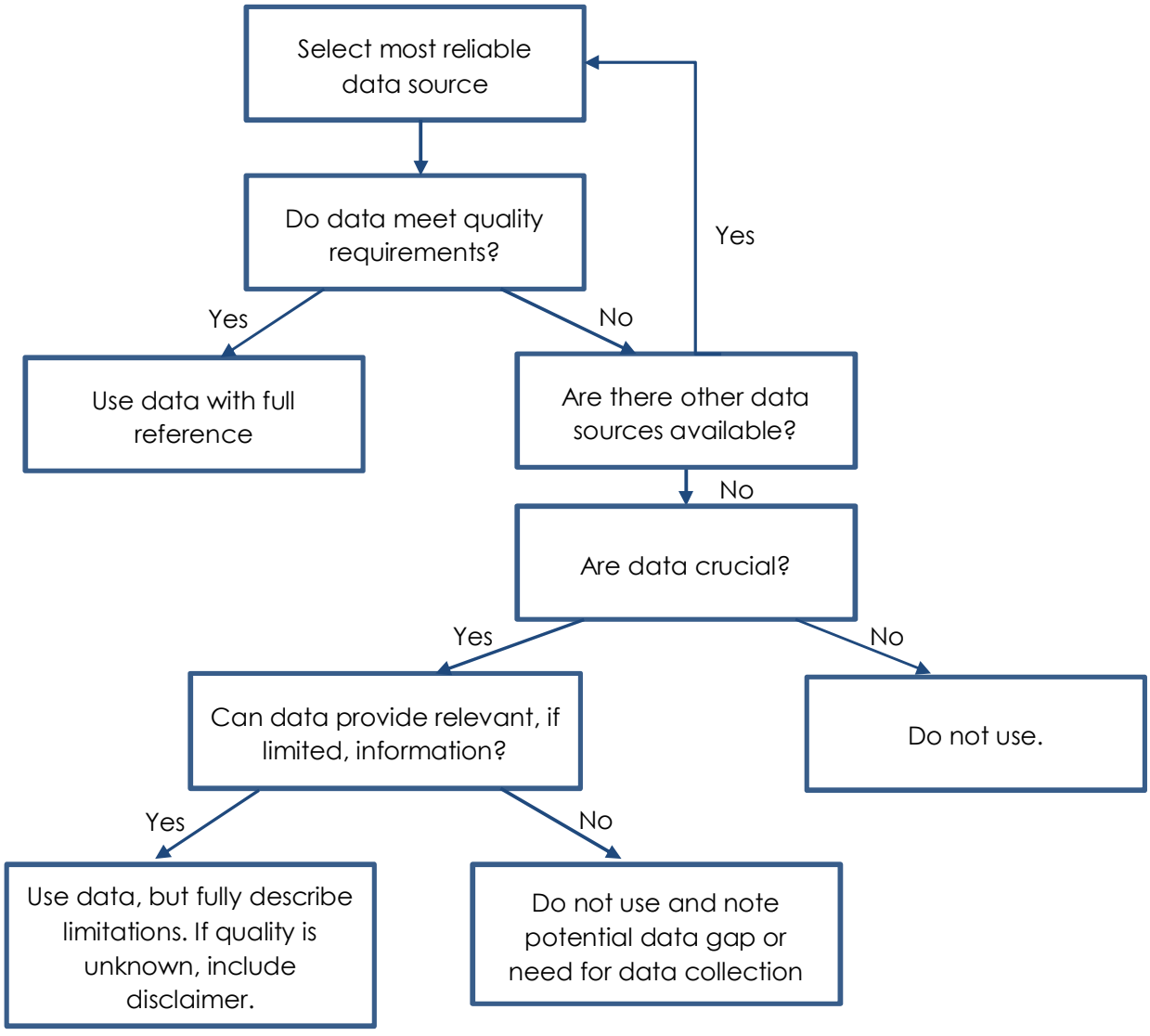

Figure 3. Data Decision Tree

If completeness is adequate, then other requirements will be assessed based on information available from the data providers or accompanying the dataset.

All project deliverables will reference the existence of this QAPP and limitations on known data quality will be fully disclosed as a disclaimer in the project deliverable.

1.4.2.2 Secondary and Modeling Data Reduction

Data alteration and reduction will be avoided to the maximum extent practicable. The types of data reduction/alteration anticipated for this project include the following:

- Data units may need to be changed for report consistency, to allow comparisons, or for use in model input.
- Certain data sets may be reduced and represented as percentages (i.e., percent of a land use type).
- Some data reduction may be used to display data in map form (i.e., average values at a site).
- Some data may be reduced for comparison with a water quality benchmark.

1.4.2.3 Secondary and Modeling Data Validation

The following measures will be taken to ensure the quality of secondary and modeling data:

- A copy of every secondary data set will be saved as a read-only, protected file to be used in the event that the integrity of the working dataset is compromised.
- Working data will be stored in a spreadsheet or ArcGIS format and will include relevant raw data, which will be locked for editing.
- Data manipulation will be minimized, but when necessary, data manipulation will start with raw data, and all formulas including units, conversion factors, and formulas will be shown in the spreadsheet.
- Prior to including in project deliverables, raw and reduced data will be displayed in graphic format and inspected to look for anomalous values. Any decision to eliminate anomalous values will be documented in the spreadsheets and will be noted in the project deliverables.

1.4.3 Modeling Data Quality Objectives

The use of existing data of known quality in modeling efforts is extremely important and helps ensure that the modeling yields accurate predictions with an acceptable level of model uncertainty. This modeling effort uses no water quality data for calibration or validation. Because of the type of data used

for watershed pollutant loading and BMP efficiency modeling, the data to be used will consist of data previously collected by state and federal agencies. Data that has been collected in accordance with a QAPP or appropriate SOPs is generally appropriate for this study. Any data that does not have a QAPP or SOP, or data of unknown quality (i.e., collected without a documented QAPP or using SOPs not approved by state or federal agencies) will be flagged and noted as either conditionally acceptable for limited use or not acceptable for use at all.

The Data Quality Objectives (DQOs) can be further refined in order to define performance criteria that limit the probability of making decision-based errors. They address the data validity and reliability of the modeling effort and each is briefly described below in the context of completeness, representativeness, and comparability. The traditional context of precision and accuracy is not included due to the fact that, in most cases, the data has already been collected and analyzed through acceptable analytical procedures by state and federal agencies.

Completeness is a measure of the amount of valid input data obtained during a process. The target completeness for models will be 100 percent – e.g. all available sources included. Note that in this case, the available data is relatively limited, i.e., available from a single source. The actual completeness may vary depending on the intrinsic availability of monitoring data. Deficiencies in meteorological or stream flow data are outside of the control of the modeling effort and will be addressed as part of the data compilation and assessment effort. This modeling project proposes to use only data sources provided by federal, state and municipal agencies. Data that is intentionally excluded from use or analysis will be noted in the modeling journal and report.

Representativeness is a measure of how closely the input or parameterization (calibration) data will reflect the physical characteristics of the watershed over time. Standardized monitoring plan design and the use of Standard Operating Procedures (SOPs) for soils identification, land cover mapping, and acquisition of weather data are crucial to ensuring representative data quality. All applicable model input or parameterization data sources will have a QAPP in place or be of documented quality prior to use in the modeling effort. Data of unknown quality (i.e., collected without a QAPP or using SOPs not approved by state or federal agencies) will be flagged and noted as either conditionally acceptable for limited use or not acceptable for use at all.

Comparability expresses the confidence with which one data set can be compared to another. Data comparability from external sources is very much tied to the individual project methodology and time at which it was collected. For the purpose of the modeling effort, comparability will be maintained by using consistent units, appropriate temporal scales, and reproducible methods. Unit conversions, datum transformations, and grid re-projections may be required to make data for the modeling comparable. Any required data transformations will be noted in the modeling journal and report. Information that exists outside a reasonable temporal scale, has been significantly changed, or will potentially diminish the modeling results are not comparable. Fuss & O'Neill will make these determinations using best professional judgment, as necessary. Comparability between other model indicators will be evaluated on

a case-by-case basis. In most cases, data of a particular type will be obtained from a single source, reducing issues of comparability.

Acceptance Criteria for Model Parameterization (calibration)

Some models are "calibrated" to a set of specific parameters. Calibration is defined as the process of adjusting model parameters within defensible ranges until the resulting predictions give the best possible fit to the observed data. The acceptance criteria for model parameterization (calibration) define the procedures whereby the difference between the predicted and observed values of the model are within an acceptable range, or are optimized. This can occur either qualitatively or quantitatively and documented accordingly (USEPA 2009). Often parameterization is the only method to ensure that model predictions correlate with values observed in the field or within ranges documented in scientific studies. Parameterization uses observed data in a systematic search for parameters that yield an acceptable fit of computed results. This search is performed to find a reasonable best estimate that will yield the minimum value of an objective function, or variable that is critical in an application. In this modeling project, that variable is pollutant loading.

Parameterization has become increasingly important with the need for valid and defensible models. Each time a model is calibrated, it is potentially altered. Therefore, all calibrations will be documented in the modeling journal, including the approaches taken (e.g. qualitative versus quantitative) along with the acceptance criteria. Because of the nature of the modeling to be performed as part of this project, calibration will consist of use of engineering professional judgment in the comparison of modeled values with typical pollutant loading models for similar land use in southern New England. As such, no formal acceptance criteria are proposed for the modeling elements of the study.

All adjustments made to model parameters will be properly documented in the project modeling journal and modeling report, describing how the calibration was conducted and tested for acceptance.

Model Corroboration (Validation)

Corroboration (validation) is defined as the comparison of modeled results with independently derived numerical observations from the simulated environment. In this project, that would be a comparison of modeled pollutant loads and load reductions with observed loads and load reductions. Model corroboration is an extension of the parameterization (calibration) process. Its purpose is to assure that the calibrated model properly assesses the range of variables and conditions that are expected within the simulation.

Because of the nature of the modeling to be performed as part of this project, validation will consist of use of engineering professional judgment in the comparison of modeled values with typical pollutant loading for similar land use in southern New England. As such, no formal acceptance criteria are proposed for the modeling elements of the study.

Model Sensitivity

Sensitivity analysis determines the effect of a change in a model input parameter or variable on the model outcome. The sensitivity of a model parameter is typically expressed as a normalized sensitivity coefficient (Brown and Barnwell, 1987). One methodology for identifying the sensitivity of a model parameter is shown below.

$$\text{Normalized Sensitivity Coefficient (NSC)} = \frac{\Delta Y_o / Y_o}{\Delta X_I / X_I}$$

Where:

ΔY_o = Change in the output variable Y_o
ΔX_i = Change in the input variable X_i

Fuss & O'Neill will qualitatively assess the sensitivity of model parameters during manual parameterization (calibration) through parameter perturbation and will document the results in the modeling journal. A summary of model sensitivity will be included in the final modeling report. Details will include the variables modified for model parameterization (calibration), the percent modification (e.g. ± 10%), percent change in the modeling results, and the normalized sensitivity coefficient (NSC).

Model Uncertainty

Uncertainty is broadly defined as the lack of knowledge regarding model input parameters and the processes the model attempts to describe. Ability to define model uncertainty is marginalized by the limited ability to accurately describe complex processes. As a result, all engineering computations are subject to a degree of uncertainty due to the simplification of natural process and the limitations of input and parameterization (calibration) data. Computed values differ from observed ones, and the magnitude and frequency of these differences characterize the uncertainty of the best model estimate. Uncertainty analysis is the terminology associated with the examination of how the lack of knowledge in model parameters, variables, and processes propagates through the model structure as model output or forecast error. Sources of model uncertainty will be characterized by Fuss & O'Neill during the initial stages of planning in order to better understand how the model input data and parameters would potentially influence model output and prediction. Potential sources of model uncertainty include:

- Estimated model parameter values.
- Observed model input data.
- Model structure and forcing functions.
- Numerical solution algorithms.

Fuss & O'Neill will be responsible for documenting any areas of potentially significant uncertainty in the modeling journal and report.

1.5 Special Training/Certification (A8)

1.5.1 Project Staff

All staff referenced in this section is assumed to be project staff at Fuss & O'Neill. Staff from Fuss & O'Neill is responsible for all data collection and handling, and modeling tasks. Staff responsible for data collection from Fuss & O'Neill will be assigned duties based on their qualifications and ability to accomplish the task. All project staff is required to be familiar with this QAPP and relevant Standard Operating Procedures (SOPs) or methods associated with any assigned tasks. The Fuss & O'Neill Project Manager will be responsible for assigning staff to individual tasks and for either training staff or ensuring that staff has adequate prior training for the completion of all assigned tasks. The Project Manager will maintain a training and qualifications log listing the staff person, assigned duties, and dates and type of training or prior qualifications.

1.5.2 Field Staff

SOPs for field efforts will be distributed to Fuss & O'Neill project staff and will be available at all times throughout the project.

Staff performing visual assessments of the watershed will be trained in the use of methodologies described in the Center for Watershed Protection Urban Subwatershed Restoration Manual Series (2005-2008), and will be familiar with the field data forms in **Appendix A** and the assessment methodologies used to complete those forms in the field.

The Fuss & O'Neill Project Manager will be responsible assigning staff to individual tasks and for ensuring that staff has adequate prior training, as described above, for the completion of all assigned tasks. The Project Manager will maintain a training and qualifications log listing the staff person, assigned duties, and dates and type of training for the activities specific to this project.

1.6 Documents and Records (A9)

The approved QAPP, and any subsequent revisions, will be distributed to all individuals identified on the distribution list. Project-related documents and records will be accessible to the project members who need to obtain information or record and disseminate data. During data collection, deviations from the approved QAPP will be recorded and all recorded deviations will be compiled for final QA summary report. **Table 3** summarizes project documentation and records management procedures.

Table 3. Documentation and Records

Document/Record	Format	Location	Person Creating /Authorized to Update	Distribution List
Quality Assurance Project Plan (QAPP)	Hard-copy and digital copy	Fuss & O'Neill Project Manager	Fuss & O'Neill Project Manager/QA Manager (subject to CTDEEP and EPA review/approval)	All persons listed on master distribution list, All QA Managers
Standard Operating Procedures (SOPs)	Electronic	Fuss & O'Neill Project Manager	Fuss & O'Neill QA Manager	All field and data collection staff
Training Log	Electronic	Fuss & O'Neill Project Manager	Fuss & O'Neill Project Manager	Fuss & O'Neill QA Manager,
Field Notebooks and Digital Photography	Electronic or Hard-copy	Fuss & O'Neill Project Manager	Visual Assessment Team	Fuss & O'Neill QA Manager
Modeling Notebook	Electronic or Hard-copy	Fuss & O'Neill Project Manager	Project Staff assigned to Modeling	Fuss & O'Neill QA Manager
QA Summary Report	Electronic or Hard-copy	Fuss & O'Neill Project Manager	Fuss & O'Neill Project Manager	All persons listed on master distribution list

Electronic data and copies of hardcopy documents will be maintained as follows:

- Electronic files will be backed-up daily.
- Hard Copy Documents will be retained for a minimum of 5 years.

1.6.1 Field Assessment Documentation

Fuss & O'Neill field staff will complete watershed field assessment forms (**Appendix A**) and will maintain field notebooks recording other information obtained and field conditions. Crews may take digital photographs to document field conditions. Locations of potential pollutant sources will be recorded with a Trimble GeoXT Sub-meter GPS receiver ("GPS"). The field record will be held by the person recording the information, providing copies to the Project Manager.

1.6.2 Modeling Documentation

Documentation of the modeling process will be recorded in a modeling journal. The modeling journal will be kept by the Fuss & O'Neill Project Manager and technical staff responsible for running the

model to identify the internal model parameters that were adjusted during the process. The journal documents all parameterization iterations made during the project along with the justification and professional reasoning behind the changes. For example, each time that a separate model parameterization run is completed, changes will be documented in the modeling journal. The level of detail in the modeling journal will be sufficient to allow another modeler to duplicate the parameterization method given the same data and model. The modeling journal will include complete recordkeeping of each step of the modeling process. The documentation will consist of information addressing the following items:

- Model assessments and selection with references.
- Model assumptions.
- Parameter values and sources.
- Input file notations.
- Output file notations and model runs.
- Parameterization (calibration) and corroboration (validation) procedures and results from the model.
- Intermediate results from iterative parameterization (calibration) runs.
- Changes and verification of changes made in code, if any.
- Summary of model sensitivity, as applicable.

The modeling journal, all data files, source codes, and executable versions of the computer software used in modeling studies will be retained for 5 years by the Pomperaug River Watershed Coalition and Fuss & O'Neill for auditing or post-project reuse. In addition, the modeling journal will be scanned and a PDF copy of the journal stored with other electronic files used in the project. These files will include:

- Version and source of the executable code used.
- Parameterization (calibration) input and output data.
- Corroboration (validation) input and output data.
- Model application input and output (i.e., for each scenario studied).
- Original source data used for model input and output development.

Fuss & O'Neill will conduct daily backup of all files stored electronically. At the conclusion of the project, electronic copies of all files will be written to CD and provided to the Pomperaug River Watershed Coalition for additional storage.

1.6.3 QAPP Modification

This section addresses procedures to be followed when modifications are needed to this QAPP. Examples of such modifications include changes in procedures, assessment and reporting.

Discussions involving changes to the QAPP may be initiated at any level. The scope of effect of the proposed change will determine the formality of the approval process. A formal QAPP revision will

include reference to the section(s) of text being modified or added to, the reason why the revision is necessary and the actual replacement/additional language. It will be the responsibility of the Fuss & O'Neill QA Manager to seek review and approval of the revision of all signatories of the original QAPP. Individuals listed in the Distribution List will receive notification of revisions once updates have been approved by QAPP signatories. Notification may be by electronic mail.

1.6.4 QAPP Distribution

This QAPP will be implemented by Fuss & O'Neill, on behalf of the Pomperaug River Watershed Coalition, once the CTDEEP and US EPA have given approval. This QAPP is to be considered a "working document." The QAPP will be periodically revised as technology, policy and protocol change. All QAPP revisions will be distributed by the Fuss & O'Neill Project Manager according to the Distribution List.

Upon approval and implementation, the original QAPP shall be kept at Fuss & O'Neill's office in Manchester, Connecticut and the signed original QAPP should be distributed by email to all partners on the signature page and distribution list. All personnel responsible for implementation will be required to review the QAPP within 7 days of approval. As new field or modeling staff or managers are hired by Fuss & O'Neill, they will be required to review this QAPP within 14 days of their hiring date.

2 Section B – Data Generation and Acquisition

2.1 Field Assessments (B1)

Visual field assessments will be conducted by Fuss & O'Neil staff following Center for Watershed Protection watershed assessment, as described in Section 1.4 of this QAPP. Fuss & O'Neill staff performing visual assessments of the watershed will be trained in the use of methodologies described in the Center for Watershed Protection Urban Subwatershed Restoration Manual Series (2005-2008), and will be familiar with the field data forms in **Appendix A** and the assessment methodologies used to complete those forms in the field.

Locations of potential pollutant sources will be determined with a Trimble GeoXT Sub-meter GPS receiver ("GPS") and documented on appropriate field forms (**Appendix A**). Digital photographs may also be taken in the field to support the documentation process. Fuss & O'Neill field staff performing the assessments will also be familiar with the Field Activity Documentation and Site Etiquette provided in the Standard Operating Procedures (SOPs) in **Appendix B**.

Any problems encountered during the visual assessments will be reported to the Project Manager and noted in the field log book. Corrective actions will be discussed between the Project Manager, QA Manager, and field staff and documented.

As conditions in the field vary, it may become necessary to implement minor modifications to the visual assessment procedures and protocols described in the QAPP. If sites are inaccessible the day of visual assessments (due to inclement weather or other conditions) the field crew will return when access is easier. Other variations in the field may arise that deviate from the QAPP. If this becomes necessary, the field crews will notify the Project Manager or the QA Officer of the situation and obtain verbal approval prior to implementing any changes. The approval will be recorded on the field log book.

2.2 Sampling Methods (B2)

Not applicable. No environmental sampling will be conducted.

2.3 Sample Handling & Custody (B3)

Not applicable. No environmental sampling will be conducted.

2.4 Analytical Methods (B4)

Not applicable. No environmental sampling will be conducted.

2.5 Quality Control (B5)

Field assessments will consist of quasi-subjective evaluations by Fuss & O'Neill field personnel. Quality control of these field assessments will be performed in accordance with the method discussed in Section 1.4 (DQOs) of this QAPP.

2.5.1 Visual Assessment Control Requirements and Acceptability Criteria

The Fuss & O'Neill Project Manager and QA Manager will conduct an internal review of the field forms for compliance with quality assurance requirements. This will consist of verifying that field data forms have been filled out consistently and completely and that field personnel have followed the methodologies described in the Center for Watershed Protection Urban Subwatershed Restoration Manual Series (2005-2008). The visual assessment leader will also check these forms on a daily basis to make sure that they have been filled out properly.

2.5.2 Secondary Data Quality Control Requirements and Acceptability Criteria

Secondary and modeling data will be internally quality controlled by Fuss & O'Neill through in-house review. Anticipated review staff members responsible for this process include the Project Manager and QA Manager. The Fuss & O'Neill Project Manager will maintain overall responsibility for examining the work to ensure that methodologies and processes are consistent with the procedures outlined in the QAPP and the overall project goals. This will include monitoring secondary data formatting to ensure that the data are consistent and appropriate for the model and overseeing the selection of appropriate model parameters and review of the input files to ensure that the information is properly entered and formatted. The Project Manager will provide advice to the Fuss & O'Neill QA Manager of any deviations from the QAPP so that appropriate actions may be taken either to correct the problem, or amend the QAPP as needed. The QA Officer will monitor the extent to which the QAPP is supporting its intended use.

2.5.3 Failures in Quality Control and Corrective Action

The professional judgement of the Project Manager and technical staff will be relied upon to evaluate the visual assessments of watershed conditions. These assessments may be rejected based on whether the information contained in the field forms have been recorded accurately, completely, and in accordance with the methodology cited previously.

Similarly, the professional judgment of the Project Manager and technical staff will be relied upon in evaluating secondary data and modeling results. Rejecting secondary data or modeling results based on unreasonableness of the information (i.e., pollutant loading values unreasonably low or high, removal efficiencies significantly greater than reported literature values, etc.) is a possibility. Evaluation criteria noted previously in this section and in Section 1.4 will be used for data review. If the quality control review results in detection of unacceptable conditions or data, the Project Manager will be responsible for developing and initiating corrective action. Corrective response actions may include:

- Review of original secondary data and re-processing to maintain data integrity.
- Review or corroboration of modeling input and parameterization data.
- Re-definition of model extents or spatial distribution.
- Performing additional model runs.
- Editing and modifying report deliverables.

Notations of secondary data or modeling data failing to meet DQOs will be noted in the final deliverables.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (B6)

The field assessment team leader will be responsible for noting and reporting issues or problems to the Project Manager or QA Officer. Any routine maintenance will be performed by the field assessment personnel. GPS equipment testing, inspection and maintenance will be performed according to manufacturer recommendations, as described in the equipment manuals. Outfall locations in impaired segments of the watershed will be collected during the study using a GPS unit, which will be inspected before each use for things such as battery life, etc. Digital cameras will be inspected before each use for battery life and sufficient storage.

Maintenance logs for field equipment will be submitted to and kept by the QA Manager. The log entry will include:

- Name of person maintaining the instrument/equipment.
- Date and description of maintenance procedure.
- Date and description of any instrument/equipment problems.
- Date and description of actions to correct problems.
- List of follow-up activities after maintenance.
- Date next maintenance will be needed.

2.7 Instrument/Equipment Calibration and Frequency (B7)

A Trimble Geo 7X Series handheld GPS unit will be used in the field to collect outfall locations in impaired segments of the Pomperaug River watershed. Operation and correct use of the GPS equipment will follow specifications in the product manual. Verification that the GPS unit is operating properly will be done prior to each visual assessment. Copies of the equipment manual will be maintained by the Visual Assessment Team and Visual Assessment Leader. The Operators Manual, including calibration information, is included in **Appendix B** of this QAPP.

2.8 Inspection of Supplies and Consumables (B8)

All supplies for field activities will be inspected by the field assessment team prior to use for compliance with the acceptance criteria. Supplies needed for visual assessments include:

- Field Data Forms.
- Maps.
- Tape measure.
- GPS unit.
- Log Books.
- Digital cameras.
- Data cards.
- Life preservers (PFDs).
- Waders.
- Pens/Pencils.

The field assessment team leader is responsible for maintaining the supplies needed for visual assessments. Supplies or consumables not meeting the acceptance criteria upon inspection will not be used. Any equipment determined to be in unacceptable condition will be replaced. The field supplies and replacement parts associated with the permanent field equipment may require replacement of wearable parts such as camera batteries. Any replacement parts for field equipment will be ordered and replaced by the Project Manager. Supplies and consumables will be stored in accordance with identified requirements of each item.

2.9 Data Acquisition Requirements (Non-Direct Measurements) (B9)

Available information on water quality and land use within the Pomperaug River Watershed will be compiled, reviewed and summarized by Fuss & O'Neill. Both mapping and tabular/narrative information summaries will be produced.

2.9.1 Data Sources

Non-direct data will be obtained primarily from federal and state agencies, regional authorities and municipalities to characterize historic and existing conditions in the watershed. Modeling efforts will also utilize peer-reviewed data related to water quality associated with particular land uses and effectiveness of various structural and non-structural management practices for bacteria and sediment load reduction. Data sources include, but are not limited to the following:

- Available water quality monitoring data for the watershed collected by PRWC, CTDEEP, United States Geological Survey (USGS) and non-profits.
- Impaired Waters Summary for Pomperaug Watershed (PRWC 2012).
- Statewide TMDL Bacteria for the Pomperaug and Weekeepeemee (CTDEEP).
- State of Watershed Report (PRWC 1999).
- Land use and Land cover data (either parcel-based land use available from the Naugatuck Valley Council of Governments (NVCOG) or UConn Center for Land Use Education and Research (CLEAR) satellite-derived land cover data).
- Riparian Land Cover Change Analysis, Agricultural Lands Analysis, Forest Fragmentation Analysis, and Land Cover Change Analysis (UConn CLEAR- 1985 to 2010).
- Land Use, Open Space, and Zoning Maps (NV COG).
- Information compiled by PRWC, NV COG, and other non-governmental organizations.
- Municipal planning documents.
- Published, peer-reviewed studies of pollutant loads from different land uses.

Summaries of the specific model input parameters and identified sources of information for those parameters are included in **Appendix D**.

CTDEEP's Environmental GIS Data Set, the University of Connecticut (UConn) Map and Geographic Information Center (MAGIC), and UConn CLEAR will serve as the primary sources of data for watershed mapping. The GIS data will be augmented by GIS mapping available from the watershed municipalities and NVCOG, as necessary.

All data sources will be fully referenced and documentation of data quality supplied in the final report and project deliverables, including links to web-based data, where appropriate.

2.9.2 Data Generators

Data generators are federal, state, and local agencies and other organizations that collect or have collected environmental data that is relevant and useful for this project and is of a sufficient quality for use.

2.9.3 Hierarchy of Data Sources

Secondary data sources preferred for use in the project will include existing data obtained from state and federal agencies, municipalities, and non-governmental organizations already conducting mapping and monitoring programs. Data sources with known and adequate quality control and quality assurance procedures will be preferred, including data from state and federal agencies and data collected or generated under a QAPP. Any known data limitations or gaps will be disclosed in the final project report and any other deliverables.

2.9.4 Rationale for Selecting Data Sources

Given the specific secondary data needs for this project (e.g., mapping of land use and land cover, water quality data, information about physical characteristics of the rivers, tributaries, and floodplains, literature sources of event mean concentrations (EMC's) for various land use types, estimates of BMP effectiveness for bacteria and sediment removal, etc.), there are, in some cases, only one or a limited number of data sources available. Where more than one data source is available, all available sources will be evaluated and the highest quality, most applicable data source will be used.

2.9.5 List of Sources of Secondary Data

The sources of all secondary data used will be listed and described in the final project report and any other deliverables. Where appropriate, links to web-based data will be provided.

2.10 Data Management (B10)

This section defines the specific policies, organization, and procedures related to data management. The data management system that will be used for the electronic data management is Microsoft Excel.

2.10.1 Field Data and Information Management

Items that require data management which are collected or generated in the field by the visual assessment team are field logbooks and field data forms.

Following watershed assessment activities, field data (including field data forms and field staff logbook copies) will be forwarded to the Project Manager and QA Manager, who are responsible for reviewing the field data for accuracy and completeness. If any field data forms are incorrect, incomplete, or missing, the package of data forms will be returned to field personnel for completion and/or correction.

Project personnel conducting the visual assessments will forward copies of the field data forms to the Project Manager. Field notebook copies will be forwarded to the Project Manager upon request.

Hard copies of all data and field forms will be retained by the Project Manager. Copies of this data will be available to team members upon request.

2.10.2 Visual Assessment Data and Information Management

Original field forms received from the visual assessment team by the Project Manager will be reviewed for accuracy and completeness. Accuracy and completeness, as defined herein, means that the requested information was collected appropriately and that the site IDs, date collected, etc. are correctly identified on the field forms.

The Project Manager will supervise the scanning of all field forms used for visual assessments in the field. The data will be reviewed and evaluated for completeness.

Hard-copy of all field forms will be retained by the Project Manager. Copies of this data will be available to team members upon request.

2.10.3 Non-Direct Data (Secondary and Modeling) Management

The following data handling equipment, hardware and software are anticipated to be used in model development and interpretation of results:

- Desktop computers using the Windows operating system.
- Microsoft Office Excel 2010 or later version.
- ArcGIS software v10 or later version.
- Watershed Treatment Model version 3.1 or later version (runs in Excel).

2.10.4 Electronic Data Management

The general approach to data storage and retrieval of electronic media is as follows:

- Data will be downloaded from the federal and state agencies websites directly or via FTP by Fuss & O'Neill. In some cases, data may have to be ordered for electronic delivery via email or FTP.
- Source data files, model input files, model executable files, and model output files will be stored in separate project subdirectories by Fuss & O'Neill.
- Fuss & O'Neill will conduct daily backup of all files stored electronically.
- At the conclusion of the project, electronic copies of all files will be written to CD and provided to the Pomperaug River Watershed Coalition for additional storage.

3 Section C – Assessment and Oversight

3.1 Assessment/Oversight and Response Action (C1)

The Fuss & O'Neill Project Manager and QA Manager are responsible for determining the need for and implementation of any corrective action measures to the visual assessments or modeling procedures. Corrective actions will be implemented upon the identification of problems discovered through system audits by field data sheet review or model oversight. If a problem is identified, the QA Manager will:

- Report the problem to the Project Manager.
- Evaluate the problem in accordance with data quality objectives.
- Determine whether implementation of corrective action is required.
- Assign and implement a corrective action.
- Evaluate the effectiveness of the corrective action.

The QA Manager will report the findings of any problems and corrective actions to the Project Manager. The following is a list of possible occurrences that may require corrective action and the corresponding action that would likely take place.

- If visual assessments of watershed conditions are not logged properly in the field data forms or do not follow the methodology outlined in the QAPP these forms will be flagged by the Visual Assessment Team Leader and Project Manager.
- If modeling results do not fall within the expected range, the model function as well as the input data will be reviewed for inaccuracies.

CTDEEP may implement, at their discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with the CTDEEP Quality Management Plan.

3.2 Reports to Management (C2)

Field data forms and/or modeling results that have passed preliminary quality control analysis may be submitted to the PRWC, CTDEEP and EPA. A caveat will accompany these or any data released on a preliminary basis, explaining that they are for review purposes only and subject to correction after completion of a full data review occurring at the end of the program.

All reports, preliminary or final, will include discussion of steps taken to assure data quality, findings on data quality, and decisions made on questionable data.

4 Section D – Data Validation and Usability

4.1 Data Review, Verification and Validation (D1)

4.1.1 Direct Data Measurements

Review, verification, and validation is a multi-step process to protect the integrity of the data collected during the visual assessments of watershed conditions and will reduce the number of field data forms that do not meet the DQOs. Verification of the visual assessments will occur at the field level.

The field data forms will be reviewed after the visual assessment date by the QA officer and Project Manager using all available QC data. Deviations will be flagged. Incomplete data will be noted, as necessary. QC results that deviate from the data quality objectives will call into question the validity of the individual field data form or all related field data forms.

The final decision on whether to include or reject the field data forms should be made by the Project Manager and QA Officer.

4.1.2 Non-Direct Measurement Data (Secondary and Modeling)

The Project Manager and QA Manager will be responsible for review, verification and validation of secondary and modeling data. The review will be conducted to both protect the integrity of the data and make sure that data was used appropriately to support the goals of the project. The review of secondary data will be conducted at the end of the existing conditions background data collection process. The Project Manager and/or QA Manager will confirm that secondary data was collected consistent with the data decision process described in this QAPP. Any data not meeting the criteria will be reviewed by the Project Manager and QA Manager and either removed from use or flagged in the dataset, with the appropriate qualifying description, for use in the report deliverables.

Similarly, modeling data will be reviewed by the Project Manager and/or QA Manager relative to the DQOs described in Section 1.4. Modeling data or results that deviate from the DQOs will be reviewed by the Project Manager and QA Manager and either removed from use or flagged in the dataset, with appropriate qualifying description, for use in the report deliverables.

4.2 Verification and Validation Methods (D2)

4.2.1 Direct Data Measurements

Data quality measures for visual field assessments will be compared to applicable data quality objectives. The verification process for the compiled field data forms of all visual assessments will involve the Project Manager visually comparing a hard copy of field data forms with the information scanned electronically into PDF format. This process will ensure that data has been accurately scanned into the Fuss & O'Neill computer system.

4.2.2 Non-Direct Data Measurements (Secondary and Modeling)

The Project Manager and QA Manager will perform visual inspection of data before including it in deliverables. The following will be observed for secondary data validation:

- A copy of every secondary data set will be saved as a read-only, protected file to be used in the event that the integrity of the working dataset is compromised.
- Working data will be stored in a spreadsheet or ArcGIS format and will include relevant raw data, which will be locked for editing.
- Data manipulation will be minimized, but when necessary, data manipulation will start with raw data, and all calculations, including units, conversion factors, and formulas will be shown in the spreadsheet.
- Prior to including in project deliverables, raw and reduced data will be displayed in graphic format and inspected to look for anomalous values. Any decision to eliminate anomalous values will be documented in the spreadsheets and will be noted in the project deliverables.

Verification and validation of modeling data will be performed by the Project Manager and will include:

- Review of modeling parameters inputs and assumption to confirm the reasonableness of those assumptions.
- Comparison of model output with similar, acceptable quality data from other studies prepared by either reliable sources (e.g., USGS, CTDEEP, EPA) or through a peer-reviewed process to assess the reasonableness of modeling results.

Any concerns regarding secondary or modeling data will be communicated to the project team. If necessary, modifications to the modeling process may be required and will be documented in accordance with this QAPP. If necessary, data qualifiers for either the secondary or modeling data will be assigned

and noted in the project database, modeling notebook, and limitations identified, as appropriate, in project deliverables.

4.3 Reconciliation with User Requirements (D3)

4.3.1 Direct Measurements Data

After reviewing the DQOs outlined in Section 1.4 related to visual assessments the Project Manager and QA Manager will evaluate overall program attainment for the direct data acquisition.

4.3.2 Non-Direct Measurements (Secondary and Modeling)

Once secondary data collection and modeling are complete, the resulting data sets will be compared with the DQOs for secondary and modeling data outlined in Section 1.4. This will include an assessment of the secondary data characteristics relative to the data decision tree in Section 1.4 and will include a narrative summary of the following:

- Number of data sets used that had full references.
- Number of data sets used with disclaimers.

It should be noted that all models are a simplification of the environmental processes they intend to represent. Although there is no consensus on model performance criteria in the literature, a number of basic statements are likely to be accepted by most professional modelers including:

- Models are approximations of reality and cannot precisely represent natural systems.
- There is no single, accepted test that determines whether or not a model is valid.
- Models cannot be expected to be more accurate than the sampling and statistical error (e.g., confidence intervals) in the input and observed data.

These considerations must be included in the development of appropriate procedures for quality assurance of the models. Despite a lack of agreement on how models should be evaluated, the following principles provide a final set of evaluation criteria for the modeling projects:

- Exact duplication of observed data is not possible, nor is it a performance criterion for projects, and in fact, for some models it may indicate a lack of ability to generalize when given new input data. The model validation process will measure the ability of the model to simulate measured values.

- No single procedure or statistic is widely accepted as measuring, or capable of establishing, acceptable model performance. Therefore the combination of graphical comparisons, statistical tests and professional judgment are proposed to provide sufficient evidence upon which to base a decision of model acceptance or rejection.
- All model and observed data comparisons must recognize, either qualitatively or quantitatively, the inherent error and uncertainty in both the model and the observations. Model sensitivity and uncertainty will be documented, where possible, as part of the modeling study.

The uncertainty in the modeling process and its impact on the usability of the results toward decision-based management will be addressed in the final project deliverable. After the review of secondary data DQO and modeling performance, the Project Manager and QA Manager will evaluate overall program attainment for the secondary data and modeling data.

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Appendix A

Field Data Forms

Reach Level Assessment **RCH**

SURVEY REACH ID: _____	**WTRSHD/SUBSHD:**	**DATE:** ___/____/___	**ASSESSED BY:**

START **TIME:** ___:___AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** ___:___AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM *(*Evidence of)
☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS

☐ Unknown	☐ Downcutting	☐ Bed scour
	☐ Widening	☐ Bank failure
	☐ Headcutting	☐ Bank scour
	☐ Aggrading	☐ Slope failure
	☐ Sed. deposition	☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank _____(ft)
RT bank _____(ft)
Width: Bottom _____(ft)
Top _____(ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5	4 3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION				
	Optimal	**Suboptimal**	**Marginal**	**Poor**
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
OVERALL BUFFER AND FLOODPLAIN CONDITION				
	Optimal	**Suboptimal**	**Marginal**	**Poor**
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: _____ **/80** + Buffer/Floodplain: _____ **/80** = **Total** Survey Reach _____ **/160**

WATERSHED:	SUBWATERSHED:	UNIQUE SITE ID:	
DATE: ___/___/_____	ASSESSED BY:	CAMERA ID:	PIC#:

A. NEIGHBORHOOD CHARACTERIZATION

Neighborhood/Subdivision Name: _____ Neighborhood Area (acres) _____

If unknown, address (or streets) surveyed:

_____

Homeowners Association? ☐ Y ☐ N ☐ Unknown If yes, name and contact information: _____

Residential *(circle average single family lot size):* _____

☐ Single Family Attached (Duplexes, Row Homes) <⅛ ⅛ ¼ ⅓ ⅓ acre ☐ Multifamily (Apts, Townhomes, Condos)

☐ Single Family Detached <¼ ¼ ½ 1 >1 acre ☐ Mobile Home Park

Estimated Age of Neighborhood: _____ years	Percent of Homes with Garages: _____% With Basements ____%	**INDEX***
Sewer Service? ☐ Y ☐ N		○
Index of Infill, Redevelopment, and Remodeling ☐ No Evidence ☐ <5% of units ☐ 5-10% ☐ >10%		○

Record percent observed for each of the following indicators, depending on applicability and/or site complexity	**Percentage**	**Comments/Notes**	
B. YARD AND LAWN CONDITIONS			
B1. % of lot with impervious cover			
B2. % of lot with grass cover			○
B3. % of lot with landscaping (e.g., mulched bed areas)			◇
B4. % of lot with bare soil			○
**Note: B1 through B4 must total 100%*			
B5. % of lot with forest canopy			◇
B6. Evidence of permanent irrigation or "non-target" irrigation			○
B7. Proportion of *total neighborhood* turf lawns with following management status:	High: ____		○
	Med: ____		
	Low: ____		
B8. Outdoor swimming pools? ☐Y ☐N ☐ Can't Tell Estimated # ____			○
B9. Junk or trash in yards? ☐ Y ☐ N ☐ Can't Tell			○
C. DRIVEWAYS, SIDEWALKS, AND CURBS			
C1. % of driveways that are impervious ☐ N/A			
C2. Driveway Condition ☐ Clean ☐ Stained ☐ Dirty ☐ Breaking up			○
C3. Are sidewalks present? ☐ Y ☐ N If yes, are they on one side of street ☐ or along both sides ☐			
☐ Spotless ☐ Covered with lawn clippings/leaves ☐ Receiving 'non-target' irrigation			○
What is the distance between the sidewalk and street? _____ ft.			◇
Is pet waste present in this area? ☐ Y ☐ N ☐ N/A			○
C4. Is curb and gutter present? ☐ Y ☐ N If yes, check all that apply:			
☐ Clean and Dry ☐ Flowing or standing water ☐ Long-term car parking ☐ Sediment			○
☐ Organic matter, leaves, lawn clippings ☐ Trash, litter, or debris ☐ Overhead tree canopy			◇

* INDEX: ○ denotes potential pollution source; ◇ denotes a neighborhood restoration opportunity

D. ROOFTOPS			
D1. Downspouts are directly connected to storm drains or sanitary sewer			◇ ○
D2. Downspouts are directed to impervious surface			
D3. Downspouts discharge to pervious area			
D4. Downspouts discharge to a cistern, rain barrel, etc.			
**Note: C1 through C4 should total 100%*			
D5. Lawn area present downgradient of leader for rain garden? ☐ Y ☐N			◇
E. COMMON AREAS			
E1. Storm drain inlets? ☐ Y ☐ N If yes, are they stenciled? ☐ Y ☐ N Condition: ☐ Clean ☐ Dirty			◇
Catch basins inspected? ☐ Y ☐ N If yes, include Unique Site ID from SSD sheet: _____			○
E2. Storm water pond? ☐ Y ☐ N Is it a ☐ wet pond or ☐ dry pond? Is it overgrown? ☐ Y ☐ N What is the estimated pond area? ☐ <1 acre ☐ about 1 acre ☐ > 1 acre			◇
E3. Open Space? ☐ Y ☐ N If yes, is pet waste present? ☐ Y ☐ N dumping? ☐ Y ☐ N			○
Buffers/floodplain present: ☐ Y ☐ N If yes, is encroachment evident? ☐ Y ☐ N			
F. INITIAL NEIGHBORHOOD ASSESSMENT AND RECOMMENDATIONS			
Based on field observations, this neighborhood has significant indicators for the following: (*check all that apply)* ☐ Nutrients ☐ Oil and Grease ☐ Trash/Litter ☐ Bacteria ☐ Sediment ☐ Other _____			○

Recommended Actions

Specific Action

- ☐ Onsite retrofit potential?
- ☐ Better lawn/landscaping practice?
- ☐ Better management of common space?
- ☐ Pond retrofit?
- ☐ Multi-family Parking Lot Retrofit?
- ☐ Other action(s) _____

Describe Recommended Actions:

Initial Assessment

NSA Pollution Severity Index

- ☐ Severe (More than 10 circles checked)
- ☐ High (5 to 10 circles checked)
- ☐ Moderate (Fewer than 5 circles checked)
- ☐ None (No circles checked)

Neighborhood Restoration Opportunity Index

- ☐ High (More than 5 diamonds checked)
- ☐ Moderate (3-5 diamonds checked)
- ☐ Low (Fewer than 3 diamonds checked)

NOTES:

WATERSHED:	SUBWATERSHED:	UNIQUE SITE ID:	
DATE: ___/___/_____	ASSESSED BY:	CAMERA ID:	PIC#:
MAP GRID:	LAT ___°_____'_____" LONG ___°_____'____"		LMK #

A. SITE DATA AND BASIC CLASSIFICATION

Name and Address: _____

_____

_____

SIC code (if available): _____

NPDES Status: ☐ Regulated ☐ Unregulated ☐ Unknown

Category: ☐ Commercial ☐ Industrial ☐ Institutional ☐ Municipal ☐ Transport-Related

Miscellaneous ☐ Golf Course ☐ Marina ☐ Animal Facility

Basic Description of Operation:

_____

	INDEX*
B. VEHICLE OPERATIONS ☐ **N/A** *(Skip to part C)*	**Observed Pollution Source?** ☐
B1. Types of vehicles: ☐ Fleet vehicles ☐ School buses ☐ Other: _____	
B2. Approximate number of vehicles: _____	
B3. Vehicle activities *(circle all that apply)*: Maintained Repaired Recycled Fueled Washed Stored	○
B4. Are vehicles stored and/or repaired outside? ☐ Y ☐ N ☐ Can't Tell Are these vehicles lacking runoff diversion methods? ☐ Y ☐ N ☐ Can't Tell	○
B5. Is there evidence of spills/leakage from vehicles? ☐ Y ☐ N ☐ Can't Tell	○
B6. Are uncovered outdoor fueling areas present? ☐ Y ☐ N ☐ Can't Tell	○
B7. Are fueling areas directly connected to storm drains? ☐ Y ☐ N ☐ Can't Tell	○
B8. Are vehicles washed outdoors? ☐ Y ☐ N ☐ Can't Tell Does the area where vehicles are washed discharge to the storm drain? ☐ Y ☐ N ☐ Can't Tell	○
C. OUTDOOR MATERIALS ☐ **N/A** *(Skip to part D)*	**Observed Pollution Source?** ☐
C1. Are loading/unloading operations present? ☐ Y ☐ N ☐ Can't Tell If yes, are they uncovered *and* draining towards a storm drain inlet? ☐ Y ☐ N ☐ Can't Tell	○
C2. Are materials stored outside? ☐ Y ☐ N ☐ Can't Tell If yes, are they ☐ Liquid ☐ Solid Description: _____ Where are they stored? ☐ grass/dirt area ☐ concrete/asphalt ☐ bermed area	○
C3. Is the storage area directly or indirectly connected to storm drain (circle one)? ☐ Y ☐ N ☐ Can't Tell	○
C4. Is staining or discoloration around the area visible? ☐ Y ☐ N ☐ Can't Tell	○
C5. Does outdoor storage area lack a cover? ☐ Y ☐ N ☐ Can't Tell	○
C6. Are liquid materials stored *without* secondary containment? ☐ Y ☐ N ☐ Can't Tell	○
C7. Are storage containers missing labels or in poor condition (rusting)? ☐ Y ☐ N ☐ Can't Tell	○
D. WASTE MANAGEMENT ☐ **N/A** *(Skip to part E)*	**Observed Pollution Source?** ☐
D1. Type of waste *(check all that apply)*: ☐ Garbage ☐ Construction materials ☐ Hazardous materials	○
D2. Dumpster condition (*check all that apply)*: ☐ No cover/Lid is open ☐ Damaged/poor condition ☐ Leaking or evidence of leakage (stains on ground) ☐ Overflowing	○
D3. Is the dumpster located near a storm drain inlet? ☐ Y ☐ N ☐ Can't Tell If yes, are runoff diversion methods (berms, curbs) lacking? ☐ Y ☐ N ☐ Can't Tell	○
E. PHYSICAL PLANT ☐ **N/A** *(Skip to part F)*	**Observed Pollution Source?** ☐
E1. Building: Approximate age: _____ yrs. Condition of surfaces: ☐ Clean ☐ Stained ☐ Dirty ☐ Damaged Evidence that maintenance results in discharge to storm drains (staining/discoloration)? ☐ Y ☐ N ☐ Don't know	○ ○

*Index: ○ denotes potential pollution source; ☐ denotes confirmed polluter (evidence was seen)

E2. Parking Lot: Approximate age _____ yrs. Condition: ☐ Clean ☐ Stained ☐ Dirty ☐ Breaking up
Surface material ☐ Paved/Concrete ☐ Gravel ☐ Permeable ☐ Don't know ○

E3. Do downspouts discharge to impervious surface? ☐ Y ☐ N ☐ Don't know ☐ None visible
Are downspouts directly connected to storm drains? ☐ Y ☐ N ☐ Don't know ○

E4. Evidence of poor cleaning practices for construction activities (stains leading to storm drain)? ☐ Y ☐ N ☐ Can't Tell ○

F. TURF/LANDSCAPING AREAS ☐ **N/A** *(skip to part G)* **Observed Pollution Source?**

F1. % of site with: Forest canopy ____% Turf grass _____% Landscaping ____% Bare Soil ____% ○

F2. Rate the turf management status: ☐ High ☐ Medium ☐ Low ○

F3. Evidence of permanent irrigation or "non-target" irrigation ☐ Y ☐ N ☐ Can't Tell ○

F4. Do landscaped areas drain to the storm drain system? ☐ Y ☐ N ☐ Can't Tell ○

F5. Do landscape plants accumulate organic matter (leaves, grass clippings) on adjacent impervious surface? ☐ Y ☐ N ☐ Can't Tell ○

G. STORM WATER INFRASTRUCTURE ☐ **N/A** *(skip to part H)* **Observed Pollution Source?**

G1. Are storm water treatment practices present? ☐ Y ☐ N ☐ Unknown If yes, please describe: _____ ○

G2. Are private storm drains located at the facility? ☐ Y ☐ N ☐ Unknown
Is trash present in gutters leading to storm drains? If so, complete the index below. ○

Index Rating for Accumulation in Gutters

	Clean				Filthy
Sediment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Organic material	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Litter	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

G3. Catch basin inspection – Record SSD Unique Site ID here: _____ Condition: ☐ Dirty ☐ Clean

H. INITIAL HOTSPOT STATUS - INDEX RESULTS

☐ Not a hotspot (fewer than 5 circles and no boxes checked) ☐ Potential hotspot (5 to 10 circles but no boxes checked)
☐ Confirmed hotspot (10 to 15 circles and/or 1 box checked) ☐ Severe hotspot (>15 circles and/or 2 or more boxes checked)

Follow-up Action:
☐ Refer for immediate enforcement
☐ Suggest follow-up on-site inspection
☐ Test for illicit discharge
☐ Include in future education effort
☐ Check to see if hotspot is an NPDES non-filer
☐ Onsite non-residential retrofit
☐ Pervious area restoration; complete PAA sheet and record Unique Site ID here: _____
☐ Schedule a review of storm water pollution prevention plan

Notes:

Pervious Area Assessment **PAA**

WATERSHED:	SUBWATERSHED:	UNIQUE SITE ID:	
DATE: ___/___/_____	ASSESSED BY:	CAMERA ID:	PIC #:
MAP GRID:	LAT ___°_____'_____" LONG ___°_____'_____"		LMK #

A. PARCEL DESCRIPTION

Size: ___acre(s) Access to site (*check all that apply)*: ☐ Foot access ☐ Vehicle access ☐ Heavy equipment access
Ownership: ☐ Private ☐ Public Current Management: ☐ School ☐ Park ☐ Right-of-way ☐ Vacant land
☐ Other (please describe) _____
Contact Information: _____
Connected to other pervious area? ☐ Y ☐ N If yes, what type? ☐ Forest ☐ Wetland ☐ Other _____
Estimated size of connected pervious area: ____ acre(s) Record Unique Site ID of connected fragment: _____

PART I. NATURAL AREA REMNANT

FOREST

B. CURRENT VEGETATIVE COVER

B1. Percent of forest with the following canopy coverage:
Open _____% Partly shaded _____% Shaded _____%
**Note – these should total 100%*
B2. Dominant tree species: _____
_____
B3. Understory species: _____
_____
B4. Are invasive species present? ☐ Y ☐ N
☐ Unknown
If yes, % of forest with invasives: _____
Species: _____

C. FOREST IMPACTS

C1. Observed Impacts (*check all that apply*): ☐ Animals
☐ Clearing/encroachment ☐ Trash and dumping ☐
Storm water runoff ☐ Other

D. NOTES

WETLAND

B. CURRENT VEGETATIVE COVER

B1. % of wetland with following vegetative zones:
Aquatic: _____
Emergent: _____
Forested: _____
**Note – these should total 100%*
B2. Dominant species: _____
_____
B3. Are invasive species present? ☐ Y ☐ N
☐ Unknown
If yes, % of wetland with invasives: _____
Species: _____

C. WETLAND IMPACTS

C1. Observed Impacts (*check all that apply*): ☐ Animals
☐ Clearing/encroachment ☐ Trash and dumping ☐
Storm water runoff ☐ Hydrologic impacts ☐ Other

D. NOTES

E. INITIAL RECOMMENDATION

☐ Good candidate for conservation/protection
☐ Potential restoration candidate
☐ Poor restoration or conservation candidate

PART II. OPEN PERVIOUS AREAS

A. CURRENT VEGETATIVE COVER

A1. Percent of assessed surface with:
Turf _____% Other Herbaceous _____% None (bare soil) _____% Trees _____% Shrubs ____ % Other _____%
(please describe): _____ **Note – these should total 100%*

A2. Turf: Height: _____ inches Apparent Mowing Frequency: ☐ Frequent ☐ Infrequent ☐ No-Mow ☐ Unknown
Condition (*check all that apply*): ☐ Thick/Dense ☐ Thin/Sparse ☐ Clumpy/Bunchy ☐ Continuous Cover

A3. Thickness of organic matter at surface: _____ inches

A4. Are invasive species present? ☐ Y ☐ N ☐ Unknown If yes, % of site with invasives: _____
Species:_____

B. IMPACTS

B1. Observed Impacts (*check all that apply*): ☐ Soil Compaction ☐ Erosion ☐ Trash and Dumping
☐ Poor Vegetative Health ☐ Other (describe): _____

C. REFORESTATION CONSTRAINTS

C1. Sun exposure: ☐ Full sun ☐ Partial sun ☐ Shade ☐ Unknown

C2. Nearby water source? ☐ Y ☐ N ☐ Unknown

C3. Other constraints: ☐ Overhead wires ☐ Underground Utilities ☐ Pavement ☐ Buildings
☐ Other (please describe): _____

D. NOTES

E. INITIAL RECOMMENDATION

☐ Good candidate for natural regeneration
☐ May be reforested with minimal site preparation
☐ May be reforested with extensive site preparation
☐ Poor reforestation or regeneration site

PART III. SKETCH

WATERSHED:	**SUBWATERSHED:**	**UNIQUE SITE ID:**
DATE: ___/___/_____	**ASSESSED BY:**	**CAMERA ID:**
MAP GRID	**RAIN IN LAST 24 HOURS** ☐ Y ☐ N	**PIC #**

A. LOCATION

A1. Street names or neighborhood surveyed:
_____

A2. Adjacent land use: ☐ Residential ☐ Commercial ☐ Industrial ☐ Institutional ☐ Municipal ☐ Transport-Related

A3. Corresponding HSI or NSA field sheet? If so, circle HSI or NSA and record its Unique Site ID here _____

B. STREET CONDITIONS

B1. Road Type: ☐ Arterial ☐ Collector ☐ Local ☐ Alley ☐ Other: _____

B2. Condition of Pavement: ☐ New ☐ Good ☐ Cracked ☐ Broken

B3. Is on-street parking permitted ☐ Y ☐ N If yes, approximate number of cars per block: _____

B4. Are large cul-de-sacs present? ☐ Y ☐ N

B5. Is trash present in curb and gutter? If so, use the index to the right to record amount.	Index Rating for Accumulation in Gutters				
	Clean				Filthy
Sediment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Organic Material	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Litter	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

C. STORM DRAIN INLETS AND CATCH BASINS

C1. Type of storm drain conveyance: ☐ open ☐ enclosed ☐ mixed

C2. Percentage of inlets with catch basin storage: _____ ☐ N/A

Sample 1-2 catch basins per NSA/HSI	**C3.** Catch basin #1	**C4.** Catch basin #2
Latitude	___° ____' ____"	___° ____' ____"
Longitude	___° ____' ____"	___° ____' ____"
LMK #		
Picture #		
Current Condition	☐ Wet ☐ Dry	☐ Wet ☐ Dry
Condition of Inlet	☐Clear ☐Obstructed	☐Clear ☐Obstructed
Litter Accumulation	☐Y ☐ N	☐Y ☐ N
Organics Accumulation	☐Y ☐ N	☐Y ☐ N
Sediment Accumulation	☐Y ☐ N	☐Y ☐ N
Sediment Depth (in feet)	_____ ft.	_____ ft.
Water Depth	_____ ft.	_____ ft.
Evidence of oil and grease	☐Y ☐ N	☐Y ☐ N
Sulfur smell	☐Y ☐ N	☐Y ☐ N
Accessible to vacuum truck	☐Y ☐ N	☐Y ☐ N

D. NON-RESIDENTIAL PARKING LOT (>2 acres)

D1. Approximate size: _____ acres

D2. Lot Utilization: ☐ Full ☐ About half full ☐ Empty

D3. Overall condition of Pavement: ☐ Smooth (no cracks) ☐ Medium (few cracks) ☐ Rough (many cracks) ☐ Very Rough (numerous cracks and depressions)

D4. Is lot served by a storm water treatment practice? ☐ Y ☐ N If yes, describe: _____

D5. On-site retrofit potential: ☐ Excellent ☐ Good ☐ Poor

E. MUNICIPAL POLLUTANT REDUCTION STRATEGIES

E1. Degree of pollutant accumulation in the system: ☐ High ☐ Medium ☐ Low ☐ None

E2. Rate the feasibility of the following pollution prevention strategies:

Street Sweeping:	☐ High	☐ Moderate	☐ Low
Storm Drain Stenciling:	☐ High	☐ Moderate	☐ Low
Catch Basin Clean-outs:	☐ High	☐ Moderate	☐ Low
Parking Lot Retrofit Potential:	☐ High	☐ Moderate	☐ Low

CATCH BASIN SKETCHES

#1

#2

Notes:

Appendix B

SOPs, Methods, Equipment Manuals

1. Field Activity Documentation
2. Site Etiquette
3. Trimble GEO 7X Calibration

FIELD NOTEBOOKS

All field personnel will carry a bound field notebook. All field activities will be documented in the field notebook, regardless of whether or not those activities involve sample collection. Each employee's book will be numbered sequentially with the format of the employee number followed by the book number (i.e. **156-01**) and will be labeled on the cover as such with the range of dates covered by the book (i.e. 10/23/03 to 8/17/04). Each page of the field notebook book will be numbered with the employee number, the book number, and the page number (i.e. **156-01-01, 156-01-02, 156-01-03**, etc.). The field notebook will document site-specific information such as:

- Project name and location
- Names of other Fuss & O'Neill personnel involved in field activities
- Time and date of arrival at the site
- Weather conditions
- Sampling locations and corresponding sample numbers
- Documentation of field calibration of instruments
- Conversations with individuals on site
- Any unusual events or observations
- All information not recorded on field data sheets
- Time of departure from the site

For field investigations that involve the collection of samples, additional forms of documentation are required. See SOPs 020100, 020200, 020300, 020400, and 020500.

Upon arrival on-site, all Fuss & O'Neill field personnel will follow the following guidelines:

1. The client/owner will be notified of site visits.

2. Field personnel will always carry their business cards for identification purposes.

3. Field personnel will strictly adhere to policies in effect at the client's facilities. An example of such a policy is signing in and out of buildings or offices and wearing facility specified safety gear (hard hats, eyeglasses).

4. The client/owner's property will be respected at all times.

5. Field personnel will not discuss specifics of sampling or contaminants with any site employees or passers-by without authorization from project management and the client.

6. Field personnel will not be permitted to smoke in the client's presence or while in indoor facilities. **In addition, no smoking will be permitted in the vicinity of sample collection.**

7. All field activities will be conducted following the established sampling plan and the site health and safety plan for the site.

8. Wells will be locked and maintained in good condition between sampling events.

9. The homeowner will be notified prior to any domestic well sampling. If no one is home and a sample cannot be obtained, field personnel will leave a note to inform the resident of the sampling attempt and the name of a contact person with whom to reschedule. A business card should always accompany this note.

10. When domestic wells are purged from an outside tap, a hose will be attached whenever possible to direct the water away from the building.

11. Contaminated and/or dirty protective gear will be properly decontaminated and removed prior to entering on-site buildings and offices.

12. No discarded materials will be left at sample locations. All trash, which has accumulated at a site as a result of field activities, will be collected disposed of according to site guidelines and waste disposal plans.

13. Field Staff will keep company vehicles clean and in presentable condition while conducting field activities.

Trimble Handheld GEO 7x Calibration

Note: The User's Guide for the Trimble Handheld Geo 7x is a protected document, available on-line at the link below. Calibration procedures for the ***Global Navigation Satellite System*** (GNSS) are found on Page 98. Calibration procedures are given for both fast calibration and full calibration.

https://www.neigps.com/wp-content/uploads/2013/12/Geo7Series_UserGuide.pdf\

Appendix C

Watershed Treatment Model Manual

Watershed Treatment Model (WTM)
2013 User's Guide

Funding Provided By:
US EPA Office of Wetlands Oceans and Watersheds
Altria Foundation
Cooperative Institute for Coastal and Estuarine Environmental Technology

June, 2013

Deb Caraco, P.E.
Center for Watershed Protection, Inc.

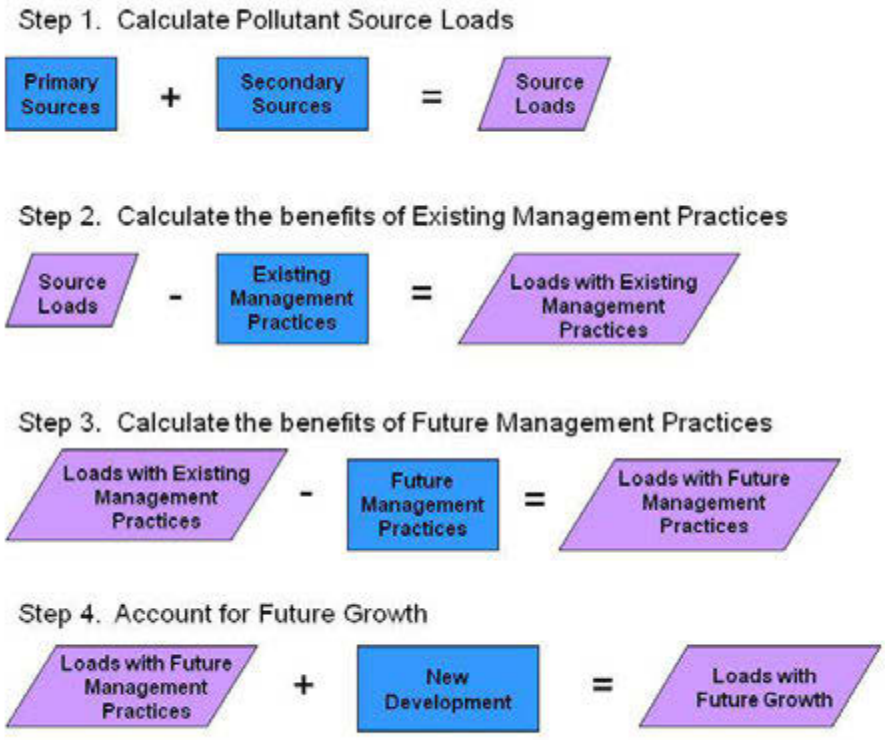

Figure 1. WTM Model Structure

Primary Sources
This worksheet summarizes the loads from sources that can be determined solely by land use. It requires basic land use information and calculates surface runoff loads. In addition, it requires basic watershed data, such as annual rainfall, stream length, and soils distribution. The loads calculated in this worksheet incorporate data from the "turf management" section of the "existing management practices" tab (see page 6), and model default values reflect typical lawn care practices.

Secondary Sources
Secondary sources are pollutant sources that cannot be calculated based on land use information alone. Many of these sources, such as CSOs and SSOs, are at least partially composed of wastewater.

Existing Management Practices
This sheet reflects programs currently in place to control loads from urban land. Users need to input information about the effectiveness and level of implementation of various programs and practices.

This sheet, and other sheets in the WTM that quantify program implementation, ask the user to input "discount factors" for each practice. "Discount factors" are used to reduce the ideal (i.e., literature value) load reductions for a practice that can rarely be achieved. For example, structural practices may lack space or have poor maintenance that can hamper practice effectiveness over time. For programmatic practices, such as lawn care education, only a fraction of the population may implement the recommendations put forward in the educational program. In both of these cases, specific design features for structural practices, or marketing approaches for education and outreach techniques can make the practice more effective. While some discount factors have default values, the WTM asks the user to input values for others In each case, the model provides guidance to select appropriate values.

Future Management Practices
This sheet reflects the planned extent of programs to control loads from urban land. By default, the model populates this sheet with values from the "Existing Management Practices" sheet. The user then enters data that describe proposed or "future" management practices given the same existing land use.

Retrofit Worksheet
Stormwater retrofits are BMP put in place after development has occurred. The retrofit worksheet allows the user to input individual stormwater retrofit practices. These are then reported in the "Future Management Practices" sheet.

Future Land Use
In this sheet, the user enters the projected future land use in the watershed. Land use can be determined from comprehensive planning or zoning documents, or forecasted using other methods. If no data are entered in this tab, the model default is to assume no growth in the watershed.

New Development
This sheet calculates the loads from future development, based on future development in the watershed, and proposed future treatment. The sheet calculates new "primary source" loadings based on the increase in area of certain land uses, then asks the user to describe the types of stormwater controls on new development. Next, it adds secondary sources, such as loads from new OSDS customers and wastewater treatment plant loads. Finally, it calculates the loads from active construction as land is developed.

Display Sheets
Three sheets display final loads and runoff volumes: *Existing Loads, Loads with Future Practices*, *Loads Including Growth*. These sheets simply sum up the loading from other sheets, and partition them into surface (both storm- and non-storm) and groundwater loads.

SECTION 2. DATA ENTRY OVERVIEW

Although the WTM is a simple model, it requires significant data input. In addition, no part of the spreadsheet is write protected, in order to allow for maximum flexibility. These decisions put a great deal of responsibility on the user, and some guidelines need to be followed to prevent errors in algorithms. This section describes some components of the WTM designed to facilitate the data input process, as well as some tips for tracking down and avoiding errors in the model.

Color Coding

In order to make data entry easier, cells are coded in four colors: green, blue, grey and purple.

BLUE CELLS must be filled out, unless a pollutant source or treatment option is not being considered. For example, the acres of commercial land only need to be filled out only if commercial land is in the watershed.

YELLOW CELLS represent model defaults that a user may want to modify. Examples include pollutant concentrations and practice efficiencies.

GREY CELLS have been calculated, and typically should not be overridden. Examples include practice load reductions.

PURPLE CELLS represent "bottom line" calculations, such as load reductions or final loads.

The worksheets of the WTM are also color coded. Of the ten tabs of the WTM, three are strictly for output, and have a purple tab color, while the remainder are green to indicate that data entry is needed.

"Pop-Up" Guidance and Comments

Many pieces of input data require some judgment on the part of the user. By clicking on many of the green cells (particularly those for discount factors), a "popup" message will appear with guidance for data values (Figure 2).

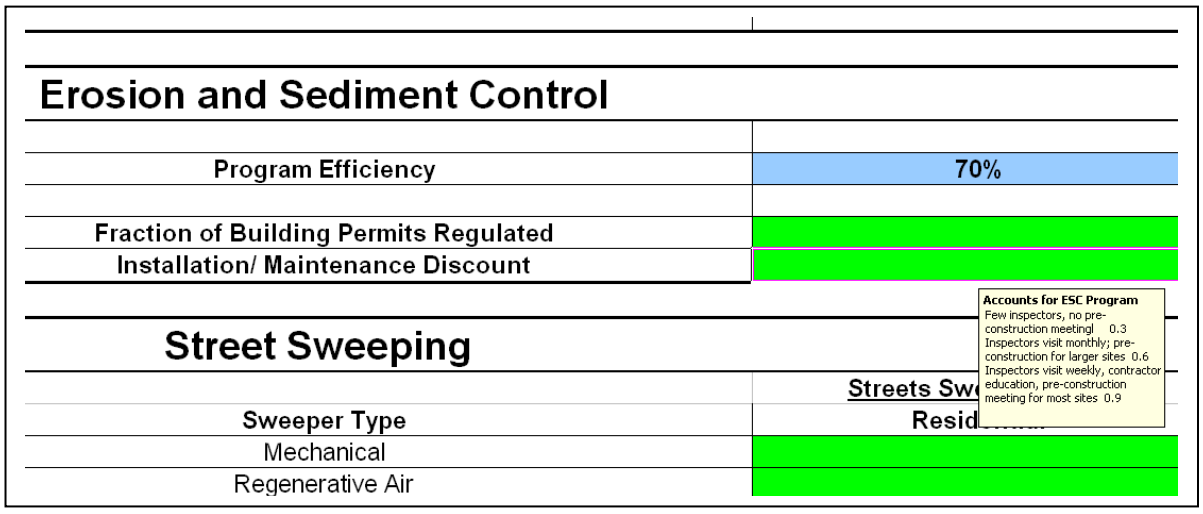

Figure 2. Example Pop-Up Guidance for the Installation/Maintenance Discount for ESC programs

Pull-Down Menus

While many of the data in the WTM require a number value, some of the inputs are multiple choice (e.g., type of practice) or "yes/no" (e.g., Do you have a program for…") questions. The WTM uses "pull down menus" for these questions. For these cells, the user should not (and cannot) select an option that does not appear in the menu.

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SECTION 3. DATA ENTRY DETAILS

This section describes in detail the data entry requirements of each worksheet of the WTM. It separates the discussion by worksheet (for each calculation sheet), but "Existing Management Practices" and "Future Management Practices" are discussed together because of the overlap between the two.

Primary Sources

This worksheet has four major sections: *Land Use*, *Partitioning Coefficients for Rural and Forest Land*, *Watershed Data*, and *Soils Information*. Data Requirements for each are as follows:

Land Use

The user is required to enter the area of each land use category. If there is a land use that is not in included the model but it is present in the watershed, the user should type in the land use category (Figure 4) and enter in appropriate values to characterize the land use in the blue cells listed below. In addition, users may override model defaults for land uses included in the model for the following data (blue cells):

- Impervious Cover %
- Turf %
- Pollutant Concentrations
- Pollutant Loading rates/R1:49:38 PMunoff Rates (lbs/acre, billion/acre or in/year). Note that, for rural and agricultural land uses, loading rates should be entered directly, since they are not determined from concentrations and runoff calculations for these land uses.

PRIMARY SOURCES - Land Use
Watershed

				Concentrations			
		Area (Acres)	Impervious Cover (%)	Turf Cover (%)	TN (mg/l)	TP (mg/l)	TSS (mg/l)
Category	Detailed Description						
Residential	LDR (<1du/acre)		12%	70%	2.1	0.31	49
	MDR (1-4 du/acre)		21%	63%	2.1	0.31	49
	HDR (>4 du/acre)		33%	54%	2.1	0.31	49
	Multifamily		44%	45%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
Commercial	Commercial		72%	22%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
Roadway	Roadway		80%	16%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
Industrial	Industrial		63%	38%	2.2	0.25	81

Figure 3. Land Use Data in the Primary Sources tab. The user needs to enter land areas (green) and may override turf and impervious cover, and pollutant concentration values.

Partitioning Coefficients for Rural and Forest Land

This section includes model defaults determining the fraction of the load from forest and rural land that occurs during storm events, versus as extended baseflow. These can be overridden if better information is available for your watershed.

Watershed Data

This section requires entry for annual rainfall and total stream length. The WTM will return errors if these values are not entered.

Soils Information
This section asks the user to describe the soils in terms of Hydrologic Soils Group (A, B, C or D) by entering the percent of the watershed soils in each category. It also asks the user to enter the break-down of soil type based on depth to groundwater (again, describing the percent of the watershed in each category).

Model defaults in this section include runoff coefficients for each land cover category (Turf, Forest, and Rural). For other land covers, the user may enter runoff coefficients in the green cells (columns I through M). Note that the runoff coefficient for turf also takes into account information provided in the *Turf Management* practice on the "Existing Management Practices" sheet.

Secondary Sources
The secondary sources worksheet sums the loads from sources that cannot be determined by land use alone, such as channel erosion or illicit discharges. The data sheet is structured so that data are entered in smaller tables, or sections of the sheet. With the exception of the general sewage use data and channel nutrient concentration provided at the top of the sheet, each section corresponds to a specific secondary source. The required data for this sheet is summarized in Table 1.

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
General Sewage Use Data	Number of single-family, detached dwelling units	• Individuals/unit • Water use/individual • Wastewater pollutant concentrations	These data are needed to compute loads from OSDSs, SSOs, CSOs, Illicit Connections
Nutrient Concentrations in Stream Channels	Concentrations	Enrichment Factor	Figure 5 provides one source for these data. Used in combination with Channel Erosion data to calculate the nutrient loads from channel erosion.
On-Site Sewage Disposal Systems (OSDSs)	• % of Dwelling Units Unsewered • % of OSDSs <100' from waterway • Soils (from pull-down menu) • System type (% of each type of system) • Description of Management (inspection and maintenance) from pull-down menu • Separation distance from groundwater • Density (#/acre)	• Failure rates (calculated from other factors) • Decay of bacteria (% reaching the surface waterway) • Delivery ratio for nutrients • Efficiencies for each OSDS type	Required data are often available from the health department or other agency responsible for OSDS management. If the user enters "other" for a system type, the efficiency ***must*** be entered.

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
SSOs	• Miles of sanitary sewer	• Overflows/1,000 miles • Volume per overflow • Fraction of load as storm flow (to partition between storm and non-storm loads)	These sections are a broad estimate of diffuse wastewater sources. If available (e.g., from an SSO/CSO or IDDE study) these data may be directly entered in the Summary table (purple cells) at the bottom of the Secondary Sources worksheet.
CSOs	• Median storm event (inches) • Sewershed area (acres) • Sewershed Impervious Cover (%)	• # CSOs/year (calculated) • Capacity of CS System (rainfall depth in inches) • CSO pollutant concentrations.	
Illicit Connections	• Fraction of watershed population illicitly connected • Number of businesses	• Fraction of businesses with illicit connections. • Characterization of businesses wash water • Business wastewater flow in gpd.	
Urban Channel Erosion	Method of calculation (Methods 1-3) from pull-down menu. All data inputs described are required data. **Method 1. Estimate based on typical estimates:** General Assessment of Channel Erosion (Low, Medium, High) **Method 2. Back calculate based on known sediment loading.** Total watershed loading (lbs TSS/year) based on monitoring data. **Method 3. Estimate based on other study results.** Sediment Load from Channel Erosion (tons/year)		The WTM offers three options for calculating urban channel erosion. Data required varies depending on the method used. Each method requires progressively more data, and provides a more accurate representation of the watershed.

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
Livestock	# of animals in each category	• % of animals exposed to runoff • Load (lbs/animal/year or billion/animal/year) • Delivery ratios of nutrients and bacteria	
Marinas	• Berths • Length of season (days)	• Occupancy (fraction of the season) • Flow rates (gallons/capita/day) • Individuals/boat	This "untreated" estimate can be significantly lowered by the "marina pumpout station" practice in Existing Management Practices.
Road Sanding	• Sand application (lbs/year) • Fraction of roads open section	• Delivery ratio (sand to the receiving water) for closed section roads. • Delivery ratio for open section roads.	This untreated estimate can be partially remedied by street sweeping.
Non-Stormwater Point Sources	• Flow (Millions of gallons/day) • Concentrations (mg/l or MPN/100 ml)	• Loads (lbs/year or billion/year)	Data can be gathered from Discharge Monitoring Reports (DMRs) for NPDES discharges

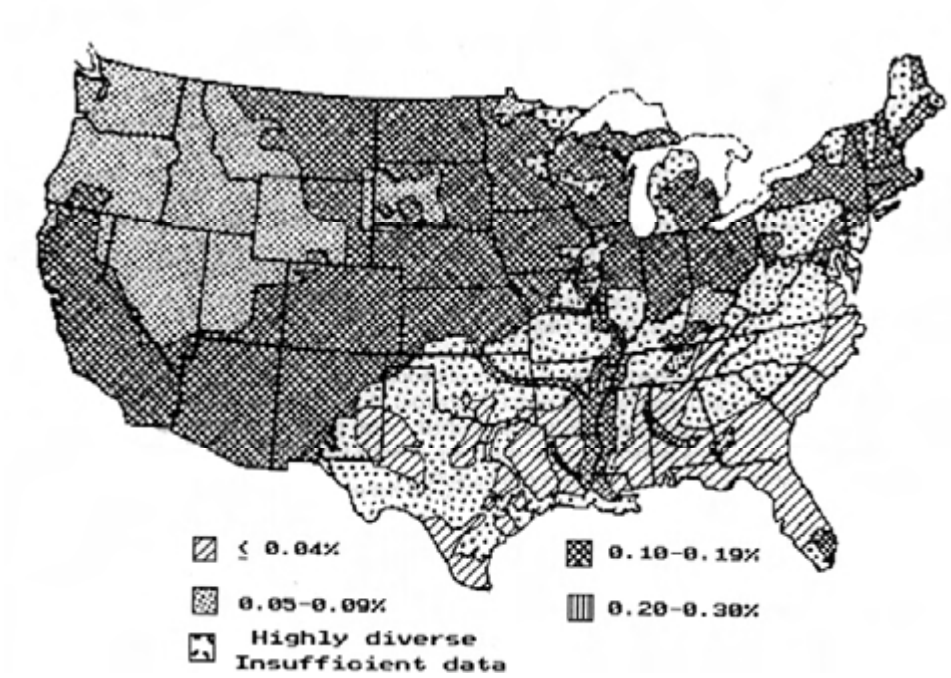

Figure 4. Soil N/P concentrations (by % mass in soil). From Haith et al., 1992

Existing and Future Management Practices

These two worksheets calculate the benefits of practices and programs in the watershed. Current land use conditions are used for the Existing and Future Management Practices worksheet (e.g. does not consider future changes in land use within the watershed). The practices entered into the Existing Management Practices worksheet are carried over to the Future Management Practices. However, additional practices and program options for non-structural practices are included in the "Future Management Practices" section. A description of the practice types and their data input is provided in Table 2. While the specific data for each practice varies, some of the discount factors appear for several practices, including the following:

- **Awareness Factor:** Applied to all educational programs, the awareness factor reflects the % of people who remember an educational message.
- **Maintenance Factor:** Typically applied to structural practices, this factor reflects the maintenance of practices over the long term.
- **Design or Technique Factor:** Reflects the quality of the practice design
- **Implementation**. Reflects the fraction of long-term capitol projects identified (e.g., SSO removal) that are implemented.

By default, the WTM will use the values from the "Existing Management Practices" worksheet for the "Future Management Practices" values. If expanded coverage of a particular practice is proposed, the user should enter values for the future condition. For example, if the watershed currently has 5 miles of riparian buffer, and a management plan proposes is to expand this by one mile, the data on the "Future Management Practices" tab should be edited by the user to include 6 miles of buffer.

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
Practices on the Existing Management Practices Sheet Only			
Turf Condition and Management Practices - Residential	• % of lawns bare/compacted • % of homes <10 years old • % off lawn area "highly managed" (high input)	• Residential turf area (calculated from Primary Sources) • Typical fertilizer applications/year • Fertilizer rate (lbs N/acre) • Distribution of fertilizer type (by %) • N and P analysis of fertilizers	Data for bare and compacted lawns and "highly managed" lawns can be gathered from field surveys. Fertilizer use and application rates are default values but can be replaced with survey or fertilizer sales data. Fertilizer losses are incorporated as a primary source (in loading rates) and as a secondary groundwater source. The turf runoff coefficient (on the primary sources tab) is modified based on the % if bare/compacted lawns.
Turf Condition and Management Practices – Other	• Management compared to residential turf (pull-down menu). Choices are "Same", "Comparatively High Management/Input", or "Better management/ nutrient management"	• Turf area calculated from Primary Sources	The simplified approach for this source "scales" loading compared with residential lawns rather than asking users for a separate assessment.
Structural Stormwater Practices	• Drainage areas to each practice • Impervious Area draining to each practice • Capture Discount (annual rainfall captured) • Design Discount • Maintenance Discount	• Turf area draining to each practice • Efficiencies and runoff reduction (%)	Although structural stormwater practices can be modified or added in the future condition, these practices are considered "Stormwater Retrofits" and accounted for separately. The model includes pop-up guidance for each discount factor.

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
Practices on Both Sheets			
Pet Waste Education*	• Program in Place (yes/no pull-down) • Number of dwelling units (unless already entered on the "Secondary Sources" worksheet) • Awareness of the Message	• Characteristics of the population (dog owners, fraction who clean up) • Fraction of the population willing to change their behavior. • Dog waste characteristics (waste production and pollutant concentrations) • Delivery factors (fraction of pollutants that reach the receiving water)	Concentrations in the "Primary Sources" tab include loads from pets. Consequently, the benefits of these programs will be subtracted from the "base loads" calculated in the primary and secondary sources tabs.
Erosion and Sediment Control	• Fraction of building permits regulated • Installation/ Maintenance discount	• Program efficiency	The model defaults and the recommended discounts can be refined based on field experience of ESC inspectors.
Street Sweeping	• Area Swept for residential streets, other streets, and parking lots. • Type of sweeper used • Sweeping frequency • Technique discount	• Sweeper efficiencies for TSS and nutrients	
Riparian Buffers	• Buffer length (miles) • Buffer width (feet) • Maintenance factor	• Buffer efficiencies • Treatability (fraction of the watershed captured). Calculated from other values.	Collect original buffer data from aerial photographs and field surveys. For the future condition, consider proposals to reforest the buffer, or to expand buffer protection.
Catch basin cleanouts	• Area captured (imperious cover) • Cleaning frequency • Disposal discount	• Efficiencies	
Marina Pumpouts	• Number of pumpouts	• Total number of berths (same as the value from "marinas" on the secondary source sheet) • Boats served per station • Fraction of owners willing to use	

Note: Cells in red font will show an "Enter Value" message if data entry is needed. If no data are entered, an error will result.

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
Practices on the Future Management Practices Sheet Only			
Residential Lawn Care Education	• Awareness of the Message • Yes/No pull-down menus to ask if several specific lawn care education programs are in place	• Turf area • Additional forest area (from turf conversion) • Revised fertilizer application rate • Distribution of fertilizer type (by %) • N and P analysis of fertilizers • Ease of implementation for each education program type	The WTM uses the same calculations to calculate Nitrogen and Phosphorus loss, but uses the forecasted results of a future education program to revise fertilizer application rates. One program goal (Add soil amendments to lawn) is actually recorded on the "Retrofit Worksheet" described on the following pages.
Residential Impervious Cover Disconnection	• Program in place (yes/no from pull down menu) • Fraction of land where applicable • Fraction of population reached by the message	• Roof area (square feet) • Fraction willing to participate	The area of disconnection produced from this program is recorded as a stormwater retrofit, and appears in the stormwater retrofit worksheet.
Urban Downsizing	• Fraction Implemented (i.e., % of planned land conversion that happens) • Acres of urban land (in each land category) converted to another use • Acres of other land use created	• Loading and runoff rates for each land use	This practice applies only to a planned urban downsizing. If another land use is created or converted, the user will need to override the land use categories and loading rates.
Redevelopment with Improvements	• Land to be redeveloped (acres) • Impervious cover reduction (%) • Turf reduction (%)	N/A	
Stormwater Retrofits	N/A	N/A	Retrofit benefits are summarized on the Future Management Practices Worksheet, but data entry are in the Retrofit Worksheet

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
Channel Protection	• Assessment option (from pull-down menu) **No Channel Protection** **Option 1: Estimate based on miles of stream stabilized** • Portion of stream channel unstable • Miles of stream channel stabilized • Fraction of watershed with flow control for the 1-year storm event. **Option 2: Enter Total Anticipated Removal** • Sediment removal (tons/year) • Phosphorus and Nitrogen Removal (lbs/year)	• For option 1, miles of unstable channel is calculated	Channel protection refers to in-stream channel protection measures. The model allows separate options to allow the user to input local values from a detailed stream study that may have resulted in estimated removals that may differ from the model default. The model default values are considered conservative,
Illicit connection removal	• Fraction of system surveyed • Fraction of repairs made	N/A	These wastewater source reduction measures all calculated reductions by multiplying the user defined fraction or reduction in events by the fraction completed over the planning horizon timeline times the load from the original secondary source load.
CSO Repair/Abatement	• CSO Events after Repairs • Fraction complete		
SSO Repair/Abatement	• Goal (% reduction) • Fraction complete		
OSDS Education	• Program (yes/no pull down menu) • Awareness of the message • Fraction willing to change behavior		OSDS education and repair measures are combined to change the characteristics of the "OSDS" load. The WWTP load resulting from retiring OSDSs is subtracted from the "point source reduction" benefit. If the retired systems are directed to a
OSDS Repair	• Program (yes/no pull down menu) • Fraction inspected • Percent willing to repair		

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	**Required Data (Green Cells)**	**Model Default Data (Blue Cells)**	**Notes**
OSDS Upgrade	• Program (yes/no pull down menu) • Fraction inspected • Fraction willing to upgrade • Type of upgrade system • System efficiencies (if "other" selected as system type)	• System efficiencies (except for "other")	treatment plant in another watershed, override the WWTP loads and change them to 0.
OSDS Retirement (convert to WWTP)	• Fraction of systems inspected • % failing among retired systems • % w/in 100' of a waterway among retired systems • WWTP Efficiencies	• WWTP loads	
Point Source Reduction	• Reduction (lbs/year of billion/year)	• WWTP load (negative) from OSDS retirement	

Retrofit Worksheet

The retrofit worksheet is a worksheet to enter individual stormwater retrofit practices. Stormwater retrofits are a type of future management practice. The Retrofit Worksheet allows the user to enter detailed design information for each practice. The worksheet asks for general practice information (and data entry options) at the top of the sheet, and then asks for individual practice information in the main section of the worksheet in the "Basic Site Information" table. (Figure 6)

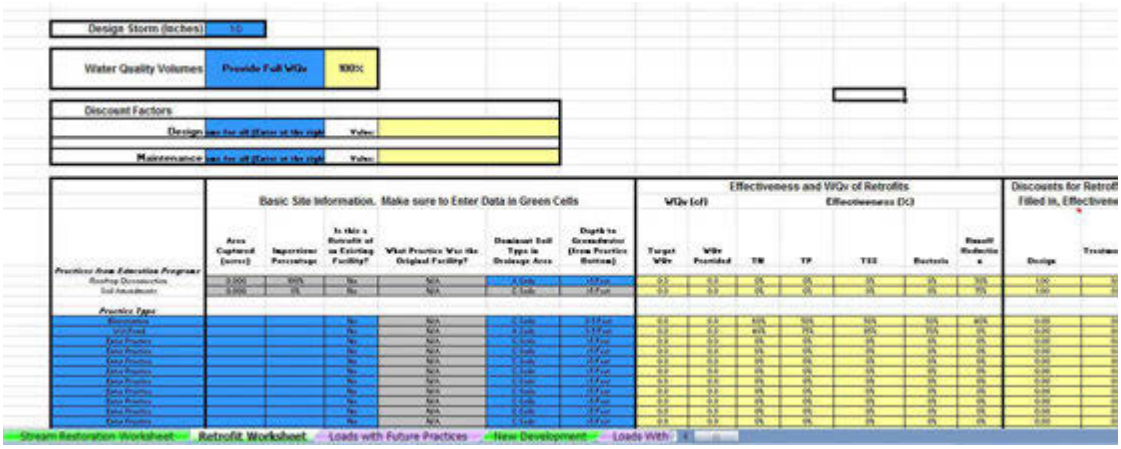

Figure 5. The Retrofit Worksheet, showing the generalized information at the top and individual practice data at the bottom (main section).

Design Storm:

The top of the retrofit worksheet asks the user for the design storm (in inches). This value should reflect the water quality design storm (typically about 1"). This is a critical value that needs to be entered.

Water Quality Volume (WQv)
The target WQv for each practice is the runoff volume from the design storm. Ideally, practices would be sized to capture this volume, but in some cases (particularly for retrofits) the practice cannot be sized to capture the entire volume. In the upper portion of the retrofit worksheet, the user selects from a pull-down menu to determine how to enter the water quality volume, among three choices:

Option 1. Provide the full water quality volume at all practices
If the user chooses this option, no further data entry is required.

Option 2. Provide a consistent fraction of the water quality volume (e.g., 80% of the Target WQv for all practices)
For this option, the user needs to enter the % of the WQv provided in all sites. The value will be entered in cell E5. When this data entry option is selected, an "Enter Value" value appears in this cell.

Option 3. Provide a different water quality volume at each site.
If this option is selected, the user needs to enter the WQv for each practice (in Column J) under the "WQv Provided" heading.

The third option provides the most flexibility, so it is the best choice when a detailed retrofit inventory has been conducted and design information is available. The other options presented represented a way to evaluate "what if" scenarios across a wide range of practices.

Discount Factors
For the design and maintenance factors, the user may either select a single value for all practices (entered in Column F), or to enter a different value for each practice. Note that, if the "Varies" option is selected, the discount factors need to be entered for each practice, in columns P and R. (Scroll over to enter these data).

Basic Site Information
For each practice, select the practice type from the pull-down menu. For each practice, the basic required data includes the following:

- Area captured (acres)
- Impervious Percentage
- Soil in the drainage area
- Depth to groundwater (from practice bottom)

This section also asks the user if this is a "new" retrofit or a retrofit of an existing facility. If the practice is a retrofit of an existing facility, such as a conversion of a dry pond to a wet pond, the user selects the type of *original* practice from a pull-down list.

Effectiveness and WQv of Retrofits
This section of the retrofit worksheet provides the target water quality volume. If the WQv needs to be input, an "Enter Value" will appear in the cells in Column J. Effectiveness (%) will be derived from a look-up table, depending on the practice type, but the user will need to input values if "Other" is selected as a practice option.

Effects of the Original Practice
The WTM reports the pollutant removal of the original practice (if this practice is a retrofit of an existing practice). In general, these cells should not be modified, but may be overridden if the user has detailed data about the effectiveness of a particular existing practice.

Practices from Education Programs
Data for rooftop disconnection and soil amendments are imported into the retrofit worksheet from the "Future Management Practices" sheet. The user does not need to enter data in these sections, although the soil type or other practice features can be modified as needed.

Future Land Use
This tab is simply a forecast of future land use or land cover in the watershed. The only caveat for this portion of the WTM is that the land use categories **must be the same** as those reported in the Primary Sources tab, or errors will occur. Another potential error on this sheet results when total land area either exceeds or is less than the original watershed area. The value under "Total Acres" will report an error if the areas are not the same.

New Development
This sheet includes four sections of data input: New Development, Controls on New Development, Data to Quantify Wastewater Loads, and Active Construction. Data requirements for each section are as follows:

New Development
This section sums the uncontrolled pollutant loads from new development. No data entry is needed, but the user can modify the characteristics of each land use category by adjusting pollutant concentrations, impervious cover and turf cover for each land use type.

Stormwater Controls on New Development
This section describes and quantifies the benefits of stormwater controls to be implemented on new development. The WTM allows three different program options. Each of these options reflects stormwater regulations that are used throughout the United States.

> Option 1: Meet a specific pollutant removal target
> If this option is selected, the user needs to enter the removal efficiencies in cells marked "Enter Value" next to the "Target % Removal" row.
>
> Option 2: Meet a target load
> If this option is selected, the user needs to enter the target load in lbs/acre/year, billion/acre/year inches/year (for runoff volume).
>
> Option 3: Show no net increase in load on each parcel
> If this option is selected, no further data are needed.

Discount Factors

Four discount factors (% regulated, capture discount, design discount, and maintenance discount) are applied to the target removals. By default, the data in these cells is derived from data in the "Existing Management Practices" and "Future Management Practices" sheets. While no data are required in this section, the user may override these default values to reflect different levels of program implementation in the future.

Channel Protection

Enter "yes" to answer the question, "Is channel protection required?" if there is some requirement in place to control small (1-year) storms either through detention or runoff reduction, in order to protect stream channels.

Data to Quantify Wastewater Loads

This section requires data to quantify the loads from future wastewater sources, including OSDSs, SSOs, CSOs, Illicit Connections, and WWTP Dischargers. This section uses simplified calculations to forecast loads from these sources. Data required are summarized in Table 3.

TABLE 3. DATA REQUIRED TO CALCULATE FUTURE WASTEWATER LOADS

Source	Data Required
OSDS	• New OSDS customers • OSDS failure rate • OSDS efficiency (High/medium low) compared to the current systems.
SSOs	• Miles of sewer constructed • SSOs/mile
Illicit Connections	• Percent of population illicitly connected
WWTP Discharges	• New wastewater customers (households) • WWTP Efficiency

Active Construction

The WTM calculates loads from active construction based on three user inputs: the program efficiency, % of new development regulated, and the "Maintenance Discount." By default the WTM imports data from the "Future Management Practices" worksheet, but these data may be adjusted by the user.

SECTION 4. INTERPRETING OUTPUT DATA

Final model results are reported in three summary sheets: Loads with Existing Practices, Loads with Future Practices, and Loads with New Growth. Each of these sheets uses exactly the same format (See Figure 6). The summary output sheets divide the load into two categories: Loads to Surface Waters, and Loads to Groundwater. The loads to Surface Waters are then further subdivided into Storm Loads (e.g., urban runoff) and Non-Storm Loads (e.g., Illicit Discharges).

Existing Loads to Surface Waters

	TN lb/year	TP lb/year	TSS lb/year	Fecal Coliform billion/year	Runoff Volume (acre-feet/year)
Urban Land	-	-	-	-	-
Active Construction	-	-	-	-	-
SSOs	-	-	-	-	-
CSOs	-	-	-	-	-
Channel Erosion	-	-	-	-	-
Road Sanding	-	-	-	-	-
Forest	-	-	-	-	-
Rural Land	-	-	-	-	-
Livestock	-	-	-	-	-
Illicit Connections	-	-	-	-	-
Marinas	-	-	-	-	-
Point Sources	-	-	-	-	-
Septic Systems	-	-	-	-	-
Open Water	-	-	-	-	-
Total Storm Load	-	-	-	-	-
Total Non-Storm Load	-	-	-	-	-
Total Load to Surface Waters	-	-	-	-	-

Existing Loads to Groundwater (Contributed from Urbanization). Note. Model does not deliver to receiving surface waters.

	TN lb/year	TP lb/year	Fecal Coliform billion/year
Urban Land	0	-	-
Septic Systems	-	-	-
Total	0	-	-

Figure 6. Output from the "Loads with Existing Practices" Worksheet

Surface Loads

While the WTM is not a continuous model, some users find it useful to separate "storm loads" from "non-storm loads." This is particularly true for bacteria loads, where violations typically occur during storm events.

Loads to Groundwater

Although the WTM is not a groundwater model, it does estimate the loads (from urban land and OSDSs) delivered to the groundwater. It is important to note that the WTM *does not* estimate the amount of this load that is ultimately delivered to the surface water. However, it *does* account for soil infiltration, so it reflects expected delivery to the groundwater system, rather than the entire mass of pollutants infiltrated.

Summaries on Other Sheets

Many of the calculation sheets also offer some summary data that may be useful for comparing practice options. These data are summarized in Table 4.

TABLE 4. DATA REQUIRED TO CALCULATE FUTURE WASTEWATER LOADS

Sheet	Summary Data	Notes
Primary Sources	Annual Surface Loads (pre-BMP) for each land use and summed in Columns P through U Total loads are divided into *storm* and *non-storm* components	The summary data on this sheet are coded grey because they are not highly useful. Although these summaries compare the contributions from each land use, the data can be deceptive because they do not include BMP implementation.
Secondary Sources	The purple cells at the bottom of the sheet report pollutant loads from each secondary source. These loads are then summed and divided into storm load, non-storm load, and loads to groundwater.	These data can be useful, but also do not include BMP implementation.
Existing Management Practices	The summary sheet at the bottom of the page (purple cells) tabulates the load reduction (or runoff reduction), from each practice The summary the divides the total load into storm, non-storm and groundwater components.	Some load reductions may be negative. This *negative reduction* actually represents an *increased load* resulting from a management practice. One example of this is the load from infiltration practices to the groundwater. The purple cells in the Future Management Practices sheet are the most useful, since they reflect the benefit of the proposed practices.
Future Management Practices	These load reductions are summarized in two sections. Grey cells reflect the load reductions from *all practices* (both existing and future). Purple cells reflect the *net reduction* from future management practices.	
Retrofit Worksheet	The benefits, and loads to groundwater, of each practice are summed in the purple cells to the right. In addition, the model sums the total benefits from each practice.	All of these data are transferred to the Future Management Practices sheet, and aggregated by practice type.
New Development	The net additional load from each source is summed at the bottom of this sheet in purple cells.	

REFERENCES

Haith, D., R. Mandel and R. Wu. 1992. *Generalized Watershed Loading Functions, Users's Manual.* Daprtment of Agricultural and Biological Engineering. Cornell University. Ithaca, NY

Appendix D

Model Input Data Needs and Sources

Watershed Treatment Model – Input Parameters and Sources

Data	Type	Need	Data Source
Watershed/ subwatershed boundary	ArcGIS FileGDB	Required for delineating watershed and subwatershed areas	CT DEEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=322898&depNav_GID=1707&depNav=| Watershed and Drainage Basins- 2006 Edition.
Land use and Land Cover	Raster dataset ESRI Shapefile	Required for defining land use distribution	UConn CLEAR 2010 Land Cover Data http://clear.uconn.edu/projects/landscapeLIS/galleryLC/map.html?webmap=a1ab06fea59149cebef945d28b32a2bb November 2012 Naugatuck Valley Council of Governments (NV COG) http://www.nvcogct.org/content/map-gallery-0 released October 2016
Hydrologic Soil Group	ESRI Shapefile	Required for drainage characteristics	CT DEEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=322898&depNav_GID=1707&depNav=| SSURGO database for State of Connecticut- March 2007
Rivers/ Streams	ArcGIS File GDB	Required for stream channel erosion calculations, riparian buffer locations, and proximity of on-site sewage disposal systems.	CT DEEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=322898&depNav_GID=1707&depNav=| Hydrography: Connecticut Hydrography (Line and Polygon)- 2005 Edition.
Surface waters	ESRI Shapefile	Required for defining land use distribution, and determining proximity of on-site disposal systems to water bodies.	CT DEEP http://www.ct.gov/deep/cwp/view.asp?a=2698&q=322898&depNav_GID=1707&depNav=| Connecticut Named Waterbody (Line and Polygon)- 2005 Edition.

Data	Type	Need	Data Source
EMCs	Literature values	Required for defining pollutant concentrations associated with land use	McCarthy, Jillian, 2008. *New Hampshire Stormwater Manual Volume 1: Stormwater and Antidegradation, December 2008*. http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_apxd.pdf. New York State Department of Environmental Conservation, 2001. *New York State Stormwater Management Manual. Appendix A: The Simple Method to calculate Urban Stormwater Loads.* http://www.dec.ny.gov/docs/water_pdf/simple.pdf Beta Group, Inc, 2006, *Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts.*
Impervious cover	Literature values; Raster data	Required for defining percent of impervious cover and subsequent runoff contribution pertaining to each land use.	Multi-Resolution Land Characteristic Consortium (MRLC) http://www.mrlc.gov/ National Land Cover Database- 2011 NLCD impervious. October 10, 2014 Edition.
Annual Rainfall	Data table	Required for runoff calculations	NOAA National weather service. http://water.weather.gov/precip/
Dwelling units and population data	ESRI Shapefile	Required for sewage use calculations	MAGIC. http://magic.lib.uconn.edu/connecticut_data.html- 2010 Census Data- released in 2010.
Nutrient concentration in stream channels	Literature values	Required for pollutant loading from stream channel erosion	Haith, D., R. Mandel, and R. Wu. 1992. Generalized Watershed Loading Functions, User's Manual.

Data	Type	Need	Data Source
Septic System Maintenance	Septic system records	To determine if there are failing septic systems in the study area	Pomperaug Health District Information/data
Sewage Treatment Plants	ESRI Shapefile	Indicates where sewage treatment plants are located along Rivers	MAGIC. http://magic.lib.uconn.edu/connecticut_data.html. Connecticut Sewage Treatment Plants- released in 1999.
Sewer Service Areas	ESRI Shapefile	Helps to define areas that have public-disposal of septic vs. septic systems	MAGIC. http://magic.lib.uconn.edu/connecticut_data.html. Connecticut Sewer Service Areas- released in 1998.
Bank stability/ channel erosion	Field assessments	Required for pollutants associated with stream degradation	Field assessments
Livestock	Field assessments	Required for pollutant load calculation from livestock	Field assessments
Road sanding application	Literature values; Town information	Required for pollutant load calculation from road sanding	Relevant municipalities; National Research Council, 1991. *Highway Deicing Comparing Salt and Calcium Magnesium Acetate*-- Special Report 235.
Acres and length of roads	ESRI Shapefile	Road sanding, catch basin clean out calculations	MAGIC, http://magic.lib.uconn.edu/connecticut_data.html Connecticut Roads, released 1984 or OpenStreetMap, http://www.openstreetmap.org/#map=6/51.255/-4.526 Released October 2016
Catch basin clean out schedule	Town information	Required to calculate benefit from catch basin cleaning BMP	Relevant municipalities
Street sweeping schedule	Town information	Required to calculate benefit from street sweeping BMP	Relevant municipalities

Data	Type	Need	Data Source
Aerial photography	Photography	Required for desktop assessment and data checking	CT ECO http://www.cteco.uconn.edu/help/info_orthos2012.htm February 2013.
Storm water drainage information	Field assessments	Required for pollutant delivery ratios for road sanding and catch basin cleanouts	Field assessments, relevant municipalities
Parcel information	ESRI Shapefile	Required for determining proximity of land use disposal systems to water bodies	Relevant municipalities
Marinas - berths and pumpouts	Field assessments/ desktop assessment	Required if watershed contains marinas for pollutant source calculations	Aerial photography, business websites
Turf Area	Raster dataset ESRI Shapefile	Required for area of turf management practices	UConn CLEAR 2010 Land Cover Data http://clear.uconn.edu/projects/landscapeLIS/galleryLC/map.html?webmap=a1ab06fea59149cebef945d28b32a2bb November 2012 Naugatuck Valley Council of Governments (NV COG) http://www.nvcogct.org/content/map-gallery-0 released October 2016
Fertilizer Use	Survey/ Field Assessment	Required for area of turf management practices	Survey, field assessment, relevant municipalities.
Practices of households with dogs	Survey	Required for pet waste contributions	Survey

FUSS & O'NEILL

Appendix C

Technical Memorandum – Pollutant Loading Model

Pomperaug River Watershed Based Plan

FUSS & O'NEILL

MEMORANDUM

TO: Pomperaug River Watershed Coalition (PRWC)

FROM: Erik Mas, P.E, Stefan Bengtson, MSc

DATE: March 5, 2018; **Revised September 27, 2018**

RE: **Pollutant Loading Model**
Pomperaug River Watershed Based Plan

This memorandum summarizes the methods and results of a pollutant loading model that was developed for the Pomperaug River Watershed. The model is used to support the development of a watershed-based plan for the Pomperaug River watershed.

1. Introduction

The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection, was used to estimate annual pollutant loads from the following Connecticut Subregional Drainage Basins (also referred to as "subwatersheds" in this document) located within the larger Pomperaug River Regional Basin watershed (**Figure 1**):

- East Spring Brook
- Hesseky Brook
- Nonnewaug River
- Pomperaug River
- Sprain Brook
- Transylvania Brook
- Weekeepeemee River.

The WTM is a screening-level model that can be used to estimate the loading of pollutants to a waterbody based on land use and other activities within a watershed. Based on user-specified input describing characteristics of the watershed, the WTM estimates pollutant loads from various land uses and activities, as well as load reductions associated with structural and non-structural best management practices. While fecal indicator bacteria impairments are the primary focus of the watershed based plan, the WTM also provides loading estimates for other pollutants including total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN). BMPs that will be recommended in the watershed based plan will not only help to reduce bacteria but may also help to reduce these other pollutants.

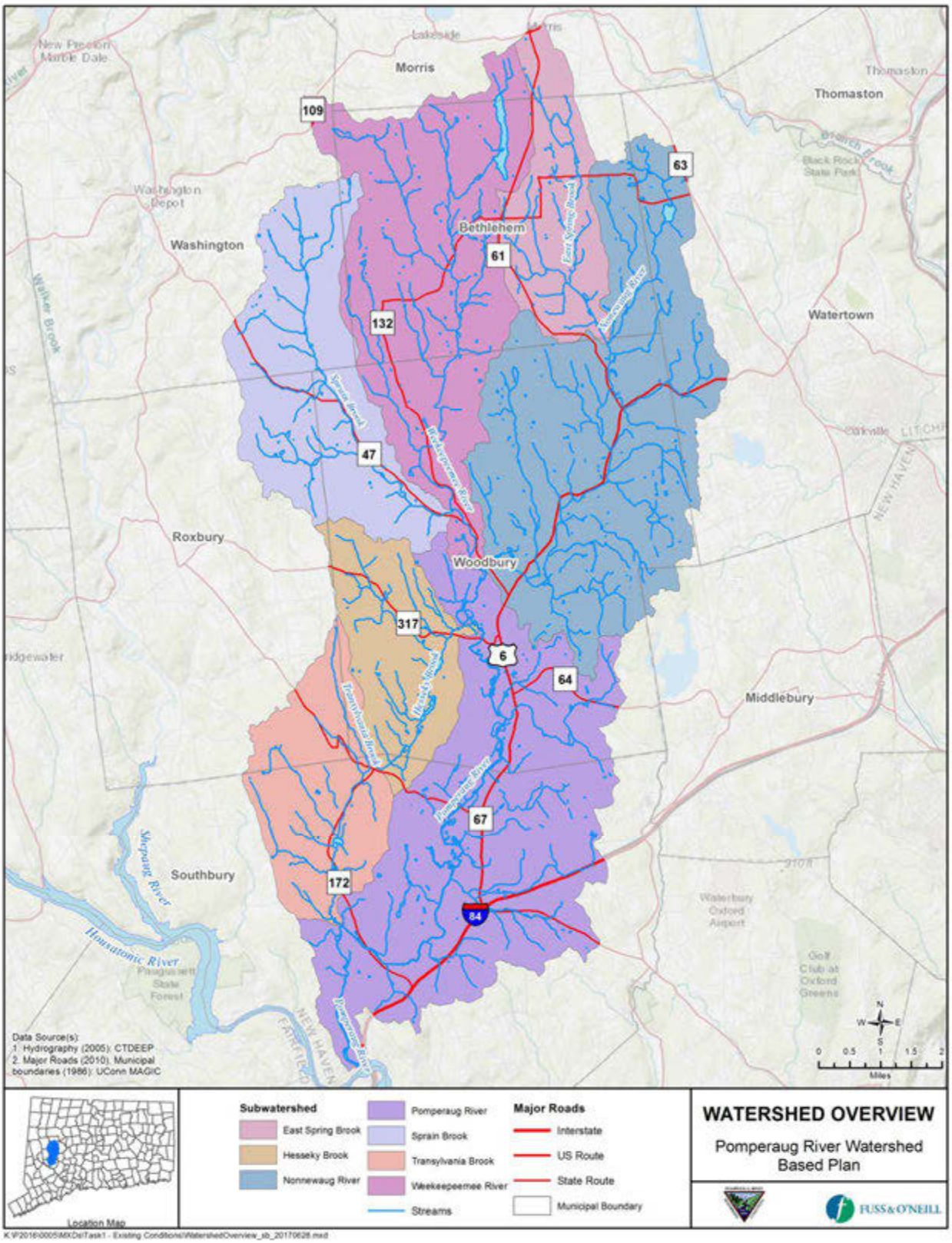

Figure 1: Subregional Drainage Basins in the Pomperaug River Regional Basin Watershed

2. Model Inputs

Primary Sources (Land Use)

Land use is considered a primary source of runoff pollutant loads in the WTM, which uses the Simple Method (Schueler, 1987) to calculate loads from urban land uses, and area loading factors to calculate loads from non-urban land uses. 2016 parcel-based land use data available from the Naugatuck Valley Council of Governments (NVCOG) were adapted for use with the WTM. Impervious area for each land use category was calculated from the National Land Cover Database (NLCD) 2011 impervious cover dataset. **Table 1** in *Attachment A* summarizes the modeled land use category and impervious area for each land use classification. **Table 2** provides a breakdown of existing modeled land use by subregional drainage basin.

Model inputs were specified for each land use category, including area, impervious cover, runoff coefficient, and runoff pollutant concentrations or export coefficients. Literature-based event mean concentration (EMC) values were used for all developed land use categories, while selected regional export coefficients were used for non-urban land uses. WTM default export coefficients were used for rural, powerline, and open water land use categories. The cropland land use category included both row crops and pasture land. The export coefficients for this land use category were approximated as the area-weighted average of the export coefficients of the two sub-categories. Discussions with the PRWC Land Use Committee revealed that some farmers in the watershed apply manure to their hay fields to increase yields, which was also considered when selecting an appropriate export coefficient for cropland. Tables 3 and 4 in Attachment A summarize the selected EMC and export coefficient values and associated references. Average annual precipitation for the watershed (51.09 inches) was estimated from the average precipitation recorded at the Woodbury station over the period of record (1967-2008) (Northeast Regional Climate Center http://www.nrcc.cornell.edu/).

Secondary Sources

In addition to pollutants generated from land uses, the WTM estimates pollutant loads from other activities or sources (secondary sources) that may be present, but are not necessarily associated with a particular land use. The following secondary sources were included in the WTM for the Pomperaug River watershed:

- **Failing or Malfunctioning Septic Systems** – Most of the Pomperaug River watershed is served by individual septic systems. A septic system failure rate of 1% was assumed for residential areas throughout the watershed. This rate represents an estimate based on regional failure rates and information provided by Pomperaug and Torrington Health Districts. Based on a review of aerial imagery, tax assessor's database information, and parcel land use mapping, an estimated 3.25% of septic systems in the watershed are within 100 feet of surface water bodies.

- **Stream Channel Erosion** – Due to the limited data available on stream channel erosion loads in the watershed, a simplified approach was used in which stream channel erosion sediment loads were estimated as a fraction of total watershed sediment load, based on overall stream channel stability. Stream channel erosion sediment loads were assumed to be 50% of the total sediment load for the watershed (reflecting "medium" stream channel degradation and stability), consistent with the model guidance.

- **Livestock** – This secondary source accounts for pollutant loads from animals that are confined (e.g., feedlots, stables). In the model, pollutant loads associated with pastured animals are simulated as Primary Sources (i.e., cropland land use). Hobby farms with a few horses are common throughout the watershed. Equestrian centers, including stables or boarding, are also prevalent. There are small and large farm operations for cattle, goats, sheep, and alpacas ranging from 10 to more than 300 head. Estimates of head per subregional drainage basin were based on information provided by Sarah Turoczi, a local resident and farmer in the watershed with first-hand knowledge of livestock head counts. Further site-specific information was derived from observations by Fuss & O'Neill personnel during field assessments and from aerial imagery. **Tables 7 and 8** in *Attachment A* summarize livestock head counts and other model inputs for the Livestock Secondary Source.

- **Road Sanding** – Sediment loads from road sanding were calculated based on a 2015 CTDOT report entitled Winter Highway Maintenance Operations. The report includes a survey of 31 municipal public works operations and reveals an average annual application rate of 6.1 tons of sand per lane mile between 2009 and 2014. This was assumed to be uniform over municipally-maintained roads in the watershed. The Connecticut Department of Transportation does not apply sand to state roads, so state-maintained roads were not included in the calculation of lane miles.

- **Potential Illicit Connections** – In areas served by sanitary sewers, illicit connections were assumed for one in every 1,000 sewered connections and 5% of businesses, consistent with values reported in several national studies, modified to account for local conditions. Model default pollutant concentrations and daily flow values were used.

- **Wastewater Treatment Plants** – Average daily flow and effluent concentrations reported in Discharge Monitoring Reports obtained from the EPA's Integrated Compliance Information System (ICIS) website were used for estimating pollutant loads from the wastewater treatment plants in the watershed, including Heritage Village, IBM Southbury, and Woodlake Condos.

Refer to **Tables 5 and 6** in *Attachment A* for a detailed description of the model inputs and assumptions.

3. Model Results

Existing Pollutant Loads

Annual loads of bacteria, TP, TN, and TSS were estimated for each subregional drainage basin (**Figures 2, 3, and 4**). Existing modeled pollutant loads are provided in **Tables 9.1 – 9.7** in *Attachment A*. The model results indicate that the Pomperaug, Nonnewaug, and Weekeepeemee River subregional drainage basins have the highest annual pollutant loads. This result is not surprising since these are the largest subregional drainage basins by land area. In addition, the primary land uses and activities in these subregional drainage basins have higher EMCs and pollutant loading factors (e.g., residential areas, agriculture, road sanding, and septic systems).

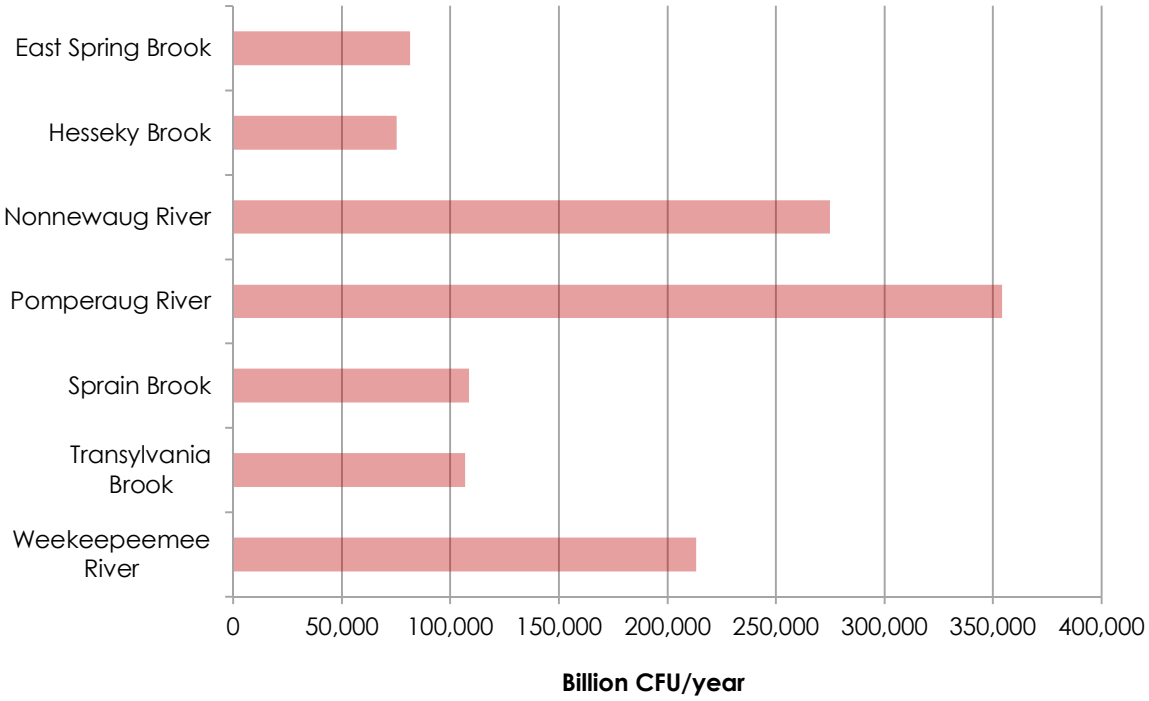

Figure 2: Modeled bacteria loads by subregional drainage basin

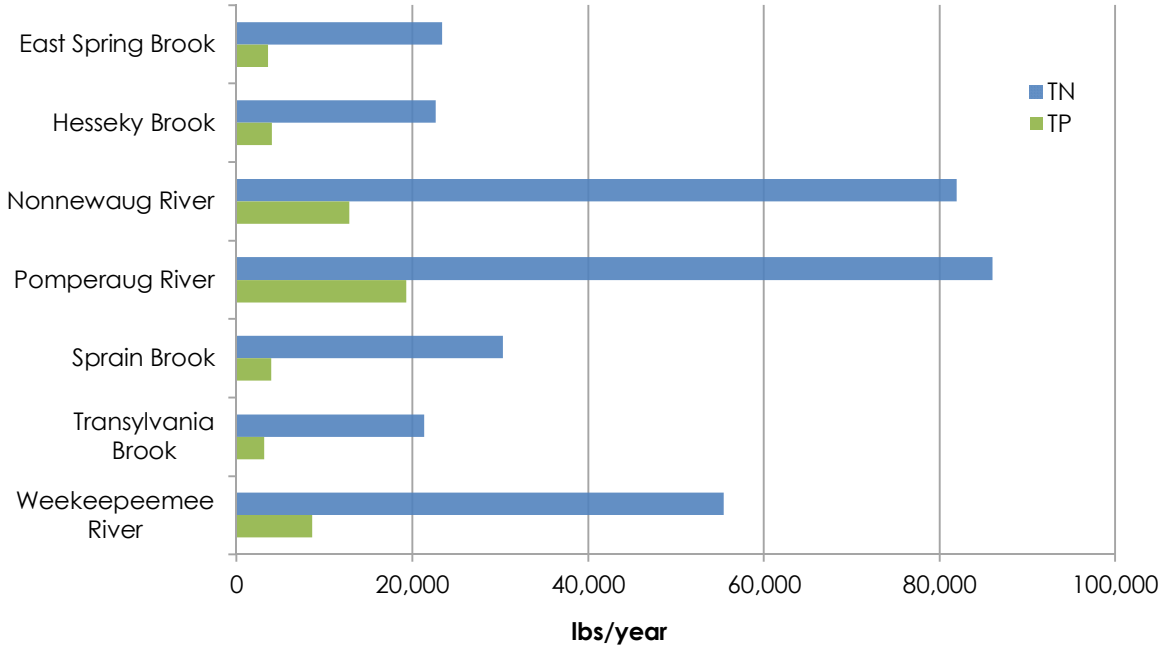

Figure 3: Modeled Total Nitrogen (TN) and Total Phosphorus (TP) loads by subregional drainage basin

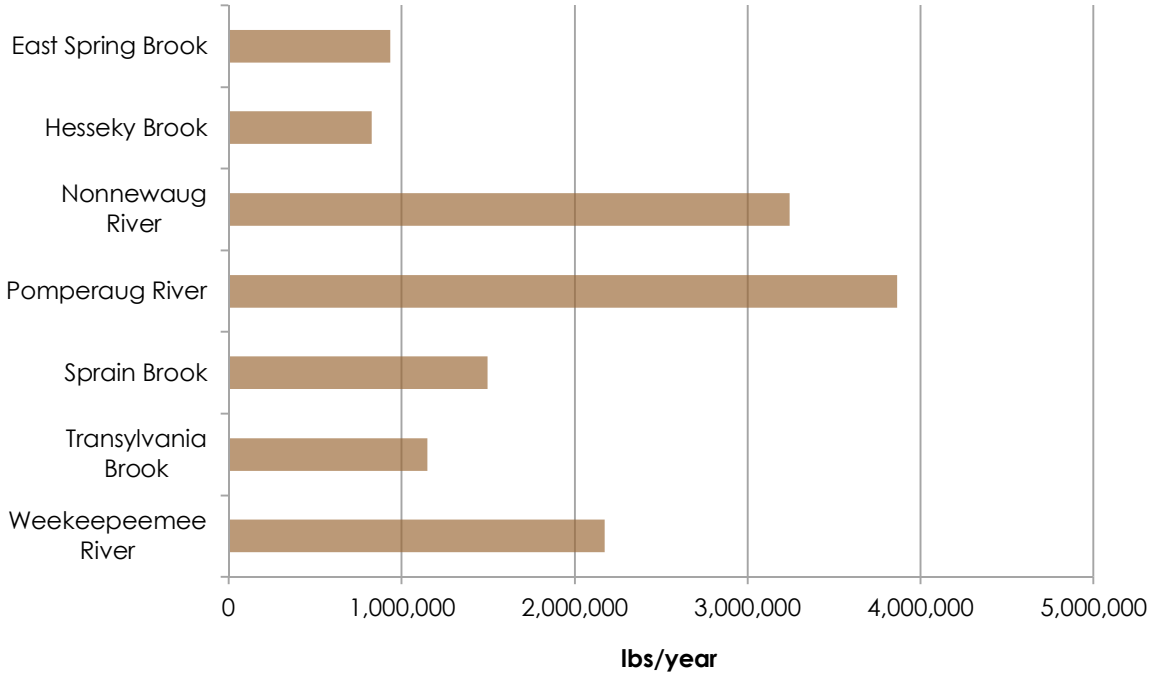

Figure 4: Modeled total suspended solids (TSS) loads by subregional drainage basin

Existing Pollutant Yields

Watersheds differ in area, which directly influences pollutant loads – a larger watershed may have a higher load than a smaller watershed simply because it has a larger area. To remove this effect, pollutant loads were divided by the subwatershed area to derive a per-acre pollutant "yield," which provides a better comparison of pollutant contributions among subwatersheds of varying sizes.

In addition to the highest annual loads, the Pomperaug River subregional drainage basin also has the highest modeled TP, TSS, and bacteria yields and among the highest TN yields (**Figures 5, 6, 7**). The Pomperaug River subregional drainage basin is characterized by a greater intensity of development and land use activities, namely larger percentages of developed land uses with higher EMCs, larger numbers of septic systems in proximity to mapped streams, greater commercial development with potential for illicit connections, and higher numbers of road lane miles subject to sanding, as well as point source discharges from wastewater treatment facilities. In contrast, the Sprain Brook subregional drainage basin, the fourth largest of the 7 subregional drainage basins considered in this study, has among the lowest annual loads and yields for all pollutants considered. This reflects the predominantly forested nature (approximately 64%) and relatively limited development and agricultural practices within this basin.

In order to assess the reasonableness of the WTM results, the modeled pollutant yields were compared with those of the U.S. Geological Survey (USGS) SPAtially Referenced Regressions On Watershed attributes model (SPARROW) for TN and TP for the overall Pomperaug River watershed. Comparison of the yields in **Table 1** shows that there is relatively good agreement between the two models. Notably, WTM results are within the same order-of-magnitude but slightly above the range of SPARROW values.

This result is not very surprising since the SPARROW results are based on data from 1993 and the patterns and intensity of development in the watershed have changed.

Table 1: Comparison of TN and TP estimates

Parameter	TN	TP
WTM (lbs/acre/yr)	4.3 – 6.4	0.6 – 1.4
SPARROW (lbs/acre/yr)	0.9 – 5.9	0.1 – 0.9

Figures 6 and 7 show that most subregional drainage basins have similar modeled nutrient and TSS yields. Despite this similarity, the sources of these pollutants in each subregional drainage basin vary. For example, in the Pomperaug subregional drainage basin, developed land use and residential turf management dominate. In the less developed East Spring Brook subregional drainage basin, agricultural land use more strongly influences pollutant yields. While there are distinct locations in every subregional drainage basin where opportunities for bacteria source reduction could be pursued, the more developed areas and areas with higher concentrations of livestock in the watershed are the dominant sources of existing modeled bacteria loads in the watershed.

Figure 5: Modeled bacteria yields by subregional drainage basin

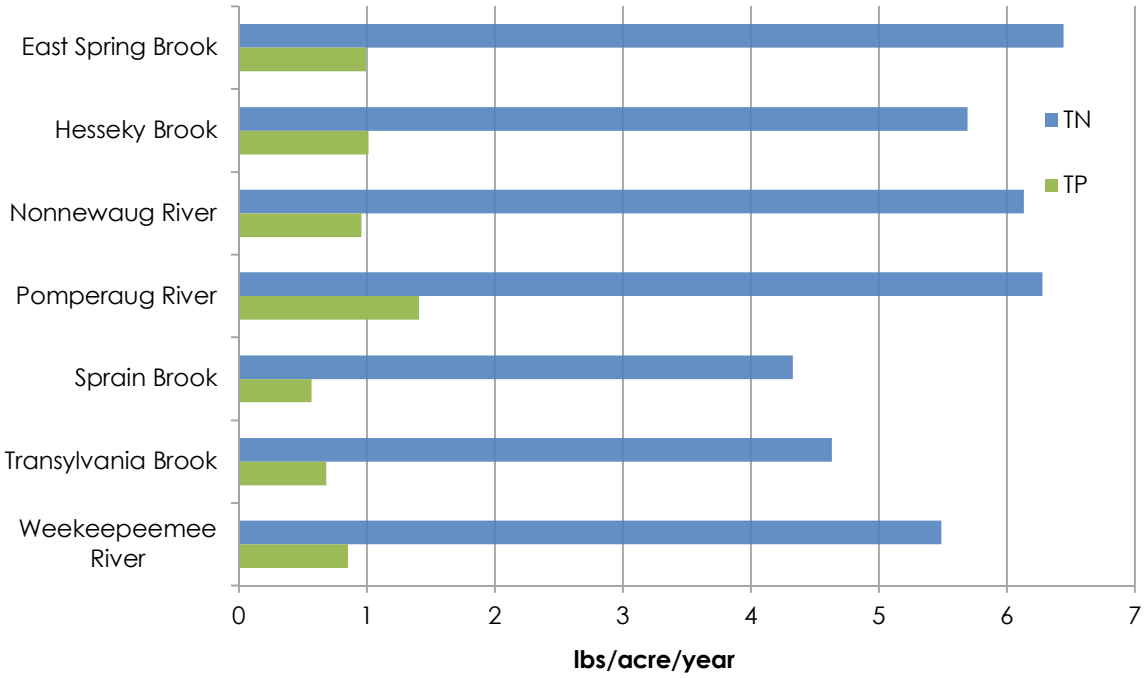

Figure 6: Modeled Total Nitrogen (TN) and Total Phosphorus (TP) yields by subregional drainage basin

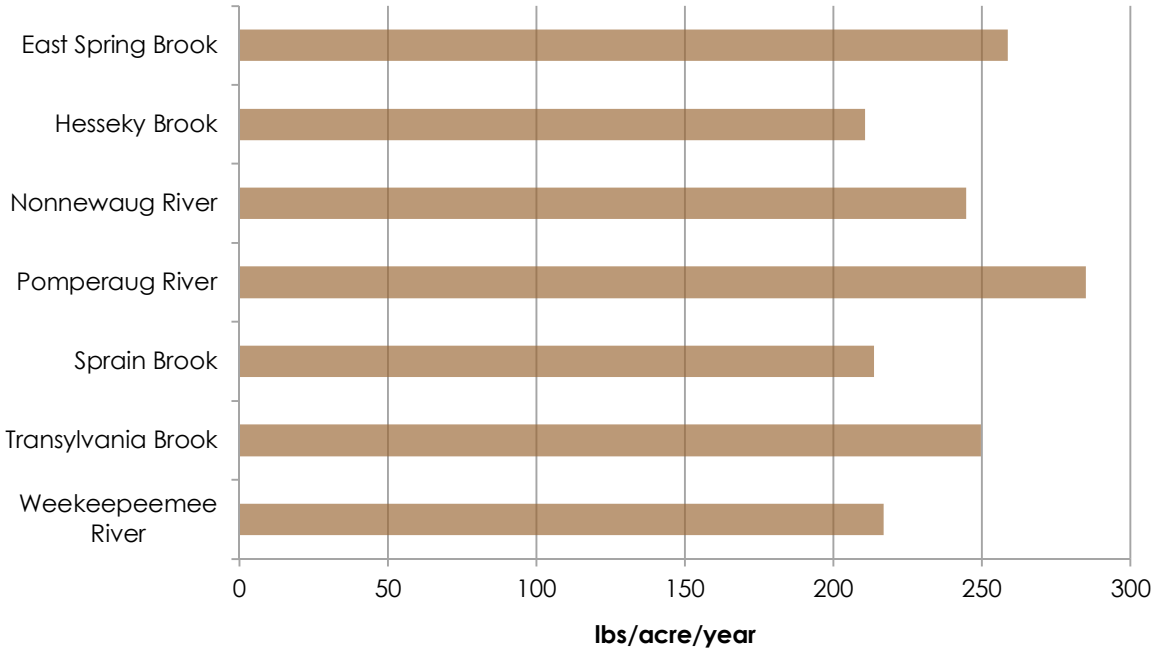

Figure 7: Modeled total suspended solids (TSS) yields by subregional drainage basin

Discussion

Bacteria sources in the watershed reflect both the underlying land use (i.e., agriculture, forest, residential, etc.) and specific activities that can result in bacteria loading to streams (e.g., livestock, septic system failures, illicit discharges). The relative contribution of bacteria from different land uses and activities is well illustrated by a comparison of the modeled loads in the various subregional drainage basins (**Figures 8-14**). In the more-developed Pomperaug River subregional drainage basin, modeled bacteria loads are dominated by stormwater runoff from urban land use (43%) and potential illicit connections associated with residential and commercial land use (31%), with agricultural sources estimated to contribute approximately 10% of the estimated annual 354,000 billion CFU load (**Figure 8**). By contrast, in the more rural Weekeepeemee River subregional drainage basin, agricultural land uses (rural land and livestock), contribute an estimated 45% of the annual bacteria load, with stormwater runoff contributing approximately one-quarter of the 213,000 billion CFU annual load (**Figure 9**).

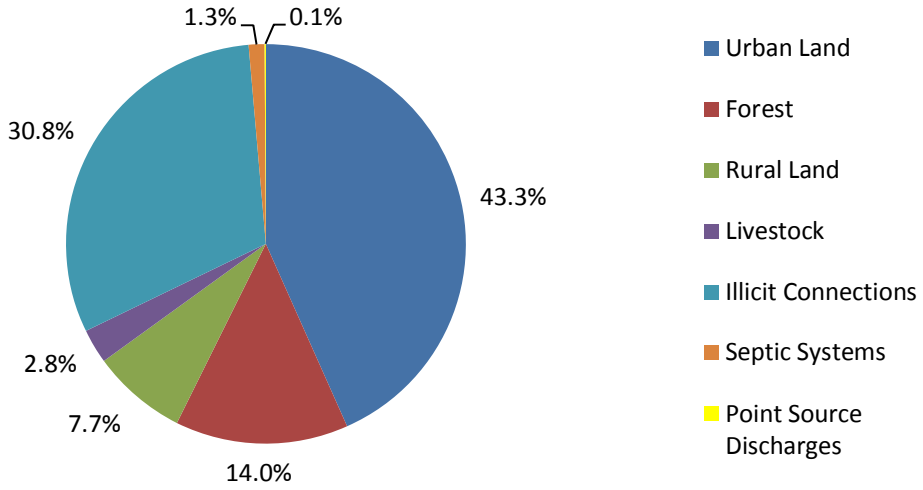

Figure 8: Relative contributions of various bacteria sources in the Pomperaug River subregional drainage basin. Total annual load: 354,000 billion CFU

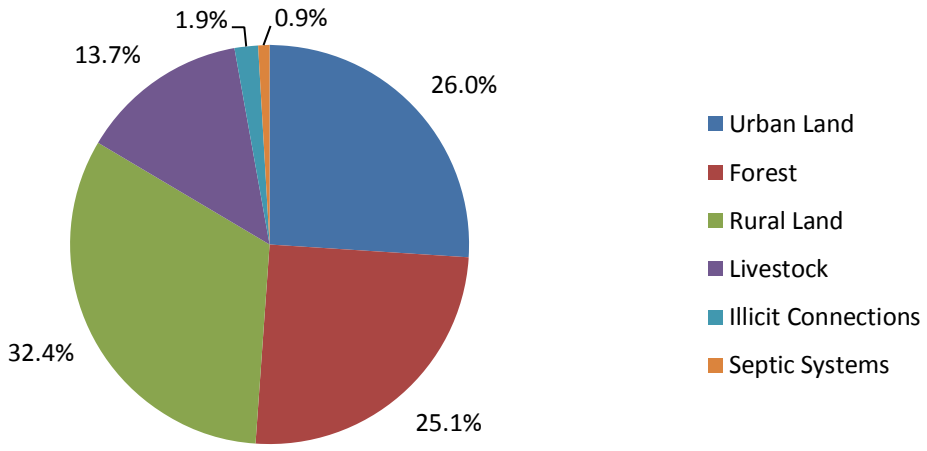

Figure 9: Relative contributions of various bacteria sources in the Weekeepeemee River subregional drainage basin. Total annual load: 213,000 billion CFU

The comparison points out some of the opportunities and challenges in watersheds with mixed land use. The modeled bacteria loads in the Pomperaug River subregional drainage basin illustrate the benefits of management measures that focus on sources of fecal indicator bacteria associated with urban stormwater runoff, including source controls, structural stormwater BMPs, education and outreach, and illicit discharge detection and elimination (IDDE). Even though the estimates of illicit connections are modest (0.1% of the subwatershed population and 5% of the businesses served by sewer), the elimination of these discrete sources of bacteria could substantially reduce bacteria loadings where sanitary-related illicit connections are present (i.e., in areas served by sanitary sewers). Consequently, implementing an IDDE program in the more developed and/or sewered areas of the watershed can be effective at reducing bacteria loads.

In contrast, in the more rural subregional drainage basins, livestock and agricultural practices are key drivers of bacteria loads, though pockets of residential and commercial development in these areas also contribute bacteria loads from urban runoff (**Figures 10-14**). Agricultural sources of bacteria typically require a combination of structural and non-structural best management practices to reduce loadings, including identification of "hot spot" bacteria sources and site-specific management strategies to achieve load reductions. Livestock in particular represent a considerable bacteria source in the Weekeepeemee River, Nonnewaug River, and Hesseky Brook subregional drainage basins. Where practicable, load reduction in these basins should focus on agricultural best management practices.

The impaired segments of the Pomperaug and Weekeepeemee Rivers are included in the Connecticut Statewide Bacteria TMDL (2012). The TMDL identifies percent reductions (**Table 2**) in geometric mean and single sample fecal indicator bacteria (*E. coli*) concentrations required to meet recreational water quality criteria. These percentages are for reducing fecal indicator bacteria concentrations at ambient monitoring locations in each river segment, not at the end of stormwater outfalls or other pollutant loads to the river. It is also important to note that these impairments and percent reductions are based on a very limited data set consisting of approximately 10 samples (wet and dry weather) collected at a single station in each river segment in 2010.

Table 2: Bacteria (E. coli) Percent Reductions to Meet TMDL

Impaired River Segment	Geometric Mean	Single Sample
Pomperaug River (CT-6800-00_01)	65%	90%
Pomperaug River (CT6800-00_03)	75%	92%
Weekeepeemee River (CT6804-00_01)	48%[1]	98%[1]

[1]The required percent reductions in *E. coli* concentrations are incorrectly reported (geometric mean and single sample percent reductions are switched) in the Weekeepeemee River Watershed Summary document for the statewide Bacteria TMDL.

Further, the TMDL and modeled load reductions are not directly comparable since the TMDL load reductions targets are daily, seasonal (i.e., worst-case) values, whereas the modeled pollutant loads are annual values. The modeled load reductions are also based on the use of fecal coliform rather than *E. coli*, the latter being a subset of fecal coliform which is more specific to humans and other warm-blooded animals. *E. coli* is the indicator bacteria for freshwater monitoring in Connecticut and was used in the TMDL. Additional bacterial monitoring is recommended, as well as further coordination between PRWC and CTDEEP to discuss the watershed based plan findings, recommendations, and modeled potential load reductions relative to the TMDL reduction goals and implications for proposed bacteria monitoring locations.

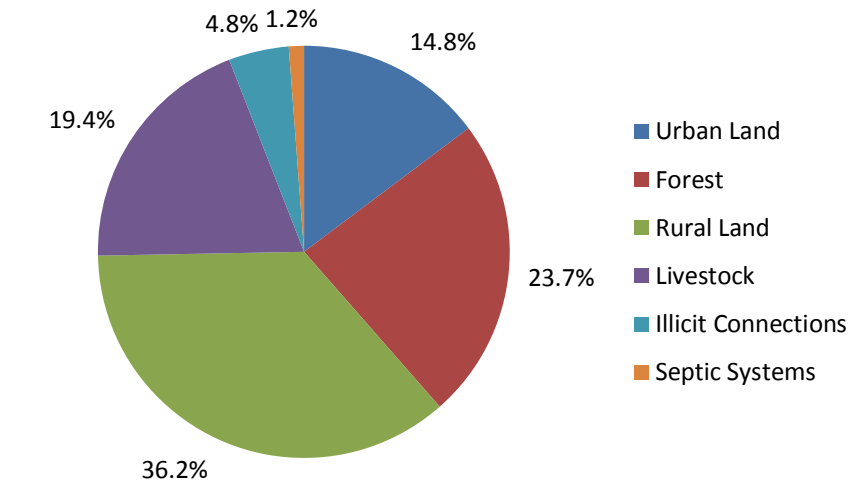

Figure 10: Relative contributions of various bacteria sources in the Nonnewaug River subregional drainage basin. Total annual load: 275,000 billion CFU

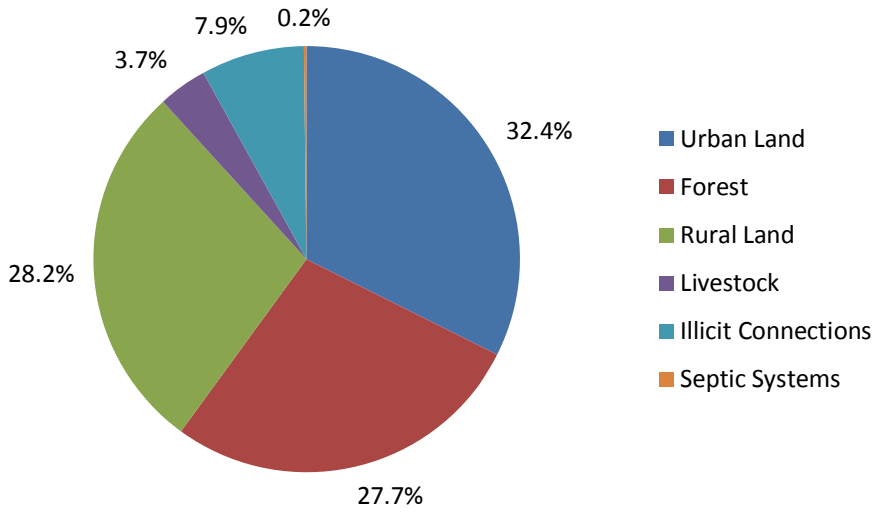

Figure 11: Relative contributions of various bacteria sources in Transylvania Brook subregional drainage basin. Total annual load: 107,000 billion CFU

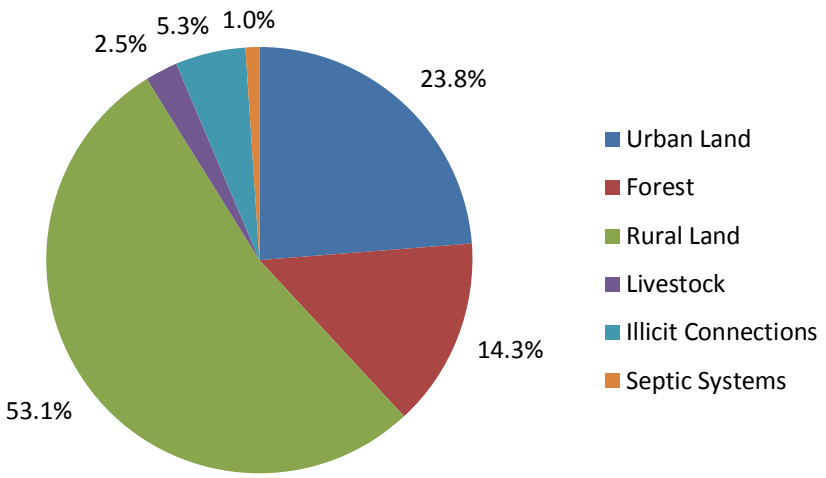

Figure 12: Relative contributions of various bacteria sources in East Spring Brook subregional drainage basin. Total annual load: 81,000 billion CFU

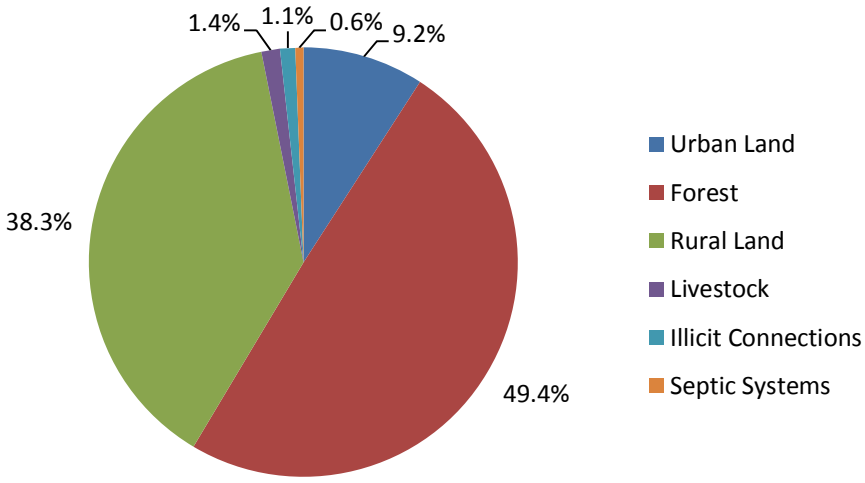

Figure 13: Relative contributions of various bacteria sources in Sprain Brook subregional drainage basin. Total annual load: 109,000 billion CFU

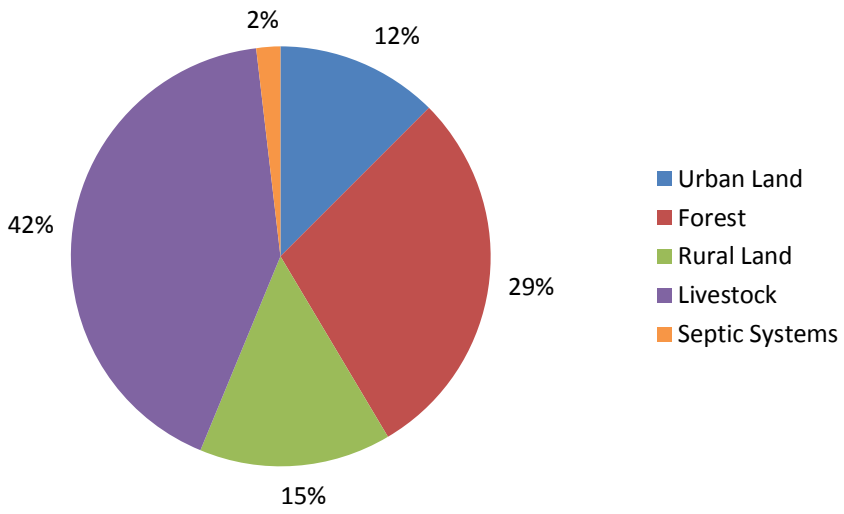

Figure 14: Relative contributions of various bacteria sources in Hesseky Brook subregional drainage basin. Total annual load: 75,000 billion CFU

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Attachment A

Watershed Treatment Model
Model Parameter Values, Input Data, and Model Results

Table 1
Land Use and Impervious Cover in the Pomperaug River Watershed (acres)

	Land Use	Percent Impervious	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River	Watershed Total
Developed	Residential - High Density	13.5	0	0.1	9.6	18.8	0	0	3.2	31.7
	Residential - Medium Density	17.9	16.6	116	126.2	876.6	1.8	78.7	48.9	1,264.90
	Residential - Medium-Low	9.4	37.3	41.9	179.4	381.3	14.9	141.1	65.4	861.5
	Residential - Low Density	2.0	1,383.60	1,561.00	4,082.20	4,664.60	1,217.30	774.9	3,089.40	16,773.00
	Developed Recreation	5.6	0.5	0	206	453.5	30.7	6.1	6.5	703.4
	Commercial	23.1	50.6	0	84.7	659.8	15.5	5	142.7	958.2
	Industrial	7.5	5.8	0	24.8	53.5	0	0	97.4	181.5
	Institutional	15.7	44	2.9	60.2	304.2	0	234.7	206.3	852.3
	Mining	0.1	0	0	87.2	408.4	0	0	0	495.6
	Roadway	17.5	13	153.8	444.8	978.9	140.4	129.7	99.4	1,960.00
	Utilities	3.0	11.5	0	0	0	0	0	0	11.5
Rural	Barren	12.0	0	0	0.2	28.4	21.2	6.5	1.4	57.7
	Cropland	1.0	1,096.20	285.6	2,550.30	699.6	1,066.60	773	1,771.80	8,243.10
	Forest	0.2	971.9	1,823.60	5,432.40	4,123.90	4,472.60	2,462.90	4,455.70	23,743.00
	Water	0.4	0.7	0	72	51.7	13.6	0	111.8	249.9
	Sub-watershed Total		**3,631.80**	**3,985.00**	**13,360.00**	**13,703.30**	**6,994.60**	**4,612.60**	**10,099.90**	**56,387.10**

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Table 2
Pomperaug Watershed Land Use Map to Modeled Land Uses

	Land Use	Modeled Land Use	Notes
Developed	Residential - High Density	High Density Residential	
	Residential - Medium Density	Medium Density Residential	
	Residential - Medium-Low	N/A	Assigned equally to Medium and Low Density Residential
	Residential - Low Density	Low Density Residential	
	Developed Recreation	Barren	Modeled as barren land use, but with FC value below Low Density Residential
	Commercial	Commercial	
	Industrial	Industrial	
	Institutional	Commercial	Assumed to be same as commercial
	Mining	Mining	
	Roadway	Highway	
	Utilities	Rural	
Rural	Barren	Barren	
	Cropland	Cropland	Combined Pasture, Hay Fields, and Row Crops
	Forest	Forest	
	Water	Open Water	

Table 3
Developed Land Uses - Event Mean Concentrations
(TN, TP, TSS in mg/L and Fecal Coliform in MPN/100ml)

Land Use	WTM Default Values				Regional Values				Selected Values			
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC
Low Density Residential	2.1	0.31	49	20,000	3.18	0.27	34	2,950	3.18	0.27	34	2,950
Medium Density Residential	2.1	0.31	49	20,000	3.5	0.41	49	12,360	3.5	0.41	49	12,360
High Density Residential	2.1	0.31	49	20,000	3.81	0.64	102	16,901	3.81	0.64	102	16,901
Highway	-	-	-	-	2.65	0.43	141	600	2.65	0.43	141	600
Commercial	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Institutional	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Industrial	2.2	0.25	81	20,000	4	0.11	42	1,467	4	0.11	42	1,467
Mining	-	-	-	-	1.18	0.15	94	300	1.18	0.15	94	300
Barren	-	-	-	-	1.74	0.11	51	5,000	1.74	0.11	51	300

Notes:
TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform

Sources:
BETA Group, Inc. (2006). Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts.
Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

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Table 4
Rural Land Uses - Export Coefficients
(TN, TP, and TSS in lb/ac/yr and Fecal Coliform in billion/ac/yr)

Land Use	WTM Default Values				Regional Values				Selected Values				Comments
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC	
Forest	2.0	0.2	100	12	2.5	0.2	100	12	2.5	0.2	100	12	Selected regional values
Rural	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Power Lines	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Open Water	12.8	0.5	155	-	0.4 (2)	0.03 (2)	2 (2)	0.4 (2)	0.4	0.03	2	0.4	Selected regional values
Cropland	-	-	-	-	Pasture 1.9 (2) 7.7 (3) 5.6 (4) Row Crops 14.4 (3) 15.7 (4)	Pasture 0.1 (2) 1.3 (3) 0.5 (4) Row Crops 4.0 (3) 0.94 (4)	Pasture 47 (2) 591 (4) Row Crops 1997 (4)	Pasture 7 (2) Row Crops -	10	0.8	300	39	Selected TN, TP, and TSS based on regional sources for pasture and row crops; FC assumed same as Rural land use

Notes:

TN = Total Nitrogen; TP = Total Phosphorus; TSS = Total Suspended Solids; FC = Fecal Coliform

Conversion equation used for Pasture/Orchard

NSQD (2005) and MA DEP QAPP do not provide rural land use data.

Cropland export coefficients are based on regional values. This category includes both pasture and crop land. Pasture land and hay fields are more prevalent in the Pomperaug River Watershed, so the selected coefficients tend towards those values. Information from the Pomperaug River Watershed Coalition Land Use Committee indicates that some farmers apply manure to hay fields, which is reflected in the choice of coefficients.

Sources:

Maestre & Pitt and Center for Watershed Protection (2005). The National Stormwater Quality Database, Version 1.1.

Caraco, D. and Center for Watershed Protection, Inc. (2013). Watershed Treatment Model (WTM) 2013 Documentation.

Regional values identified by number:

1. CDM (2004). Merrimack River Watershed Assessment Study - Screening Level Model.
2. BETA Group, Inc. (2006). Quality Assurance Project Plan. Development of a Watershed Based Plan for Massachusetts. Converted values presented in mg/L into lb/ac/yr assuming 0% impervious area for Forest and 2% impervious area, 46 inches of rain per year, for agricultural land uses.
3. Reckhow et al. (1980): "Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients." From Lin, J. (2005) Review of Published Export Coefficient and Event Mean Concentration (EMC) Data. Converted values from kg/ha/yr to lb/ac/yr.
4. CH2M HILL (2001). PLOAD version 3.0, An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects: User's Manual.

Table 5
Sources and Model Assumptions

Parameter	Sources	Model Assumptions & Notes
Primary Sources		
Watershed Boundary	CTDEEP – Subregional basins	The Watershed Boundary for the subregional basins within the Pomperaug River watershed.
Land Cover and Land Use	NVCOG – Land Use 2016 NLCD 2011 CTECO – 2016 Orthophotography	NVCOG land use classifications were simplified for input into WTM. Acreage for various classifications was determined in ArcGIS by intersecting the land use with the Sub Watersheds. NVCOG land use classifications include Medium-Low Density Residential, which was equally divided and assigned to both Medium Density and Low Density Residential. Because NVCOG does not include Morris, Washington, and Roxbury, their land uses were converted from raster to vector from national land cover data and manually assigned to NVCOG land use categories based on 2016 CT aerial imagery (3-inch resolution).
Pollutant Event Mean Concentrations (EMCs) and Export Coefficients	WTM Default Values, Selected Regional Values used in MA Watershed Based Plan (2006)	Selected regional EMCs used for residential, transitional, commercial, highway, and industrial land use categories. WTM default values used for rural, powerlines, and open water land use categories.
Impervious %	NLCD, 2011	The impervious surface data set available from USGS NLCD as a nationwide dataset representing impervious surfaces in 2011. The percent impervious for land use classes in each subwatershed was determined by intersecting the raster with the 2016 land use data.
Annual Rainfall	Northeast Regional Climate Center	Weather station on Saw Pitt Hill Rd, Woodbury. Period of record 1967-2008.
Stream Length	CTDEEP Hydrography Line	Stream lengths in each subwatershed were calculated based on intersecting the CTDEEP Hydrography Line data layer with the Sub Watershed boundaries.
Soils Information	CTDEEP Soils Data – NRCS SSURGO-Certified Soils 2009	Hydrologic Soils Group data were available from SSURGO and matched to CTDEEP soils data based on the Soil Map Unit Key (MUKey) field An estimate of the depth to groundwater was made by converting USDA drainage classes, which are essentially an estimate of seasonal high water table. Depth to groundwater was estimated at 3-5 ft across the watershed.
Runoff Coefficients	Virginia Erosion & Sediment Control Handbook, 1980.	Runoff coefficients for Rural Land Uses were selected from a range of values listed in the Virginia Erosion & Sediment Control Handbook. Values for Cropland ranged from 0.15 to 0.4 and for Pasture/Orchard, etc. values ranged from 0.12 to 0.35.

Parameter	Sources	Model Assumptions & Notes
Secondary Sources		
General Sewage Data	UConn MAGIC, NVCOG parcel-based land use and WTM defaults	Parcel-based land use in NVCOG area includes dwelling units. The sum of these within the sewered area delineated by UConn MAGIC data was used.
Nutrient Concentration in Stream Channels	Haith et al. 1992	A mid- range value of 0.15 was used for Soil P (%) and Soil TN (%). See figures 4.1 and 4.2 in the WTM 2013 Documentation.
On-Site Sewage Disposal (OSDS)	UConn MAGIC Sewered Areas, NVCOG land use and WTM defaults	All dwelling units assumed to be served by OSDS unless the parcel is within an area served by sanitary sewers. Unsewered areas were set to Clay/Mixed Soils. The default failure rate of 10% was assumed. System type was set to 100% conventional, with medium maintenance. Typical separation from groundwater was assumed to be 3-5 ft. The OSDS density was set at 1-2 per acre based on calculated dwelling unit density in unsewered areas.
SSOs, CSOs,	NA	It was assumed that neither SSOs nor CSOs exist in the study area based on the typical design of sanitary systems in the region.
Illicit Connections	NVCOG Parcel-based land use 2016	In sewered areas, 1/1000 residential connections and 5% of business connections assumed to be illicit. Defaults used for pollutant concentrations and percent wash water.
Stream Channel Erosion	NA to Non-urban watersheds.	Method 1 was selected as the method to estimate channel erosion which is assumed that some fraction of the total watershed load comes from stream channel erosion. A stream degradation value of "medium" (50% of the total sediment load) was applied to each sub watershed.
Livestock	Sarah Turoczi, aerial imagery, Fuss & O'Neill watershed survey	Livestock head counts based on information from Sarah Turoczi, a farmer who has first-hand knowledge of many farm operations in the watershed. Other farms were identified by aerial imagery and head counts inferred based on observations made by Fuss & O'Neill personnel during a watershed assessment. Nutrient loads converted from daily loads in kilograms (Ruddy et al., 2006). E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).

Parameter	Sources	Model Assumptions & Notes
Road Sanding	Winter Highway Maintenance Operations, 2015 UConn MAGIC – Connecticut Roads (2010)	Based on the CTDOT report, state agencies switched from sand to sodium chloride. An anonymous survey of 31 municipalities in Connecticut showed that 6.143 tons/lane mile of sand was used. This rate was multiplied by the lane miles under municipal jurisdiction to determine the amount of road sand applied per HUC12 Sub Watershed/WTM Area. Road miles were determined by intersection of the Connecticut Roads layer with the shape file containing the respective HUC12 Sub Watershed/WTM Area. Lane miles were double, because all municipal roads are two-lane. The fraction of roads that are open is determined by dividing the amount of roadway that is open by the amount of road that drains to catch basins. Open sections do not have catch basins. Based on the rural/suburban nature of the study area, the length of road within the Municipal Separate Storm Sewer System (MS4) regulated area was used to estimate that 60% of roads were classified as open, on the assumption that urbanized areas are more likely to have closed section roads than more rural areas.
Non-Stormwater Point Sources	EPAs ICIS web data service	Daily discharge values of reported effluent concentrations on the EPA ICIS website were used for evaluating the contributing load from this source. The two treatment facilities with data available through this website were Heritage Village and IBM.

Haith, DA, R Mandel, and RS Wu. 1992. Generalized Watershed Loading Functions, Version 2.0 User's Manual. Department of Agricultural and Biological Engineering, Cornell University, Ithaca, NY.

Northeast Regional Climate Center. 2015. CLIMOD2: Woodbury, CT Precipitation Record 1967 – 2008.

USGS. 2011. National Land Cover Dataset.

Virginia Erosion and Sediment Control Handbook, 1980. Virginia Soil and Water Conservation Committee.

Winter Highway Maintenance Operations, 2015. Connecticut Academy of Science and Engineering report to the Connecticut Department of Transportation.

Table 6
Additional Model Inputs

	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River
Road Sanding (lbs/yr) - Entire Watershed	558,563	614,684	1,861,852	2,778,710	752,034	768,705	1,258,228
% With storm drains	20	20	20	40	20	20	20
% Without storm drains	80	80	80	60	80	80	80
Total length of streams (miles)	16.1	17.0	58.2	46.3	22.2	17.8	38.0
Dwelling units	611	1,050	2,368	5,807	466	761	1,446
Percentage of dwelling units un-sewered	100	100	100	58.3	100	21.7	100
Percentage of dwelling units with onsite septic within 100 ft of surface water[1]	10	10	10	10	10	10	10
Residential Sewered units	0	0	0	2,422	0	596	0
Commercial/Business Sewered units	0	0	0	161	0	2	0
Hydrologic Soil Group (Percent)							
A	2.6	4.3	10.4	10.2	2.8	1.8	4.1
B	23.8	41.2	33.9	51.9	59.7	44.1	52.2
C	57.6	32.6	26.8	14.5	18.3	33.6	25.9
D[2]	16.1	21.9	28.9	23.4	19.3	20.5	17.8

[1]An estimated 10% of dwelling units with septic systems are assumed to be located within 100 feet of a waterbody based on a review of aerial imagery and parcel land use mapping.

[2]Hydrologic soil group designation does not consider surface water. This area has been included under Group D which has the most similar infiltrative properties.

Table 7
Livestock Pollutant Loading Rates/Export Coefficients

Livestock	Nitrogen[1] (lbs/animal/year)	Phosphorus[1] (lbs/animal/year)	E. coli[2] (billion cfu/AU/year)
Bovine	164	26	1,966
Equine	102	18	84
Ovine	18.5	3.2	7,165
Poultry	1.1	0.4	85

[1] Ruddy et al (2006). Loads converted from daily loads in kilograms.

[2] E. coli loads converted from daily loads reported by Borel et al. (2015), which are based on those from Wagner and Moench (2009), who incorporated daily fecal production and fecal coliform concentration into their load estimates. These loads are based on the concept of an animal unit (AU), which standardizes animals based on unit forage intake, relative to cows (Scarnecchia 1985).

Table 8
Estimated Head of Livestock by Subregional Drainage Basin

Livestock	East Spring Brook	Hesseky Brook	Nonnewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River
Bovine	20	175	450	100	15	40	150
Equine	60	40	50	100	15	25	40
Ovine	25	40	25	15	0	0	40
Poultry	30	75	50	50	250	25	50

Notes:

Livestock head counts based on information from Sarah Turoczi, a local resident and farmer who has first-hand knowledge of farming practices in the watershed. Other farms were identified by aerial imagery and head counts inferred based on observations made by Fuss & O'Neill personnel during field assessments.

Table 9. 1
Modeled Pollutant Loads in the East Spring Brook Subregional Basin

	Existing Loads to Surface Waters					Percent of total load				
Source	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	19,335	8,125	2,241	78,182	2,146	15.72	34.72	62.31	8.32	61.85
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	5	5	168,847	-	-	0.02	0.14	17.98	-
Road Sanding	-	-	-	256,939	-	-	-	-	27.36	-
Forest	11,663	2,430	194	97,190	140	9.48	10.38	5.40	10.35	4.03
Rural Land	43,200	11,015	885	330,010	1,184	35.12	47.07	24.61	35.14	34.12
Livestock	2,010	630	68	-	-	1.63	2.69	1.90	-	-
Illicit Connections	24,633	39	10	277	-	20.03	0.17	0.27	0.03	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	22,151	1,158	193	7,723	-	18.01	4.95	5.37	0.82	-
Open Water	0.28	0.28	0.02	1.40	-	0.00	0.00	0.00	0.00	-
Total Storm Load	76,209	15,482	3,070	888,448	3,470	61.96	66.16	85.36	94.60	100.00
Total Non-Storm Load	46,785	7,920	527	50,720	-	38.04	33.84	14.64	5.40	-
Total Load to Surface Waters	122,993	23,402	3,596	939,168	3,470	100.00	100.00	100.00	100.00	100.00

Table 9. 2
Modeled Pollutant Loads in the Hesseky Brook Subregional Basin

Source	Existing Loads to Surface Waters FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	Percent of total load FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	9,396	8,734	2,623	128,496	2,624	6.74	38.49	64.97	15.30	82.83
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	4	4	146,900	-	-	0.02	0.11	17.49	-
Road Sanding	-	-	-	282,755	-	-	-	-	33.67	-
Forest	21,883	4,559	365	182,360	253	15.69	20.09	9.03	21.72	7.98
Rural Land	11,138	2,856	228	85,680	291	7.99	12.59	5.66	10.20	9.19
Livestock	31,574	4,508	479	-	-	22.64	19.87	11.86	-	-
Illicit Connections	27,380	36	6	241	-	19.64	0.16	0.15	0.03	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	38,067	1,991	332	13,272	-	27.30	8.77	8.22	1.58	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	73,992	16,954	3,521	799,387	3,167	53.06	74.73	87.22	95.20	100.00
Total Non-Storm Load	65,447	5,735	516	40,318	-	46.94	25.27	12.78	4.80	-
Total Load to Surface Waters	139,439	22,689	4,037	839,705	3,167	100.00	100.00	100.00	100.00	100.00

Table 9. 3
Modeled Pollutant Loads in the Nonnewaug River Subregional Basin

Source	Existing Loads to Surface Waters					Percent of total				
	FC load (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	40,606	26,931	7,672	382,699	7,432	9.39	32.87	59.98	11.70	68.19
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	18	18	589,396	-	-	0.02	0.14	18.02	-
Road Sanding	-	-	-	958,854	-	-	-	-	29.32	-
Forest	65,189	13,581	1,086	543,240	770	15.08	16.57	8.49	16.61	7.07
Rural Land	99,462	25,503	2,040	765,090	2,697	23.01	31.12	15.95	23.40	24.75
Livestock	53,224	11,254	1,192	-	-	12.31	13.73	9.32	-	-
Illicit Connections	87,851	136	32	953	-	20.33	0.17	0.25	0.03	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	85,849	4,490	748	29,932	-	19.86	5.48	5.85	0.92	-
Open Water	29	29	2	144	-	0.01	0.04	0.02	0.00	-
Total Storm Load	258,510	57,774	11,072	3,108,590	10,899	59.81	70.51	86.56	95.05	100.00
Total Non-Storm Load	173,701	24,167	1,718	161,719	-	40.19	29.49	13.44	4.95	-
Total Load to Surface Waters	432,210	81,941	12,791	3,270,308	10,899	100.00	100.00	100.00	100.00	100.00

Table 9. 4
Modeled Pollutant Loads in the Pomperaug River Subregional Basin

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	153,444	55,974	15,925	1,056,415	14,799	24.96	65.06	82.45	27.06	92.40
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	18	18	592,836	-	-	0.02	0.09	15.19	-
Road Sanding	-	-	-	1,583,865	-	-	-	-	40.57	-
Forest	49,487	10,310	825	412,390	544	8.05	11.98	4.27	10.56	3.40
Rural Land	27,284	6,996	560	209,880	673	4.44	8.13	2.90	5.38	4.20
Livestock	9,893	2,690	287	-	-	1.61	3.13	1.49	-	-
Illicit Connections	251,484	407	105	2,903	-	40.91	0.47	0.54	0.07	-
Point Source Discharges	352	3,204	524	2,764	-	0.06	3.72	2.71	0.07	-
OSDS/Septic	122,737	6,419	1,070	42,794	-	19.97	7.46	5.54	1.10	-
Open Water	21	21	2	103	-	0.00	0.02	0.01	0.00	-
Total Storm Load	240,129	67,355	17,200	3,793,263	16,016	39.06	78.29	89.06	97.16	100.00
Total Non-Storm Load	374,574	18,682	2,114	110,687	-	60.94	21.71	10.94	2.84	-
Total Load to Surface Waters	614,703	86,038	19,314	3,903,950	16,016	100.00	100.00	100.00	100.00	100.00

Table 9. 5
Modeled Pollutant Loads in the Sprain Brook Subregional Basin

	Existing Loads to Surface Waters					Percent of total load				
Source	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	9,951	8,003	2,170	99,613	1,976	8.20	26.42	54.59	6.66	54.56
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	8	8	281,857	-	-	0.03	0.21	18.86	-
Road Sanding	-	-	-	345,936	-	-	-	-	23.14	-
Forest	53,671	11,182	895	447,260	605	44.21	36.91	22.51	29.92	16.71
Rural Land	41,597	10,666	853	319,980	1,040	34.26	35.21	21.47	21.41	28.73
Livestock	1,537	405	44	-	-	1.27	1.34	1.10	-	-
Illicit Connections	14,638	21	4	146	-	12.06	0.07	0.11	0.01	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	-	-	-	-	-	-	-	-	-	-
Open Water	5	5	0.41	27	-	0.00	0.02	0.01	0.00	-
Total Storm Load	106,762	19,346	3,446	1,417,949	3,621	87.94	63.87	86.70	94.86	100.00
Total Non-Storm Load	14,638	10,945	529	76,870	-	12.06	36.13	13.30	5.14	-
Total Load to Surface Waters	121,400	30,291	3,974	1,494,819	3,621	100.00	100.00	100.00	100.00	100.00

Table 9. 6
Modeled Pollutant Loads in the Transylvania Brook Subregional Basin

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	34,588	6,096	1,849	114,373	1,991	27.60	28.52	59.00	9.94	63.23
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	6	6	202,703	-	-	0.03	0.19	17.61	-
Road Sanding	-	-	-	353,604	-	-	-	-	30.72	-
Forest	29,555	6,157	493	246,290	350	23.59	28.81	15.71	21.40	11.13
Rural Land	30,147	7,730	618	231,900	807	24.06	36.17	19.73	20.15	25.64
Livestock	3,948	1,041	111	-	-	3.15	4.87	3.53	-	-
Illicit Connections	21,087	29	5	194	-	16.83	0.13	0.17	0.02	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	5,987	313	52	2,087	-	4.78	1.46	1.66	0.18	-
Open Water	-	-	-	-	-	-	-	-	-	-
Total Storm Load	98,237	14,087	2,744	1,101,051	3,148	78.39	65.91	87.53	95.65	100.00
Total Non-Storm Load	27,074	7,286	391	50,101	-	21.61	34.09	12.47	4.35	-
Total Load to Surface Waters	125,311	21,373	3,135	1,151,152	3,148	100.00	100.00	100.00	100.00	100.00

Table 9. 7
Modeled Pollutant Loads in the Weekeepeemee River Subregional Basin

Source	Existing Loads to Surface Waters					Percent of total load				
	FC (billion/year)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	Runoff Volume (acre-feet/yr)	FC (%)	TN (%)	TP (%)	TSS (%)	Runoff Volume (%)
Urban Land	55,460	19,820	5,399	212,994	5,254	18.16	35.75	62.72	9.72	69.36
SSOs	-	-	-	-	-	-	-	-	-	-
Channel Erosion	-	12	12	403,028	-	-	0.02	0.14	18.40	-
Road Sanding	-	-	-	578,785	-	-	-	-	26.42	-
Forest	53,468	11,139	891	445,570	598	17.51	20.09	10.35	20.34	7.89
Rural Land	69,100	17,718	1,417	531,540	1,723	22.63	31.96	16.47	24.26	22.74
Livestock	29,111	3,893	414	-	-	9.53	7.02	4.81	-	-
Illicit Connections	45,786	67	14	459	-	14.99	0.12	0.16	0.02	-
Point Source Discharges	-	-	-	-	-	-	-	-	-	-
OSDS/Septic	52,423	2,742	457	18,278	-	17.17	4.95	5.31	0.83	-
Open Water	45	45	3	224	-	0.01	0.08	0.04	0.01	-
Total Storm Load	207,185	38,198	7,444	2,074,430	7,575	67.84	68.91	86.48	94.68	100.00
Total Non-Storm Load	98,209	17,237	1,164	116,448	-	32.16	31.09	13.52	5.32	-
Total Load to Surface Waters	305,393	55,435	8,608	2,190,878	7,575	100.00	100.00	100.00	100.00	100.00

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Appendix D

Structural BMP Prioritization Matrix

Pomperaug River Watershed Based Plan

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
POMPERAUG RIVER SUBWATERSHED										
Equestrian 1 (Pomperaug-01 and Transylvania Brook)	East Flat Hill Road, Southbury	Horse manure in paddocks Two drainage paths - one flows through Audubon old pasture, excellent buffer; another flows out drainage ditch to Transylvania Brook.	• Bioretention in drainage ditch adjacent to Audubon Property • Filter berm at bottom of paddock • Improved buffer around intermittent streams on equestrian property or reconfigured paddocks/runs/training areas • Move drainage away from the center of paddocks/pasture	• Outreach for manure management best practices • Connecticut Horse Environmental Awareness Program (HEAP) and Connecticut Horse Farm of Environmental Distinction Program	Medium (bioretention) High (filter berm/buffer)	Medium Medium	Medium Low	Yes	YES - LARGE	
Public School 1, Golf 1, Golf 2, Golf 3 (Pomperaug-03)	Old Field Road & Poverty Road, Southbury	Geese observed at both golf courses and in field adjacent to river at elementary school.	• Increase vegetated buffer around water hazards and adjacent to streams/river • Implement other waterfowl deterrent strategies		Medium (buffer) Low (other deterrent strategies)	Low Medium	Low High	Yes	YES - SMALL	
Residential Neighborhood 3 (Pomperaug-03)	Flood Bridge / River Hill neighborhood, Southbury	Failing or malfunctioning septic systems. Stormwater runoff.	• Sanitary/septic survey of Branch Road/Riverhill Road neighborhood • Infiltration in ROW or underground • Inspect Flood Bridge Road houses along riverbank for proper septic system sizing and function		Medium (IDDE/Septic investigation) High (infiltration BMP)	Medium High	N/A High	Yes	YES – LARGE Combine with Residential Neighborhood 2	
Residential Neighborhood 4 (Pomperaug-03)	River Trail, Spring Road, Middle Road ("Cedarlands"), Southbury	Failing or malfunctioning septic systems. Raw sewage odor noted during stream walk near River Trail.	• Investigate septic odor • Encourage septic system inspections • Educate homeowners and homebuyers about proper use and maintenance of septic systems • IDDE investigation of drainage discharging at Cedarland Park		High	Low	Low	Yes		
Residential Neighborhood 1 (Pomperaug-01)	Western side of Pomperaug River outlet to the Housatonic, North of River Road	Stormwater runoff	• Infiltration below roadway, especially cul-de-sac at Pascoe Drive and Pomperaug Trail and at Pascoe Drive and Berkshire Road intersection • Increase buffer along river • More frequent catch basin cleaning		High	High	High	Yes	YES - LARGE	
Residential Neighborhood 1 (Pomperaug-01)	Western side of Pomperaug River outlet to the Housatonic, North of River Road	Failing or malfunctioning septic systems	• Advanced subsurface sewage disposal systems (sand filter or similar) in riverside lots • Inspect septic systems for failure • Ledge/bedrock could be a constraint • Educate homeowners and homebuyers about proper use and maintenance of septic systems		High	High	High	Yes		
Residential Neighborhood 2 (Pomperaug-01)	Eastern side of Pomperaug River outlet to the Housatonic, North of River Road	Stormwater runoff	• Underground infiltration (limited space in ROW)	• Septic system inspection and outreach • Turf management • Grass clippings – outreach or establish collection for disposal	High	High	High	Yes	YES – LARGE Combine with Residential Neighborhood 3	

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Mixed Residential / Commercial Complex 1 (Pomperaug-03)	Heritage Road, Southbury	Stormwater runoff	• Underground infiltration in ROW • Bioretention cells where feasible • Pervious pavement at older parking lots (e.g. Meeting House) needing maintenance	• Heritage Village should be included as a priority area in the Town of Southbury's MS4 Stormwater Management Program, including IDDE program implementation • Conduct a stormwater BMP retrofit inventory/feasibility study for Heritage Village, which would support Southbury's efforts to reduce and disconnect DCIA as required by the MS4 Permit	High	High	High	Yes	YES - LARGE	
Wastewater Treatment Facility 1 (Pomperaug-03)	Heritage Road, Southbury	Wastewater treatment plant	• Conduct additional ambient water quality monitoring at new sampling locations to determine extent of impairment and possible source(s) of bacteria		N/A	Low	N/A	Yes		
Commercial Complex 1 (tributary to Pomperaug-03)	East side of intersection of Route 6 and Main Street South, Southbury (South of Bullet Hill Brook)	Stormwater runoff, waste management, past septic issues	• Incorporate LID retrofits into site redevelopment • Underground infiltration, permeable pavement • Inspect septic systems for failure (due to size this falls under DPH or DEEP jurisdiction)	• Cover dumpsters with roof • Review stormwater control plan, if exists • Heavily channelized stream • Conduct survey for potential illicit discharges from businesses in plaza	High	High	High	Yes		

Business District 1 (Pomperaug-03)	Main Street South Corridor, Southbury (particularly concentrated at Municipal Complex west of the intersection with Peter Road	Stormwater runoff	• Develop and implement GI/LID "master plan" for Main Street South corridor
			• LID retrofits of municipal and commercial properties and within the municipal ROW between Route 6/Southbury Plaza and South Britain Road (Route 172)
			• Potential municipal sites include:
			  ○ Southbury Police, Fire, and DPW
			  ○ Southbury Town Hall
			  ○ Southbury Park and Recreation
			  ○ Rochambeau Middle School
			  ○ Pomperaug Elementary School
			  ○ Southbury Library
			  ○ Municipal ROW
			• Numerous commercial redevelopment sites along the corridor
					High	High	High	Yes		

Health Care 2 (tributary to Pomperaug-03)	Intersection of Main Street South and Garage Road	Dry weather discharge (pavement stained)	• Follow up sampling of dry weather discharge and removal of any illicit connections found		Medium	Low	Low	Yes		

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Equestrian 2	Pomperaug River Crossing on Route 172, South Britain	Equestrian facility, manure piles, paddock	• Move manure piles to alternative site with filter berms or drainage away from Pomperaug • Filter berms or increased buffer to pond • Bank stabilization and buffer improvement along river edge • Evaluate need for farm pond • Move and regrade paddock/training areas to improve buffer	• Manure management in place • Most paddocks drain away from Pomperaug and toward a pond with algal mats that drains to Pomperaug • Farm to the north allows cows/cattle access to tributary. Add buffer and fencing around stream. • Outreach for manure management best practices • Connecticut Horse Environmental Awareness Program (HEAP) and Connecticut Horse Farm of Environmental Distinction Program	High	Medium	Low	Yes	YES - SMALL	
Equestrian 4	Intersection of Route 67 and Crook Horn Drive	Manure in open dumpsters	• Cover dumpsters or ensure drainage away from river	• Outreach for manure management best practices	High	Low	Low	Yes		
State Facility 1	Garage Road, Southbury	Stormwater runoff, potential illicit discharges (buried stream)	• Good housekeeping/pollution prevention • Infiltration where possible					No		
Town Park 2	Judson Avenue / Jack's Bridge Road, Woodbury	Pet and wildlife waste	• Pet waste management • Increase buffer width					No	YES – SMALL	
Earthworks / Quarry 1	Route 67, Southbury	Sedimentation ponds, dynamic river channel, non-bacterial	• N/A					No		
Town Park 1		Pet and wildlife waste	• Pet waste management					No		
Dog Park 1	Route 67 along the north bank of the Pomperaug River, Southbury	Pet waste, bank erosion	• Increase buffer width, already slated for bank stabilization project					No	YES - SMALL	
Residential Complex 2	Main Street South, Woodbury just north of the Southbury Town Line	Concerns about large residential septic system	• Inspect septic system for proper function					No		

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Equestrian 3	Route 67 along South Branch of Bullet Hill Brook	Stream running through paddock	• Encourage sufficient buffer • Animal exclusion fencing					No		
Residential Complex 3	Route 6 across intersection from South Pomperaug Avenue, Middle Quarter, Woodbury	Past septic issues	• Inspect septic system for proper function					No		
Commercial Complex 2	West side of Route 6; south of intersection with Route 64, Middle Quarter Woodbury	Historical groundwater contamination Septic failure issues	• Inspect septic system for proper function					No		
Health Care 1	North of intersection of Route 172 and Main Street South, Southbury adjacent to Pomperaug River	Past septic issues	• Inspect septic system for proper function					No		
WEEKEEPEEMEE RIVER SUBWATERSHED										
Cropland / Livestock 1 (Weekeepeemee-01)	Intersection of Chohees Trail & Weekeepeemee Road	Run-off from livestock pasture and feeding paddocks. Livestock access to intermittent stream. Row crops.	• Filter berms along pasture and Weekeepeemee • Increased vegetated buffer width • Infiltration BMP on north farm next to road • Remove stream access through buffer and/or fencing	• Fencing in good repair, encourage maintenance • Encourage effective manure application (e.g., not before rain storm)	High	Medium	Low	Yes	YES - SMALL	

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Equestrian 5 (Weekeepeemee-01)	Weekeepeemee Road Woodbury, just south of the Bethlehem town line	Livestock (horses, goats, alpaca) manure	• Filter berms along intermittent stream • Increase buffer width	• Fencing in good repair, encourage maintenance • Outreach for manure management best practices	High	Medium	Low	Yes		
Cropland 1 (Weekeepeemee-01)	Weekeepeemee Road South of Peter Road, Woodbury	Row crops	• Increase buffer width	Timing relevant to application of manure / fertilizer on the fields	High	Medium	Low	Yes		
Livestock (Weekeepeemee-01)	Weekeepeemee Road South of Peter Road, Woodbury	Livestock (few head);	• Filter berms along Weekeepeemee • Increase buffer width	• Encourage effective manure application (e.g., not before rain storm) • Outreach for manure management best practices	High	Medium	Low	Yes	YES - SMALL	
Cropland 2 (tributary to Weekeepeemee-01)	North of Peter Road, adjacent to Carmel Hill Brook	Row crops / vegetable	• Increase buffer width		High	Medium	Low	Yes		
Livestock 3	Guilds Hollow Road	Livestock grazing and feed lot	• Filter berm along Dowd Brook	• Feeding appears to occur in a local depression, ensure that it does not drain under road	High	Medium	Low	Yes	YES – SMALL	
Cropland / Livestock 2	Thomson Road, Bethlehem	Livestock access to tributary	• Increased buffer and fencing or filter berms	• Evaluate manure storage • Outreach for manure management best practices	High	Low	Low	Yes	YES - SMALL	

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Livestock 2	Robert Leather Road, Bethlehem	Convent with active farm operation. Past grant recipient for cattle management to get cows out of a wetland area.	• Encourage effective manure management					Yes		
Earthworks 2 (Weekeepeemee-01)	North of Crane Hollow Road, east of Weekeepeemee River	Earth excavation and school bus yard	• Encourage effective sediment and erosion controls, runoff infiltration					No		
Residential Neighborhood 6	Kasson Grove, Bethlehem	Lake side housing community -- old seasonal camps, many now year round residences	• Inspect septic system for proper function and sizing					No		
Residential Neighborhood 5	Lake Drive	Lake side housing community -- old seasonal camps, many now year round residences	• Inspect septic system for proper function and sizing					No		
Dairy Farm 1	West of Todd Hill Road, north of intersection with Wood Creek Road, Bethlehem	Manure storage	• Encourage effective manure management	• Evaluate manure storage • Outreach for manure management best practices				No		

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Equestrian 6	east of Todd Hill Road, south of Bergman Hill Road, Bethlehem	Manure storage	• Encourage effective manure management	• Evaluate manure storage • Outreach for manure management best practices				No		
Equestrian 7	Middle Road Turnpike, Woodbury	Horse access to tributary stream	• Filter berms and/or increased buffer in pasture • Reconfigure paddocks to avoid stream	• Some buffer exists in parts of pasture land • Outreach for manure management best practices • Connecticut Horse Environmental Awareness Program (HEAP) and Connecticut Horse Farm of Environmental Distinction Program	High	Medium	Low	Yes	YES - SMALL	
Dairy Farm 2	Artillery Road, Woodbury	Livestock access to tributary. Incomplete coverage of manure storage.	• Filter berms or fencing and increased buffer around stream to prevent livestock access • Reconfigure manure composting to divert runoff away from catch basins • Consider covered manure storage or manure composting		High	Medium	Low	Yes		

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Residential Neighborhood 7	Quassapaug Road at Soucy Road, Woodbury	Impacts to wetland areas Historic (chronic) septic failures	• Ensure wetland limits have been respected • Septic inspections					No		
Livestock 4	Hard Hill Road South, approximately 1/4 mile north of intersection with Nonnewaug Road, Bethlehem	Livestock paddock near farm pond Possible junkyard	• Encourage adequate buffer to water body • Ensure proper waste storage and disposal					No		
Plant Nursery 1	North of Washington Road (Route 47 Bridge), Woodbury	Fertilizer and pesticide applications	• Encourage effective application (and storage) strategies and timing					No		

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Livestock 7	West side of Flanders Road near intersection with Church Hill Road, Woodbury	Cattle	• Encourage effective manure management	• Outreach for manure management best practices				No		
Livestock 6	West side of Flanders Road near intersection with Church Hill Road, Woodbury	Cattle, chickens, pigs, etc	• Encourage effective manure management	• Outreach for manure management best practices				No		
Livestock 5	Route 6 near Guernseytown Road on the Woodbury/Watertown townline	Cattle, chickens, pigs, etc	• Encourage effective manure management	• Outreach for manure management best practices				No		
Cropland 3	East of Main Street North (Route 6), north of Scratchville Road along Nonnewaug River	Cornfield – application of manure as fertilizer	• Encourage effective application strategies and timing • Enhance width of riparian buffer					No		

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BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
EAST SPRING BROOK SUBWATERSHED										
Equestrian 7	Route 61, Morris north of fairgrounds	Manure storage	• Increase buffer to stream	• Manure management measures appear to be in place • Outreach for manure management best practices • Connecticut Horse Environmental Awareness Program (HEAP) and Connecticut Horse Farm of Environmental Distinction Program	High	Low	Low	Yes		
Fish Hatchery 1	Nonnewaug Road, Bethlehem	Nutrients	• If still active, encourage effective waste management, possibly through multi-trophic aquaculture					No		
Dairy Farm 3	Magnolia Hill Road and Hard Hill Road South, Bethlehem	Livestock access to tributary. Manure storage	• Filter berms or fencing and increased buffer around stream to prevent livestock access • Evaluate manure storage practices	• Outreach for manure management best practices				No		
TRANSYLVANIA BROOK SUBWATERSHED										
State Facility 2	Route 172, Southbury north of South Britain Historic District	Ag easement, including leases to local farming operations	• Encourage effective manure management and timing for spread of fertilizer/manure on cropland areas	Outreach for manure management best practices				No		
State Facility 2	Route 172, Southbury north of South Britain Historic District	Waterfowl	• Establish / increase riparian buffer width to filter runoff from fields where geese graze	Pond infested with water chestnut				No	YES - SMALL	

BMP Prioritization Matrix for Potential Areas of Concern

Pomperaug River Watershed Based Plan

New Site ID (Impaired Segment)	Location Description	Bacteria Sources	Potential Best Management Practices (BMPs)	Other Recommendations and Notes	Relative BMP Pollutant (Bacteria) Removal	Relative Cost	Maintenance Requirements	Field Visit Conducted	BMP Concept Development	Photo
Dairy Farm 4	Spruce Brook Road, Southbury	Manure storage	• Encourage effective manure management	• Outreach for manure management best practices				No		
HESSEKEY BROOK SUBWATERSHED										
Residential Complex 4	Transylvania Road & Woodlake Road	Private sewage treatment plant	• Ensure correct sizing and effective monitoring for failures					No		
Dairy Farm 5	north of intersection of Grassy Hill Road and North Road, Woodbury	Manure storage / Cattle pastured on slope draining to pond with minimal buffer width	• Filter berms or fencing and increased buffer around stream to prevent livestock access	• Outreach for manure management best practices				No		

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Appendix E

Site-Specific BMP Concept Cost Estimates

Pomperaug River Watershed Based Plan

Pomperaug River Watershed Based Plan
Planning-Level Costs for Site-Specific BMP Concepts

Location and Element		Order of Magnitude Cost Range													
		Construction				Planning and Design		Cost Range			Life Cycle				
		Unit Cost	Unit	Quantity	Cost (2018$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Residential 1															
1	Subsurface Infiltration	$20.00	cf runoff treated	2,700	$54,000	30%	$16,200	$71,000	$50,000	$107,000	20	$5,220	10%	$520	$5,740
Add-on	Permeable Pavement - Replace cul-de-sac	$3.07	sf	4,300	$13,201	30%	$3,960	$18,000	$13,000	$27,000	20	$1,320	10%	$130	$1,450
							Total	**$89,000**	**$63,000**	**$134,000**					
Residential 2															
1	Subsurface Infiltration	$20.00	cf runoff treated	4,400	$88,000	30%	$26,400	$115,000	$81,000	$173,000	20	$8,460	10%	$850	$9,310
2	Infiltration Basin, I-84 On-Ramp	$18.72	cf runoff treated	600	$11,232	30%	$3,370	$15,000	$11,000	$23,000	20	$1,100	10%	$110	$1,210
3	Infiltration Basin, Oakdale Road	$18.72	cf runoff treated	2,200	$41,184	30%	$12,360	$54,000	$38,000	$81,000	20	$3,970	10%	$400	$4,370
							Total	**$184,000**	**$130,000**	**$277,000**					
Residential 3															
1	Bioretention Area, north	$35.62	sf	350	$12,467	30%	$3,740	$17,000	$12,000	$26,000	20	$1,250	10%	$130	$1,380
2	Bioretention Area, south	$35.62	sf	1,000	$35,620	30%	$10,690	$47,000	$33,000	$71,000	20	$3,460	10%	$350	$3,810
3	Subsurface Infiltration	$20.00	cf runoff treated	4,000	$80,000	30%	$24,000	$104,000	$73,000	$156,000	20	$7,650	10%	$770	$8,420
							Total	**$168,000**	**$118,000**	**$253,000**					
Residential/Commercial Mixed 1															
1	Linear Bioretention	$35.62	sf	900	$32,058	30%	$9,620	$42,000	$29,000	$63,000	20	$3,090	10%	$310	$3,400
2	Subsurface Infiltration, Bank	$20.00	cf runoff treated	1,700	$34,000	30%	$10,200	$45,000	$32,000	$68,000	20	$3,310	10%	$330	$3,640
3	Subsurface Infiltration, 460 Heritage Road	$20.00	cf runoff treated	3,600	$72,000	30%	$21,600	$94,000	$66,000	$141,000	20	$6,920	10%	$690	$7,610
4	Infiltration Basin, Village Green	$18.72	cf runoff treated	8,300	$155,376	30%	$46,610	$202,000	$141,000	$303,000	20	$14,860	10%	$1,490	$16,350
5	Infiltration Basin, Heritage and Poverty Roads	$18.72	cf runoff treated	1,700	$31,824	30%	$9,550	$42,000	$29,000	$63,000	20	$3,090	10%	$310	$3,400
6	Vegetated Water Quality Swale	$10.96	sf	1,600	$17,536	30%	$5,260	$23,000	$16,000	$35,000	16	$1,970	10%	$200	$2,170
7	Permeable Pavement	$3.07	sf	39,750	$122,033	30%	$36,610	$159,000	$111,000	$239,000	20	$11,700	10%	$1,170	$12,870
							Total	**$607,000**	**$424,000**	**$912,000**					
State Facility 2															
1	Permeable Pavement	$3.07	sf	59,200	$181,744	30%	$54,520	$237,000	$166,000	$356,000	20	$17,440	10%	$1,740	$19,180
2	Bioretention Area, Hartford Hill	$35.62	sf	1,000	$35,620	30%	$10,690	$47,000	$33,000	$71,000	20	$3,460	10%	$350	$3,810
3	Bioretention Area, Constitution Hill	$35.62	sf	2,500	$89,050	30%	$26,720	$116,000	$81,000	$174,000	20	$8,540	10%	$850	$9,390
4	Bioretention Area, Liberty Lane	$35.62	sf	1,200	$42,744	30%	$12,820	$56,000	$39,000	$84,000	20	$4,120	10%	$410	$4,530
5	Vegetated Water Quality Swale, north	$10.96	sf	1,400	$15,344	30%	$4,600	$20,000	$14,000	$30,000	16	$1,720	10%	$170	$1,890
6	Vegetated Water Quality Swale, south	$10.96	sf	4,500	$49,320	30%	$14,800	$65,000	$46,000	$98,000	16	$5,580	10%	$560	$6,140
7	Buffer Restoration	$12,166.62	acre	1.06	$12,848	30%	$3,850	$17,000	$12,000	$26,000	20	$1,250	10%	$130	$1,380
							Total	**$558,000**	**$391,000**	**$839,000**					
Golf Course, Public School, and Town Park															
1	Bioretention Areas	$19.97	sf	1,400	$27,955	30%	$8,390	$37,000	$26,000	$56,000	20	$2,720	10%	$270	$2,990
2	Subsurface Infiltration	$20.00	cf runoff treated	9,539	$190,780	30%	$57,230	$249,000	$174,000	$374,000	20	$18,320	10%	$1,830	$20,150
3	Permeable Pavement	$3.07	sf	4,700	$14,429	30%	$4,330	$19,000	$13,000	$29,000	20	$1,400	10%	$140	$1,540
4	Buffer Restoration	$12,166.62	acre	0.75	$9,105	30%	$2,730	$12,000	$8,000	$18,000	20	$880	10%	$90	$970
Add-on	Permeable Pavement - front parking rows	$3.07	sf	5,800	$17,806	30%	$5,340	$24,000	$17,000	$36,000	20	$1,770	10%	$180	$1,950
							Total	**$341,000**	**$238,000**	**$513,000**					

Pomperaug River Watershed Based Plan
Planning-Level Costs for Site-Specific BMP Concepts

Location and Element		Order of Magnitude Cost Range													
		Construction				Planning and Design		Cost Range			Life Cycle				
		Unit Cost	Unit	Quantity	Cost (2018$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Dog Park 1															
1	Infiltration Basin	$18.72	cf runoff treated	1,100	$20,592	30%	$6,180	$27,000	$19,000	$41,000	20	$1,990	10%	$200	$2,190
2	Buffer Restoration	$12,166.62	acre	0.25	$3,017	30%	$900	$4,000	$3,000	$6,000	20	$290	10%	$30	$320
							Total	**$31,000**	**$22,000**	**$47,000**					
Town Park 2															
1	Buffer Restoration	$12,166.62	acre	3.70	$45,016	30%	$13,500	$59,000	$41,000	$89,000	20	$4,340	10%	$430	$4,770
							Total	**$59,000**	**$41,000**	**$89,000**					
Livestock 1															
1	Buffer Restoration, grazing area	$12,166.62	acre	0.11	$1,397	30%	$420	$2,000	$1,000	$3,000	20	$150	10%	$20	$170
2	Buffer Restoration, pasture	$12,166.62	acre	0.51	$6,145	30%	$1,840	$8,000	$6,000	$12,000	20	$590	10%	$60	$650
3	Shade Structure	$1.60	sf	300	$480	30%	$140	$1,000	$1,000	$2,000	15	$90	10%	$10	$100
							Total	**$11,000**	**$8,000**	**$17,000**					
Livestock 3															
1	Buffer Restoration, feeding area	$12,166.62	acre	0.37	$4,469	30%	$1,340	$6,000	$4,000	$9,000	20	$440	10%	$40	$480
2	Buffer Restoration, hay and grazing	$12,166.62	acre	1.91	$23,182	30%	$6,950	$31,000	$22,000	$47,000	20	$2,280	10%	$230	$2,510
Add-on	Filter Berm	$13.86	ft	375	$5,198	30%	$1,560	$7,000	$5,000	$11,000	15	$630	10%	$60	$690
							Total	**$44,000**	**$31,000**	**$67,000**					
Cropland/Livestock 1															
1	Buffer Restoration	$12,166.62	acre	0.69	$8,379	30%	$2,510	$11,000	$8,000	$17,000	20	$810	10%	$80	$890
2	Exclusion Fencing	$15.00	linear foot	1,250.00	$18,750	30%	$5,630	$25,000	$18,000	$38,000	20	$1,840	10%	$180	$2,020
							Total	**$36,000**	**$26,000**	**$55,000**					
Cropland/Livestock 2															
1	Buffer Restoration 1	$12,166.62	acre	2.66	$32,400	30%	$9,720	$43,000	$30,000	$65,000	20	$3,160	10%	$320	$3,480
2	Buffer Restoration 2	$12,166.62	acre	0.19	$2,346	30%	$700	$4,000	$3,000	$6,000	20	$290	10%	$30	$320
3	Filter Berm	$13.86	ft	325	$4,505	30%	$1,350	$6,000	$4,000	$9,000	15	$540	10%	$50	$590
							Total	**$53,000**	**$37,000**	**$80,000**					
Equestrian 1															
1	Buffer Restoration	$12,166.62	acre	0.75	$9,125	30%	$2,740	$12,000	$8,000	$18,000	15	$1,080	10%	$110	$1,190
2	Exclusion Fencing	$20.00	foot	1,300.00	$26,000	30%	$7,800	$34,000	$24,000	$51,000	15	$3,060	10%	$310	$3,370
							Total	**$46,000**	**$32,000**	**$69,000**					
Equestrian 2															
1	Buffer Restoration, Equestrian	$12,166.62	sf	0.20	$2,430	30%	$730	$4,000	$3,000	$6,000	15	$360	10%	$40	$400
Add-on	Bank Stabilization	$57.70	linear foot	850.00	$49,045	30%	$14,710	$64,000	$45,000	$96,000	20	$4,710	10%	$470	$5,180
							Total	**$68,000**	**$48,000**	**$102,000**					
Equestrian 7															
1	Buffer Restoration	$12,166.62	acre	0.73	$8,938	30%	$2,680	$12,000	$8,000	$18,000	15	$1,080	10%	$110	$1,190
2	Exclusion Fencing	$20.00	foot	900.00	$18,000	30%	$5,400	$24,000	$17,000	$36,000	15	$2,160	10%	$220	$2,380
							Total	**$36,000**	**$25,000**	**$54,000**					
							All Projects:	**$2,331,000**							

Notes:
Rate of Inflation used = 2%
Interest (discount) rate used = 6%
*Projects are proposed for these locations already. Costs estimated in this table are for adding ecological and water quality elements to the assumed original purpose of the proposed projects.
Costs should be used for planning purposes only based on screening-level evaluations of site characteristics. Construction costs could vary significantly.

Unit Costs

Element	2018 Adjusted Cost	Unit	Cost	$YEAR	Source
Low Impact Development/Green Infrastructure Practices					
Curbside Bioswale	$ 15,000.00	ea			Recent bids for New Haven West River Bioswales, Fuss & O'Neill.
Large Bioretention Retrofit	$ 13.10	cf runoff treated	$ 10.50	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-3
Small Bioretention Retrofit (<0.5 acre)	$ 35.62	sf	$ 32.50	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Rain Garden	$ 7.98	sf	$ 7.28	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Water Quality Swale	$ 10.96	sf	$ 10.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Porous Asphalt	$ 3.07	sf	$ 2.80	2012	UNH Stormwater Center 2012 Biennial Report. Page 12
Permeable Pavers	$ 10.96	sf	$ 10.00	2012	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-5
Reinforced Gravel Parking	$ 5.07	sf	$ 5.07	2013	http://www.boddingtonsonline.com/products/grass-ground-reinforcement/grass-reinforcement-protection/bodpave-85-permeable-gravel-pavers.php; Added $2/sf for installation
Subsurface Infiltration	$ 20.00	cf runoff treated	$ 20.00	2018	Fuss & O'Neill, City of Pawtucket Grant Application, 2018.
Green Roof	$ 25.21	sf	$ 23.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Blue Roof	$ 5.48	sf	$ 5.00	2012	NYC Department of Environmental Protection (2012), Rooftop Detention: A Low-Cost Alternative for Complying with New York City's Stormwater Detention Requirements and Reducing Urban Runoff.
Subsurface Gravel Wetland	$ 23.93	cf runoff treated	$ 21.83	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Pond Retrofit	$ 13,852.80	impervious acre of runoff treated	$ 11,100.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-2
French Drain/Infiltration Trench	$ 19.97	lf	$ 16.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Tree Box	$ 6,576.00	ea	$ 6,000.00	2012	UNH Stormwater Center 2012 Biennial Report, adjusted based on professional judgement, inflation, and materials cost.
Infiltration Basin	$ 18.72	cf runoff treated	$ 15.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted
Constructed Wetland	$ 5.08	sf	$ 4.07	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Restoration Practices					
Vegetated Buffer Restoration	$ 12,166.62	ac	$ 10,543	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Stream Channel Restoration	$ 14,232.28	ac	$ 12,333	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Remove Invasive Species	$ 3,692.80	acre	$ 3,200	2010	Professional Engineering Experience
Tree Planting	$ 500.00	ea			Street tree cost
Bank stabilization	$ 57.70	river mile	$ 50.00	2010	Professional Engineering Experience
Educational Signage	$ 1,200	ea	$ 1,200	2013	Professional Engineering Experience
Agricultural Practices					
Filter Berm	$ 13.86	linear foot	$ 12.65	2013	Warner et al. (2013) Designing Contour Weep Berms to Reduce Agricultural Nonpoint Source Pollution. Applied Engineering in Agriculture 29: 521-528. $41.50 per linear meter. Converted to linear feet.

Inflation Rates

Inflation from	Inflation to	Percent
2004	2018	33.40%
2006	2018	24.80%
2010	2018	15.40%
2011	2018	11.80%
2012	2018	9.6%
2013	2018	8.0%

http://www.usinflationcalculator.com/

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Appendix F

PRWC Land Use Committee Meetings

Pomperaug River Watershed Based Plan

PRWC Land Use Committee

Monday October 31, 2016 at 1:00 PM-2:30PM
Southbury Town Hall, Room 205
501 Main Street South, Southbury

MEETING NOTES

1. Welcome / Sign-In

Reminder: This ties in with the matching funds requirements of the grant.

Present: Vince McDermott, Gail McTaggart, Ingrid Davis, Arthur Milnor, Dick Leavenworth, Neal Lustig, Petra Volinski, Aaron Budris, Chris Wood, DeLoris Curtis, Leslie Kane, Carol Haskins, David Askew
Absent: Susan Peterson, Norma Carey, Kyle Turoczi

2. Introduce Consulting Team from Fuss & O'Neill

David Askew, Project Manager, from Fuss & O'Neill was introduced and provided a brief background of experience developing watershed plans both from the non-profit perspective and, more recently, the consulting perspective. Fuss & O'Neill was selected through the RFP process to serve on this project. F&O's team for this project is made up of six staff where David serves as the Project Scientist. He will lead the watershed assessment process including the field assessments, BMP site selection, implementation strategy, and plan development.

3. Existing Information / Data

a. Review attached list
b. Committee input on missing items to add to the list*

Potential Additional Sources of Data to Consider

- Waste Water Treatment System Reports (from DEEP and/or DPH)
- NV COG will have 2016 updates to Land Use Maps
- CLEAR is expected to have 2015 Land Cover Data available soon
- Pomperaug MesoHABSIM report (Piotr Parasiewicz) – Instream habitat availability
    - especially sections relating to Orton Pond / Three Rivers

- Large Sewage Systems – DEEP Map or Site List
    - Lutheran Home, Route 6 and Dublin Hill Road, Southbury (17,000 gals)
    - Southbury Green, 700 Main Street South, Southbury (15-20,000 gals)
    - Woodlake Condominiums, Transylvania Road, Woodbury
- Municipal Zoning Regs – density concerns / build-out model
- Wetlands Enforcement Records – help identify areas of concern
- Water Quality Data from CT DEEP
    - data since the most recent Water Quality Report to Congress)
- Missing Data / Gaps -- identify need for monitoring program potential?

4. Hot Spots / Areas of Concern

a. Committee input on sites of concern to consider in the Plan development

HOT SPOTS identified during the meeting

- Above/Below Waste Water Treatment Plant
  (Heritage Village), Heritage Road, Southbury
- Three Rivers Park, Woodbury
  Jacks Bridge Road (Weekeepeemee) / Judson Avenue (Pomperaug)
- Orton Pond, Orton Lane, Woodbury
- East Meadow Brook?
    - Dry channel – at Strong Meadow Preserve, Scratchville Road, Woodbury
    - headwaters to Brook is the pond at Flanders Nature Center, Church Hill Road, Woodbury
- Blow out near State Garage, Bullet Hill Brook, Garage Road, Southbury
- Old Trolley Bed, Woodbury Reservoir Property, South Brook, Erosion of trail off Scuppo Road, Woodbury
- Horse Farm (?) along headwaters area of Weekeepeemee River, Todd Hill Road/Bergemann Hill Road, Bethlehem
- Kasson Grove (Long Meadow Lake), Bethlehem
- March Farms, Munger Hill Road, Bethlehem
- Newport Academy, Double Hill Road, Bethlehem
- Arch Bridge School / Wellspring, Arch Bridge Road, Bethlehem
- Pabst Farm / Blue Ribbon Farm (Woodbury?) – Tim Pabst Property
- Kasergus Farm, Crane Hollow Road, Bethlehem/Woodbury Line
- The Farm
    - Weekeepeemee River, Chohees Road, Woodbury (Beef Cattle)
    - Carmel Hill Brook, Peter Road, Woodbury (Crops)
- Logue Farm (Dairy – No Manure Management)
    - Quassapaug Road / Artillery Road, Woodbury

- Woodbury Ski & Racket, Spring Brook, Route 47, Woodbury
- Old Water Mill on Route 47 upstream from Woodbury Ski
    - (which way does it flow... Pomperaug or Shepaug?)
- O& G Industries, Pomperaug River, off Route 67, Woodbury/Southbury line
- Southbury Training School, Cassidy Road / Constitution Hill, Southbury
    - Farm Pumps?
    - Upper ag fields with new farming leases
    - Spruce Brook feeding Transylvania
- Abbey of Regina Laudis (cattle and other livestock), Flanders Road, Bethlehem
    - How's the septic?
- Sabil's Horse Stable, Bullet Hill Brook, Route 6, Southbury
- Eden Acres, Quassapaug Road / McVeigh Road / Middle Road Tpke, Woodbury
- Middle Quarter Mall, Route 6 / South Pomperaug Ave, Woodbury
    - Groundwater contamination - VOCs
    - Septic issues in commercial area
- Tappe Preserve, Transylvania Brook (severe bank erosion), East Flat Hill Road, Southbury
- Large Sewage Systems – DEEP Map or Site List?
    - Lutheran Home, Route 6 and Dublin Hill Road, Southbury (17,000 gals)
    - Southbury Green, 700 Main Street South, Southbury (15-20,000 gals)
    - Woodlake Condominiums, Transylvania Road, Woodbury

Additional "HOT SPOTS" identified post LUC meeting by PRWC Staff/ Board/LUC Members

- Flood Bridge Road and Cedarland Neighborhoods along Pomperaug River, Southbury
  Old fishing camps converted to year round residences, potential septic issues
- Southbury Training School, Route 172, Southbury
  Large population of Canada geese on lawn sloping to Stibbs Pond / Transylvania Brook
- Horse Stables located at Crook Horn Road and Route 67, Southbury
- Horse Stables on East Flat Hill Road (Pomperaug River/Transylvania Brook) near Audubon at Bent of the River
- Horse Stables on Route 172 in Southbury, just upstream of the South Britain Dam
- Southbury Dog Park, O&G Property of Route 67 Southbury
- Tietz earthmoving operation, Weekeepeemee River, Crane Hollow Road, Woodbury
- Platt Farm, Spruce Brook Road, Southbury (along Spruce Brook feeding Transylvania Brook)
- River Glen Health & Rehabilitation Center, Route 172, Southbury (Septic issues)
- Pomperaug Woods, retirement facility, Hertiage Road, Southbury
- Former Baskin Robbins facility (KanPak now), Route 6 (Main Street North), Southbury
- Condo / Townhouse Complex, Old Field Hill Road, Southbury
- Townhouses / Apartments, 1080 Main Street South, Woodbury (large septic? Pomperaug River frontage)

- Spruce Bank state subsidized senior housing, Main Street South, Woodbury (Septic)
- Fish Hatchery, East Spring Brook, Nonnewaug Road, Bethlehem
- Farm / Junkyard, Hard Hill Road South, Bethlehem (extends to Nonnewaug Road)
    - Contributor to both East Spring Brook and Nonnewaug River?
- Cattle Farm, Magnolia Hill Road, Bethlehem, East Spring Brook
- Southbury Plaza (K-mart/Stop & Shop), Route 6, Southbury (Septic)

5. Vision / Goals for Plan

a. Committee input to draft "Vision Statement and Goals" for Plan*

DRAFT VISION STATEMENT

PRWC's vision is that this Plan will be used as a road map to return impaired waters to swimmable and fishable conditions and that this document can be used to evaluate changes through time. PRWC's goal for the Pomperaug Watershed Based Plan is develop a document that:

- establishes an up-to-date baseline of conditions in the watershed;
- evaluates contributing factors in areas of known impairments;
- identifies water quality monitoring needs;
- identifies and prioritizes steps to reduce pollutant inputs to impaired rivers and streams;
- incorporates proactive measures to protect/maintain high quality streams; and,
- establishes community buy-in through public engagement in the planning process.

6. Next steps

a. Overview of General Timeline of Tasks Ahead

b. Next committee meeting

Immediate tasks that lay ahead are to:

- Develop a Quality Assurance Project Plan (QAPP), which the team from Fuss & O'Neill has already begun drafting. Once the QAPP is approved, they will begin assembling GIS and other related data to begin assessing Land Use and Land Cover factors associated with impairments. From that and the list of "hot spots" identified by the LUC, they will then conduct an on the ground Visual Assessment Survey in the impaired stream segments and determine
- Provide Fuss & O'Neill with a more organized list of potential hot spots – i.e. group them by stream corridor and progression from mouth to headwaters (possibly in map form).
- Update "List of Existing Data Sources" with LUC input. Begin annotating that list with key information pulled from each report.
- Start developing a communications strategy to notify riparian landowners about forthcoming Visual Assessment Surveys and the overall WMP project.

Next Committee Meeting will be scheduled for mid-January. Please expect emails to the full committee and to specific members asking for input and participation in the interim.

FUSS & O'NEILL

Agenda
Land Use Committee Meeting

Pomperaug River Watershed Based Plan

July 20, 2017

1. Introductions
2. Quality Assurance Project Plan (QAPP)
3. Compilation and Review of Existing Data, Plans & Studies
4. Existing Watershed Conditions Mapping
5. Watershed Assessments
6. Next Steps
7. Additional Discussion

Land Use Committee Meeting Notes
Southbury Town Hall, Room 205

July 20, 2017 ~ 9:00 to 11:00 am

1. **Introductions & Sign-in**

Begin presentation by Erik Mas of Fuss & O'Neill

2. **QAPP Update – no comments**

3. **Existing Data Gaps – no comments**

4. **Existing Conditions mapping – discussion notes follow**

Impervious Cover

- We will also estimate impervious cover at the CT DEEP Local Basin scale
- Note: Anything below 5% on the subregional watershed scale is considered very low (11% is usually the tipping point for degradation and 25% for "impacted" streams and urban drainage). If you were looking at the DEEP local basin scale, the % would be higher. However, when setting water quality goals and impervious cover limits, the subregional watershed is really the scale that should be used.Question about NLCD picking up low density residential impervious cover and whether or not that should be incorporated into the pollutant load modeling?

Land Use

- NVCOG dataset shows how land is used on a parcel level, which may help refine coefficients in the pollutant load modeling which will otherwise be based on the land cover dataset.

Land Cover

- UConn CLEAR may have more detail in the developed land cover class with the 2015 version. They are also developing an update to impervious cover for the new CT MS4 Permit, including a 2012 baseline to account for the 5-year "look back" for impervious cover reductions that are required in Years 4 and 5 of the CT MS4 Permit. Where does it stand? Fuss & O'Neill to check on both.
- Fuss & O'Neill to compare the 2010 and 2015 CLEAR land cover data to see what changes have occurred in this timeframe, which will provide some indication of the reliability of the 2011 National Land Cover Data to represent current conditions.
- Comment: Cows in Weekeepeemee River. Some farmers are applying fertilizer to pasture/hay fields. Can/should the Pasture/Hay land cover category be teased apart from a bacteria loading perspective? Similar discussion for Table 12 that lumps Agriculture, Turf, and Grass into a broad categories found within the riparian corridors.

Riparian zone

- Riparian zone development analysis – Check the date of the land cover data used by UConn CLEAR in the analysis (2006 versus 2010)
- Overlay riparian zone and protected open space for restoration/conservation opportunities analysis

Forest fragmentation

- Check the date of the land cover data used by UConn CLEAR in the analysis (2006 versus 2010)
- Overlay forest fragmentation and protected open space for conservation opportunities analysis

Open Space

- AREA OF CAUTION - Land preservation is a hot button issue in the towns.
    - Committee will come up with a single definition and criteria about what will be considered with a focus on permanently protected open space parcels (e.g. not CT Public Act 490 or 4742A land, which is <u>not</u> permanently protected from development).
    - NVCOG to update and share their parcel-based protected land information.
    - It would be helpful for Fuss & O'Neill to separate protected open space by use and/or mechanism of protection
    - Fuss & O'Neill to share protected land attribute tables to get committee input on the permanence of protection mechanisms
    - NVCOG to provide available open space data for their watershed communities, which is based on legacy data (collected and tracked by COGCNV over several decades), municipal parcels, and discussion with town officials and land trusts.
    - Roxbury conservation commission has some protected open space mapping
        - Barbara Henry First Selectman at 860-354-3478 is a resource
    - Note: Open Space map will not be used in the pollutant load model. However, this map may factor into BMP recommendations and help prioritize recommendations for future open space acquisitions.

Groundwater resources

- Are the aquifer protection areas all level A or some level A/B? A few committee members commented that the APA areas shown on the map look larger than they had remembered, possibly indicating that they may reflect earlier Level B mapping. Fuss & O'Neill will confirm.
- Surficial geology or USGS mapping. Vince McDermott suggested reviewing the available surficial materials mapping produced by USGS for the lower Housatonic Valley. He can also provide a hard copy for reference.

Hydrologic soil groups

- Town centers are a focus for development in the Statewide Conservation and Development Policies Plan for Connecticut, rather than scattershot. It therefore makes sense to tie into community septic systems. Hydrologic soil groups and other soils information may help suggest possible locations.
- Soil group categorizes the runoff / infiltration potential in an area and will be used broadly to help identify areas suitable for infiltration best management practices. Soils are also a factor related to on-site sewage treatment systems.
- Note: A and B soils = infiltration. C and D soils = runoff.

Water quality impairments

- Add CT DEEP ambient water quality and benthic macroinvertebrate monitoring locations to the map (other monitoring data?)
- Revise map to differentiate between assessed stream segments (green lines) that meet water quality standards and unassessed segments (blue lines).
- Recommendation in watershed plan: additional monitoring locations to help determine source(s) of impairments.
- Wastewater These data will be used in the pollutant load model that will estimate TSS, N, P, and Bacteria inputs from the watershed based on existing conditions.
- Need additional on septic systems (i.e., areas of failing septic systems) for pollutant load modeling
    - Map presented shows permitted discharges >5000 gallons per day
    - Fuss & O'Neill to contact CT DPH to for information on septic systems in the watershed that are regulated by CT DPH (2,000-4,999 GPD systems) – Wellspring and/or Newport Academy in Bethlehem may fall in this category (not on map provided)
        - Len DeJong may be a good resource, knows people at DPH from his time in drinking water
    - For locally-regulated septic systems, need failure rate information from Pomperaug (Woodbury, Southbury), Torrington (Watertown, Bethlehem, Middlebury, Morris), and Newtown (Roxbury) health districts
- Indicate permitted discharge type (by color) in discharge list/table
- CT Water Company may have updated sewer service area information
- Woodlake Condos has a treatment plant with a surface discharge

Areas of Concern

- Kyle Turoczi's daughter will compile a list for the committee to share with Fuss & O'Neill detailing farm locations, and crops grown/animals raised

5. Watershed Assessments

Pollutant load modeling

- Fuss & O'Neill to create and circulate a table of EMCs and loading factors used in each watershed to get coalition input

Visual field assessments

- Committee has a field work notification letter used by USGS for their sampling. Fuss & O'Neill needs something similar. We should also contact selectmen and local PDs prior to field work. PRWC can facilitate the notification process.

6. Next Steps

Fuss & O'Neill to provide updated link for latest set of maps.
https://fando.filetransfers.net/downloadPublic/o0anpku7so

Next meeting to likely occur in September, with public meetings following in October/November

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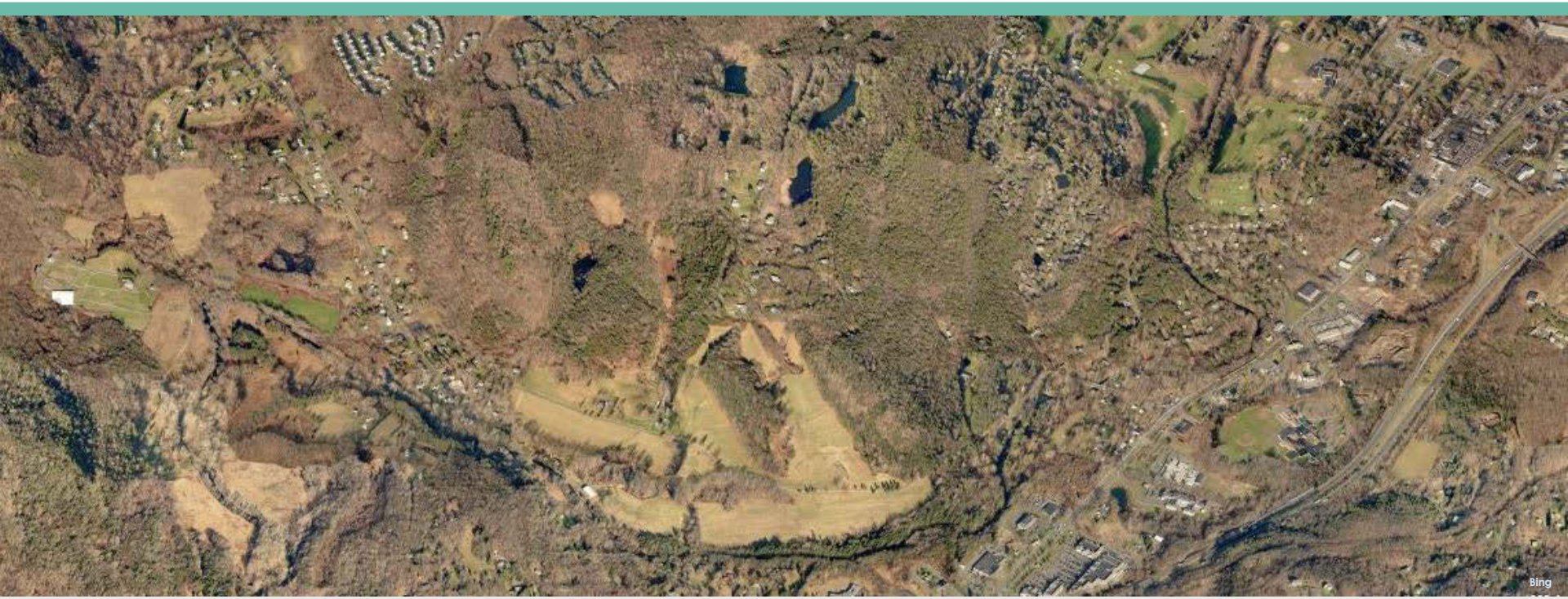


PRWC Land Use Committee Meeting

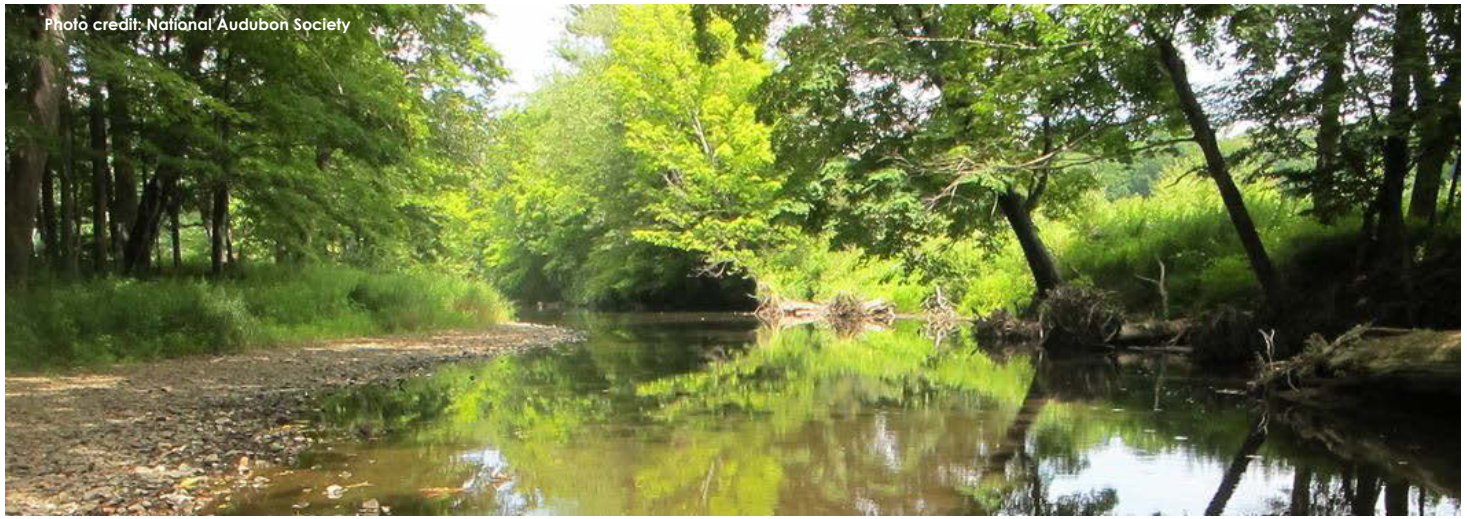
Pomperaug River Watershed Based Plan

July 20, 2017

POMPERAUG RIVER WATERSHED COALITION

Presentation Outline

1. Quality Assurance Project Plan (QAPP)
2. Compilation and Review of Existing Data, Plans & Studies
3. Existing Watershed Conditions Mapping
4. Watershed Assessments
5. Next Steps
6. Additional Discussion



POMPERAUG RIVER WATERSHED COALITION

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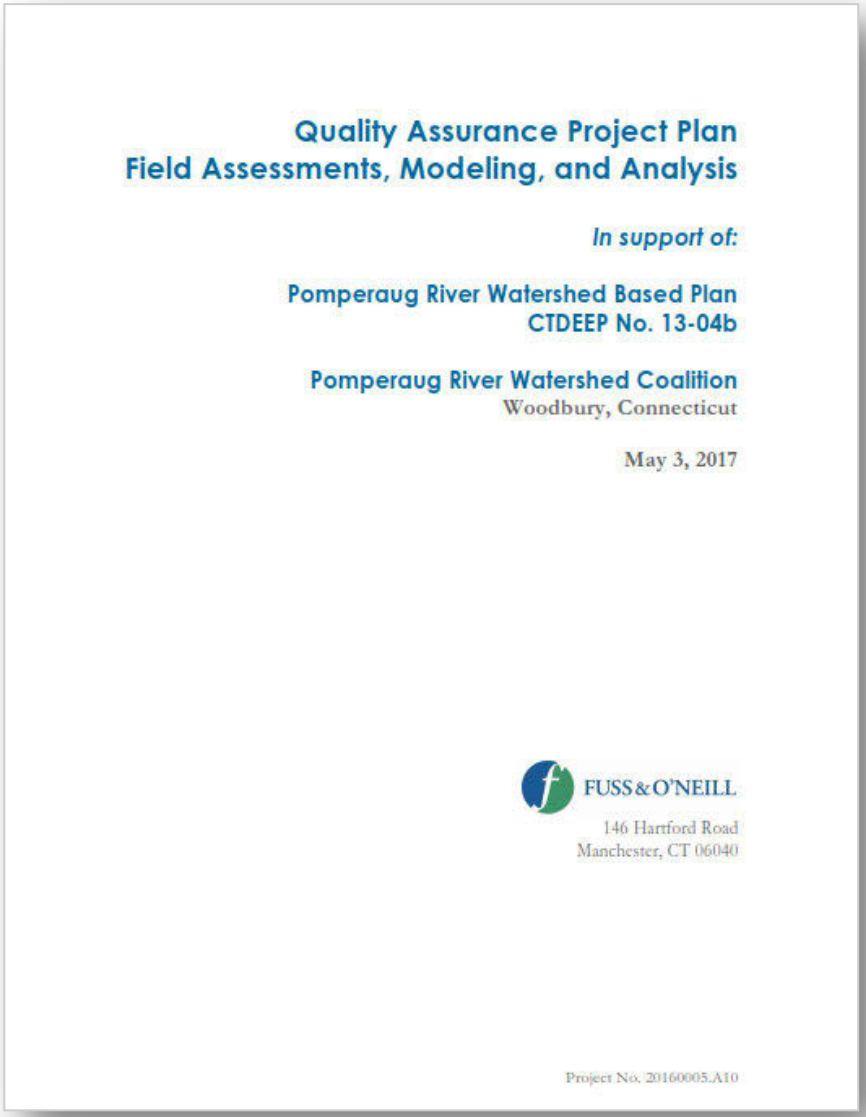
Quality Assurance Project Plan (QAPP)

- Includes
  - Field assessments
  - Pollutant load modeling
  - Secondary data usage
- Approved May 3, 2017



Quality Assurance Project Plan
Field Assessments, Modeling, and Analysis

In support of:

Pomperaug River Watershed Based Plan
CTDEEP No. 13-04b

Pomperaug River Watershed Coalition
Woodbury, Connecticut

May 3, 2017

FUSS & O'NEILL
146 Hartford Road
Manchester, CT 06040

Project No. 20160005.A10

POMPERAUG RIVER WATERSHED COALITION

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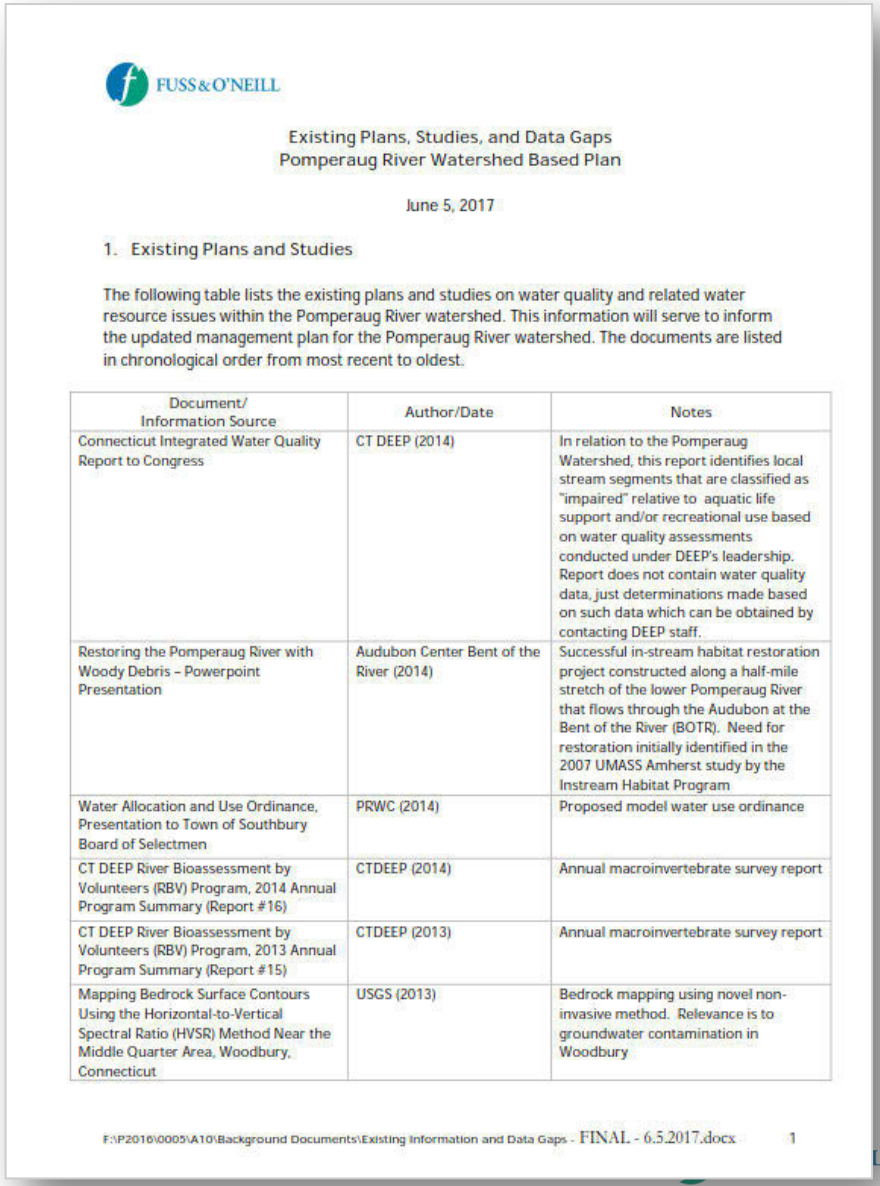
Existing Data, Plans & Studies

- Completed June 5, 2017
- Existing plans and studies
  - 34 documents identified
- Data gaps
  - Update existing conditions
  - Sources of Impairments
  - Pollutant Loads
  - Site-specific recommendations



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Existing Plans, Studies, and Data Gaps
Pomperaug River Watershed Based Plan

June 5, 2017

1. Existing Plans and Studies

The following table lists the existing plans and studies on water quality and related water resource issues within the Pomperaug River watershed. This information will serve to inform the updated management plan for the Pomperaug River watershed. The documents are listed in chronological order from most recent to oldest.

Document/ Information Source	Author/Date	Notes
Connecticut Integrated Water Quality Report to Congress	CT DEEP (2014)	In relation to the Pomperaug Watershed, this report identifies local stream segments that are classified as "impaired" relative to aquatic life support and/or recreational use based on water quality assessments conducted under DEEP's leadership. Report does not contain water quality data, just determinations made based on such data which can be obtained by contacting DEEP staff.
Restoring the Pomperaug River with Woody Debris – Powerpoint Presentation	Audubon Center Bent of the River (2014)	Successful in-stream habitat restoration project constructed along a half-mile stretch of the lower Pomperaug River that flows through the Audubon at the Bent of the River (BOTR). Need for restoration initially identified in the 2007 UMASS Amherst study by the Instream Habitat Program
Water Allocation and Use Ordinance, Presentation to Town of Southbury Board of Selectmen	PRWC (2014)	Proposed model water use ordinance
CT DEEP River Bioassessment by Volunteers (RBV) Program, 2014 Annual Program Summary (Report #16)	CTDEEP (2014)	Annual macroinvertebrate survey report
CT DEEP River Bioassessment by Volunteers (RBV) Program, 2013 Annual Program Summary (Report #15)	CTDEEP (2013)	Annual macroinvertebrate survey report
Mapping Bedrock Surface Contours Using the Horizontal-to-Vertical Spectral Ratio (HVSR) Method Near the Middle Quarter Area, Woodbury, Connecticut	USGS (2013)	Bedrock mapping using novel non-invasive method. Relevance is to groundwater contamination in Woodbury

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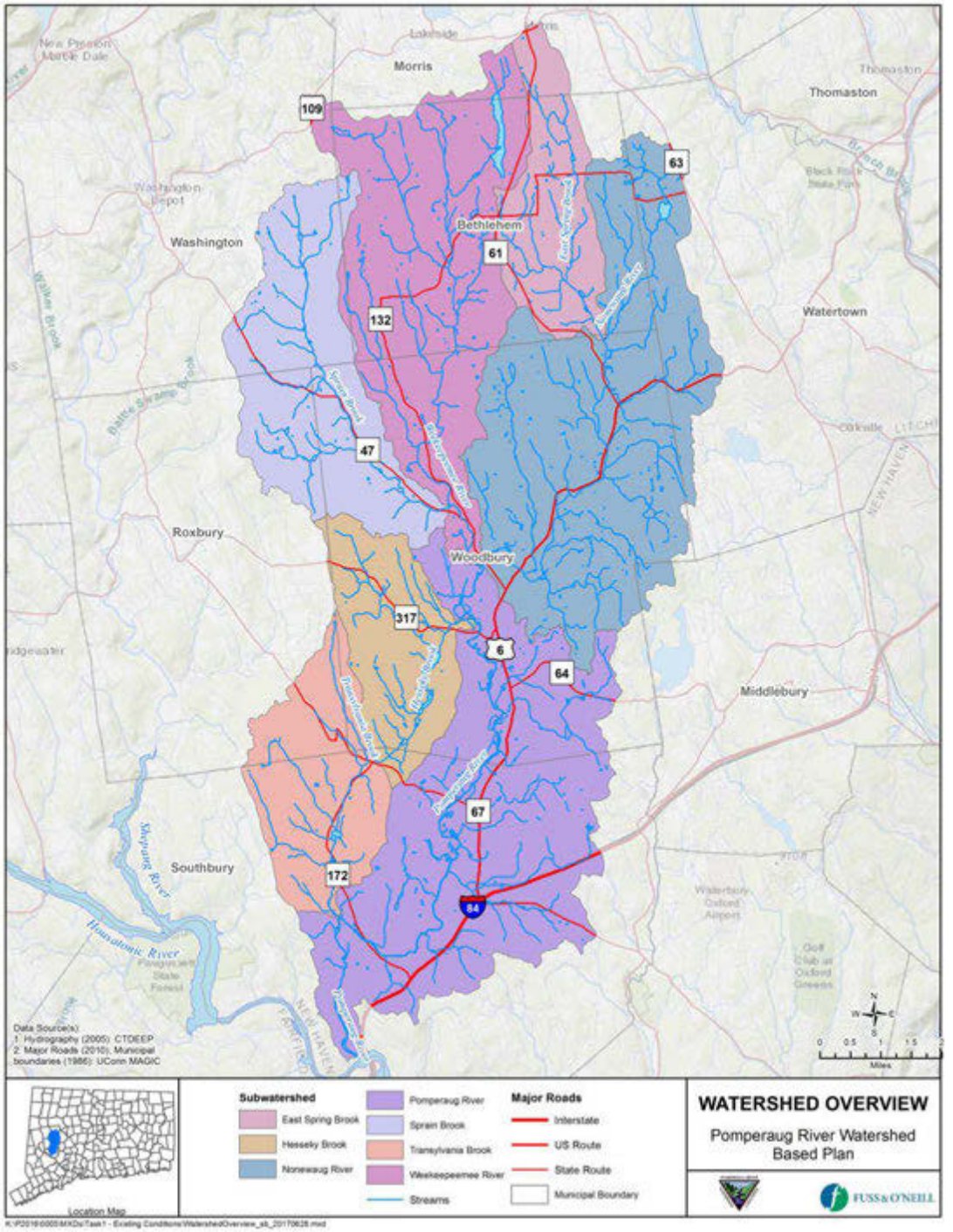
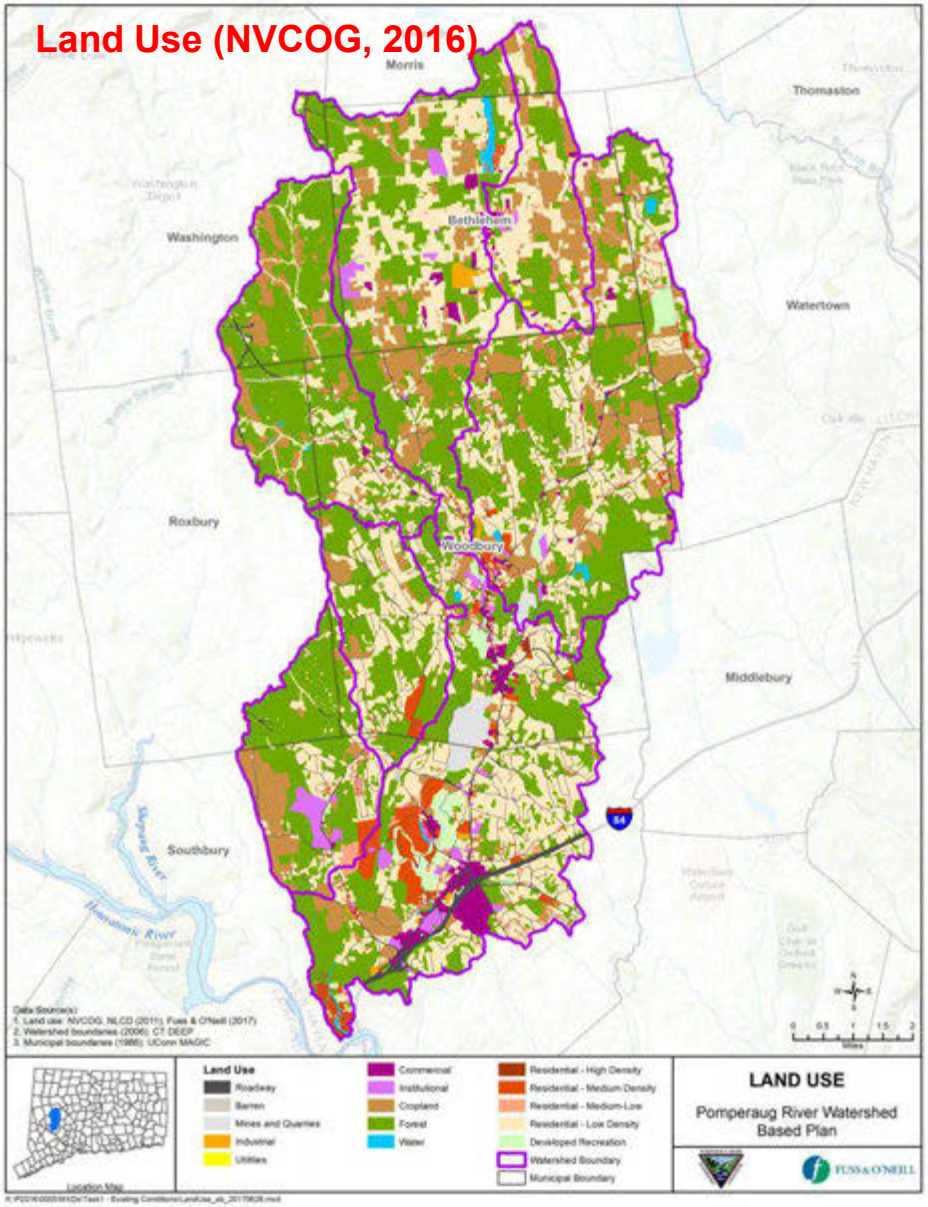
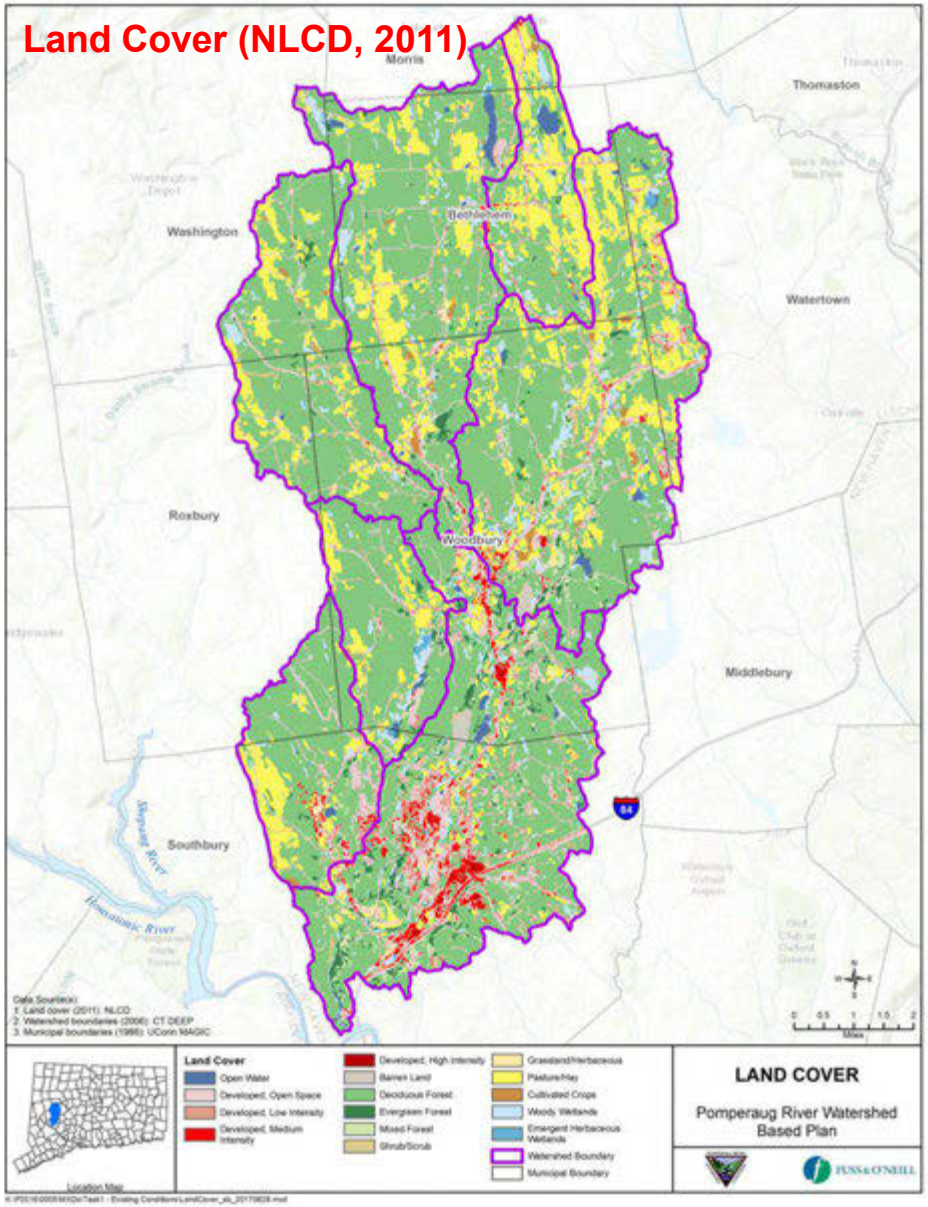
Watershed Mapping

- Draft watershed mapping completed
- Subwatersheds defined at DEEP Sub-regional Basin Scale
- Looking for feedback from PRWC and LUC
- Updated existing conditions narrative to be developed from mapping



Land Use / Land Cover





Land Use / Land Cover

Land Cover	Area (sq mi)	Percent of Watershed
Open Water	0.7	0.8
Developed, Open Space	7.2	8.1
Developed, Low Intensity	3.5	3.9
Developed, Medium Intensity	1.1	1.2
Developed, High Intensity	0.2	0.2
Barren Land	0.3	0.4
Deciduous Forest	53.6	60.3
Evergreen Forest	1.5	1.7
Mixed Foreset	1.3	1.5
Shrub/Scrub	1.6	1.8
Grassland/Herbaceous	0.5	0.6
Pasture/Hay	13.6	15.3
Cultivated Crops	0.5	0.6
Woody Wetlands	3.0	3.3
Emergent Herbaceous Wetlands	0.3	0.3
Total	89.0	100.0

- Top three land cover types:
  - Forest, Pasture/Hay, Developed
- Top three land uses:
  - Forest, Cropland, Low-density residential

Land Use	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River	Pomperaug Average
Barren	0.0	0.0	0.0	0.2	0.3	0.1	0.0	0.1
Commercial	1.4	0.0	0.6	4.8	0.2	0.1	1.4	1.2
Cropland	29.3	7.2	18.7	5.1	15.2	16.7	17.2	15.8
Developed Recreation	0.0	0.0	1.5	3.3	0.4	0.1	0.1	0.8
Forest	26.0	45.8	39.9	30.1	63.8	53.4	43.2	43.6
Industrial	0.2	0.0	0.2	0.4	0.0	0.0	0.9	0.2
Institutional	1.2	0.1	0.4	2.2	0.0	5.1	2.0	1.6
Mines and Quarries	0.0	0.0	0.6	3.0	0.0	0.0	0.0	0.5
Residential - High Density	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Residential - Low Density	37.0	39.2	30.0	34.1	17.4	16.8	30.0	29.5
Residential - Medium Density	0.4	2.9	0.9	6.4	0.0	1.7	0.5	1.9
Residential - Medium-Low	1.0	1.1	1.3	2.8	0.2	3.1	0.6	1.5
Roadway	0.3	3.9	3.3	7.1	2.0	2.8	1.0	2.9
Utilities	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.0	0.0	0.5	0.4	0.2	0.0	1.1	0.3
Total	97	100	98	100	100	100	98	100.0

Top 3 land uses by percent in red

Totals less than 100% are the result of parcel-based land cover, which does not include roadways in Bethlehem

POMPERAUG RIVER WATERSHED COALITION

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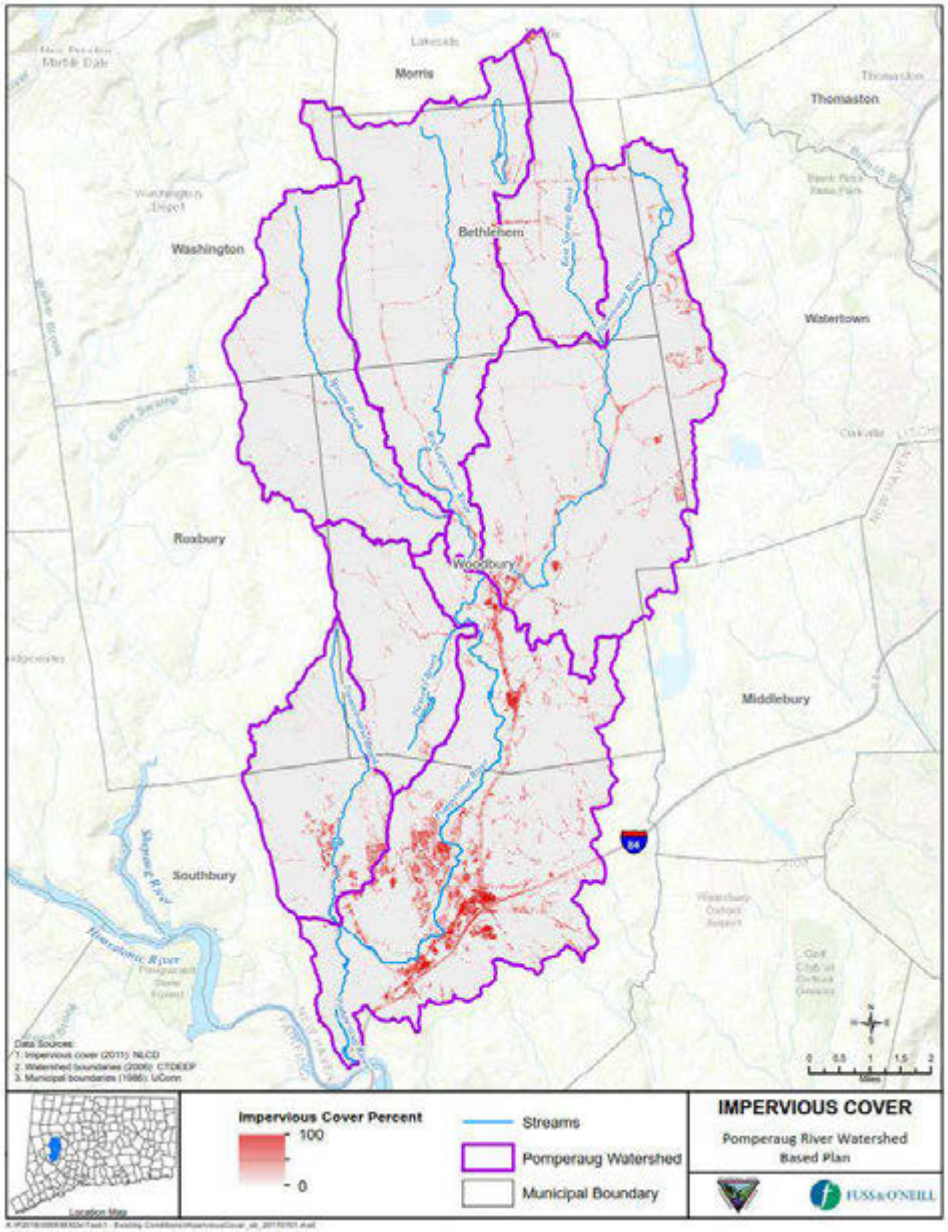
Impervious Cover



Subwatershed	Impervious Cover Percent
East Spring Brook	2.04
Weekeepeemee River	1.06
Nonewaug River	2.04
Sprain Brook	0.64
Hesseky Brook	1.17
Pomperaug River	6.64
Transylvania Brook	2.60
Watershed	2.78

- Sub-regional Basin analysis
- Pomperaug River sub-watershed has highest impervious cover
- None above 10% threshold
- Also evaluating DEEP Local Basins

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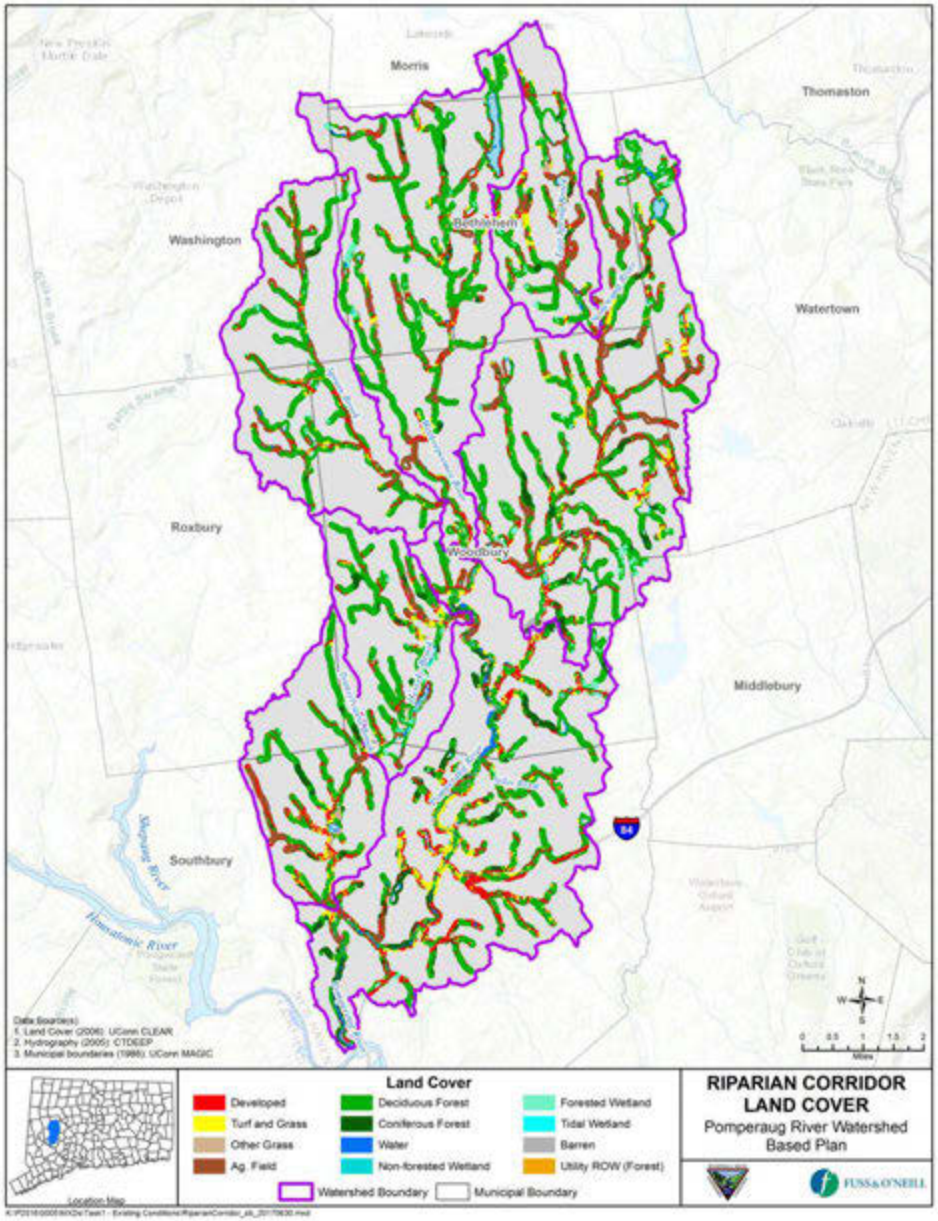
Riparian Corridor Land Cover



- UConn Center for Land Use Education And Research (CLEAR), 2006 Statewide Analysis
- 300-foot buffer either side of stream centerline
- All mapped perennial and intermittent streams in watershed

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Riparian Corridor Land Cover

- Mostly forest and wetland
- Pomperaug River subwatershed more developed than agricultural
- Other subwatersheds show the opposite pattern

Land Cover Category	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River
Developed, Other Grasses, Barren	10.33	10.33	12.05	22.05	11.74	17.63	9.89
Agriculture, Turf & Grass	30.38	14.91	26.76	14.54	15.98	20.13	19.36
Forest, Wetland, Water	59.29	74.76	61.20	63.41	72.28	62.24	70.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

POMPERAUG RIVER WATERSHED COALITION

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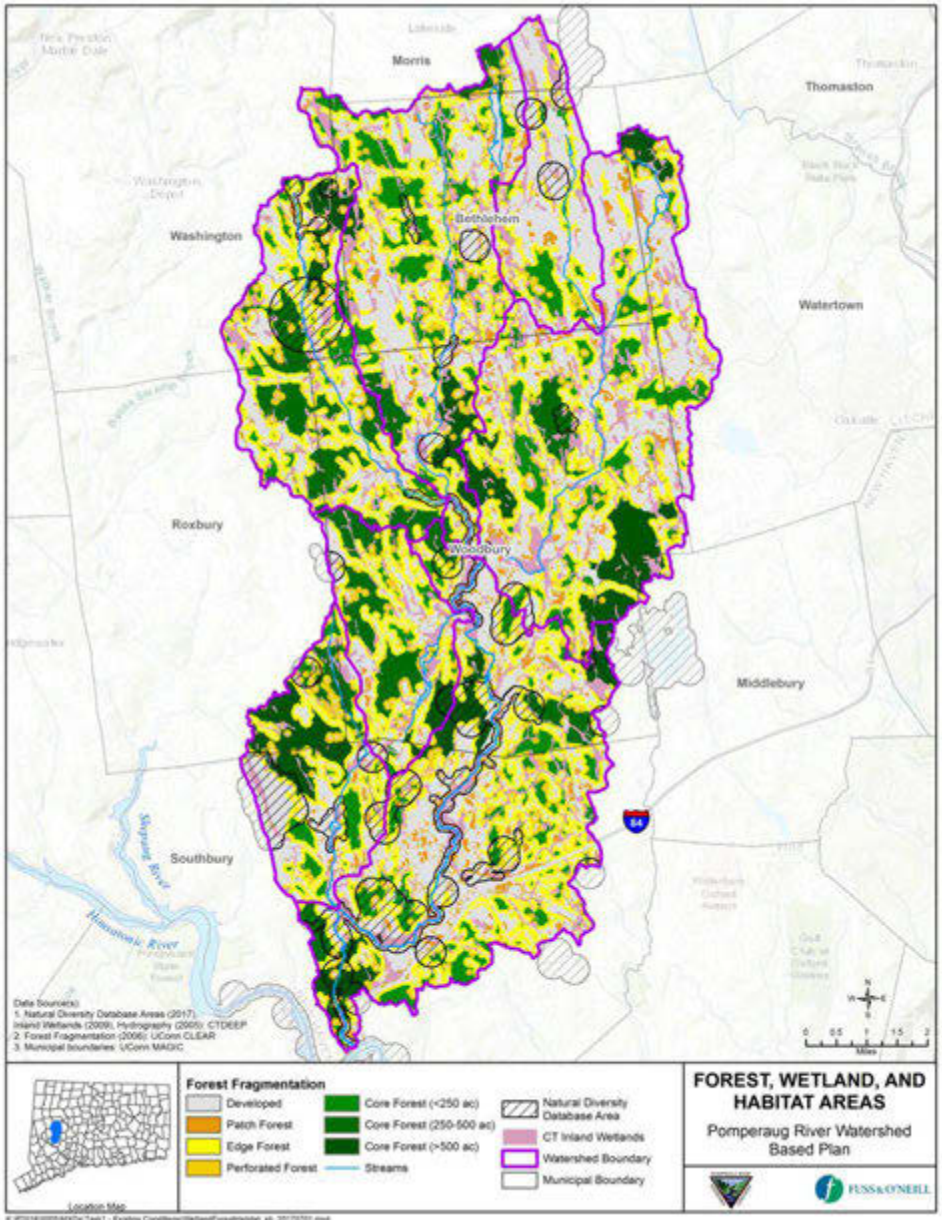
Forests, Wetlands, Critical Habitat



- UConn CLEAR
  - Forest fragmentation analysis, 2006
- CT DEEP
  - Wetlands (soil-based determination), 2009
  - National Diversity Database (NDDB), June 2017

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Forests, Wetlands, Critical Habitat

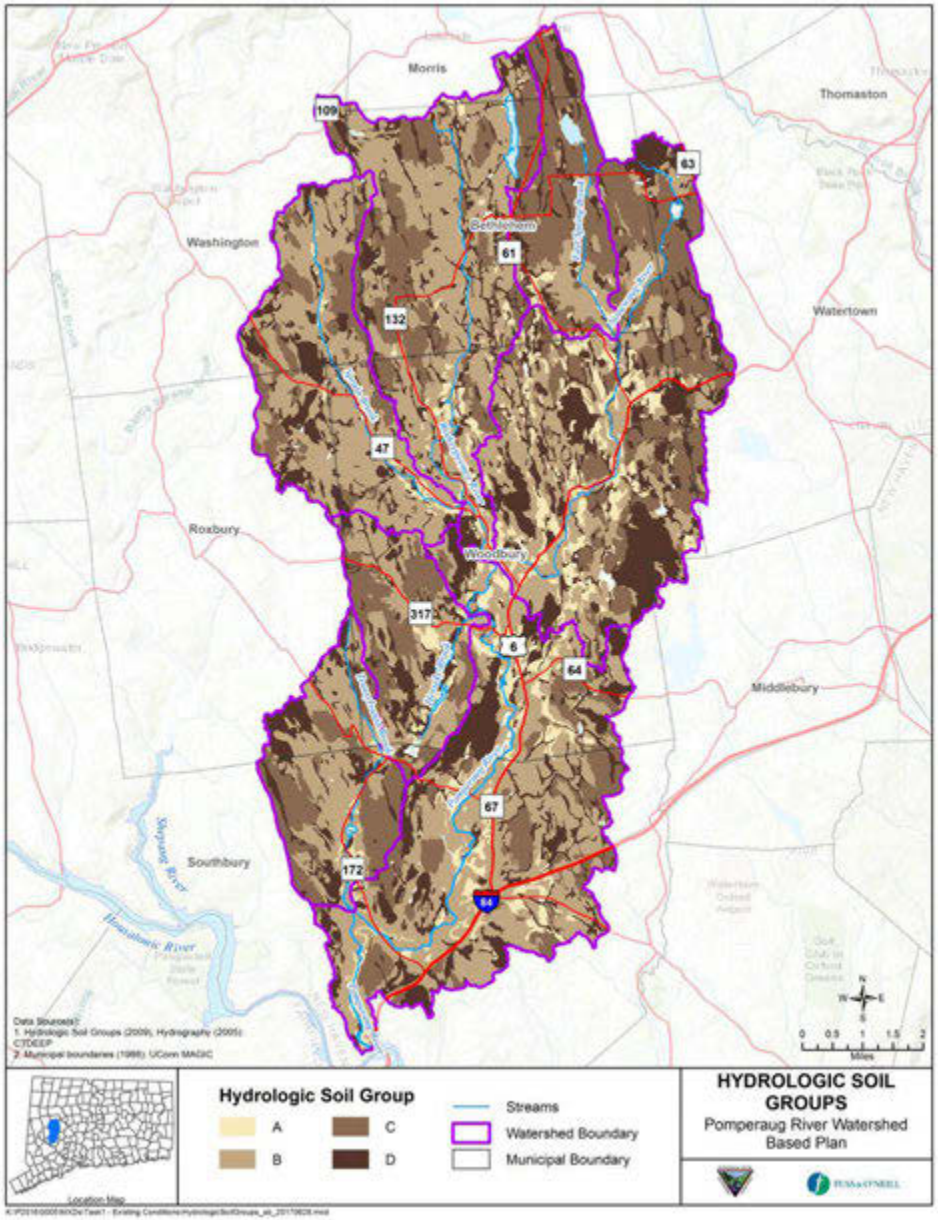
Subwatershed	Percent Core Forest
East Spring Brook	9.5
Weekeepeemee River	25.9
Nonewaug River	24.0
Sprain Brook	32.5
Hesseky Brook	31.6
Pomperaug River	21.6
Transylvania Brook	31.4
Average	25.2

- 25-30% Core Forest
  - East Spring Brook
- 9-15% Wetland
- 2-25% Critical Habitat

Subwatershed	Percent Wetland
East Spring Brook	12.6
Hesseky Brook	10.0
Nonewaug River	14.6
Pomperaug River	11.7
Sprain Brook	9.8
Transylvania Brook	8.9
Weekeepeemee River	15.0
Average	11.8

Subwatershed	Percent NDDB Area
East Spring Brook	8.6
Hesseky Brook	4.9
Nonewaug River	1.7
Pomperaug River	25.4
Sprain Brook	13.7
Transylvania Brook	24.9
Weekeepeemee River	4.5
Average	12.0

NRCS Hydrologic Soil Groups



- CTDEEP (NRCS)
  - Soils, 2009
- Infiltration capacity higher in A&B soils
- Impacts the feasibility and design of infiltration-based GI/LID and septic systems

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NRCS Hydrologic Soil Groups

- Approximately even distribution of soil groups across the watershed
- Variability at the subwatershed scale

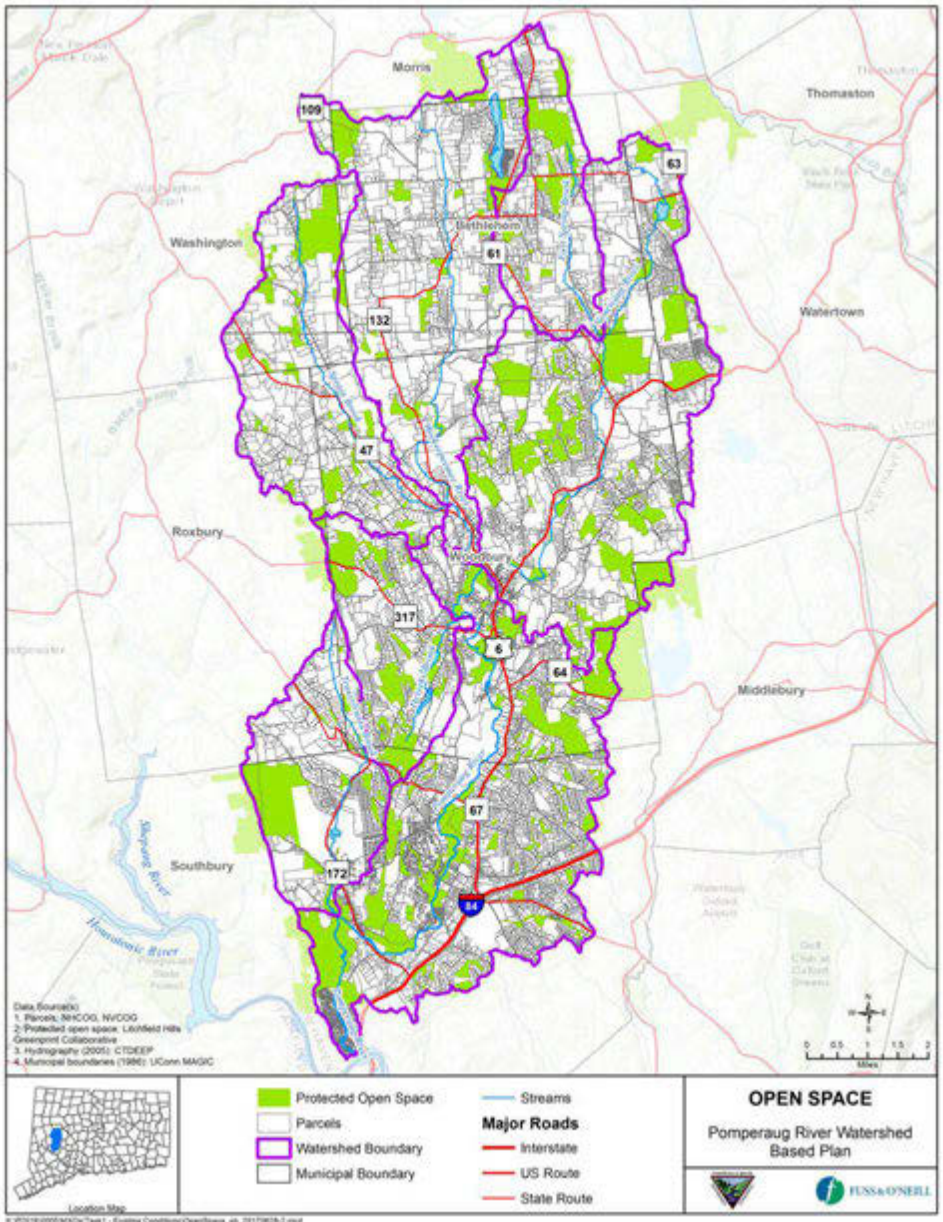
Total Area

Hydrologic Soil Group	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River	Total Area (sq mi)
A & B	1.5	2.8	9.4	13.3	6.8	3.3	9.1	46.3
C & D	4.2	3.3	11.7	7.8	4.1	3.9	6.8	41.7
Water	0.1	0.1	0.2	0.3	0.0	0.0	0.2	1.0
Total	5.8	6.2	21.3	21.4	11.0	7.2	16.1	89.0

Percent

Hydrologic Soil Group	East Spring Brook	Hesseky Brook	Nonewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River
A & B	26.3	45.5	44.3	62.1	62.4	45.9	56.3
C & D	71.4	52.4	54.8	36.6	37.3	53.8	42.3
Water	2.3	2.1	0.9	1.3	0.2	0.3	1.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Protected Open Space



- Open space data from Litchfield Hills Greenprint Collaborative
- Parcels from NVCOG and NHCOG

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Protected Open Space

- Mix of publicly-owned, land trust, and private easement land
- Variety of protection mechanisms
- Most large, undeveloped tracts already protected

Subwatershed	Protected Open Space (sq mi)	Protected Open Space (percent)
East Spring Brook	0.92	15.8
Hesseky Brook	1.40	22.5
Nonewaug River	3.90	18.3
Pomperaug River	4.26	19.9
Sprain Brook	1.56	14.3
Transylvania Brook	1.25	17.4
Weekeepeemee River	1.25	7.8
Total	14.54	16.3

POMPERAUG RIVER WATERSHED COALITION

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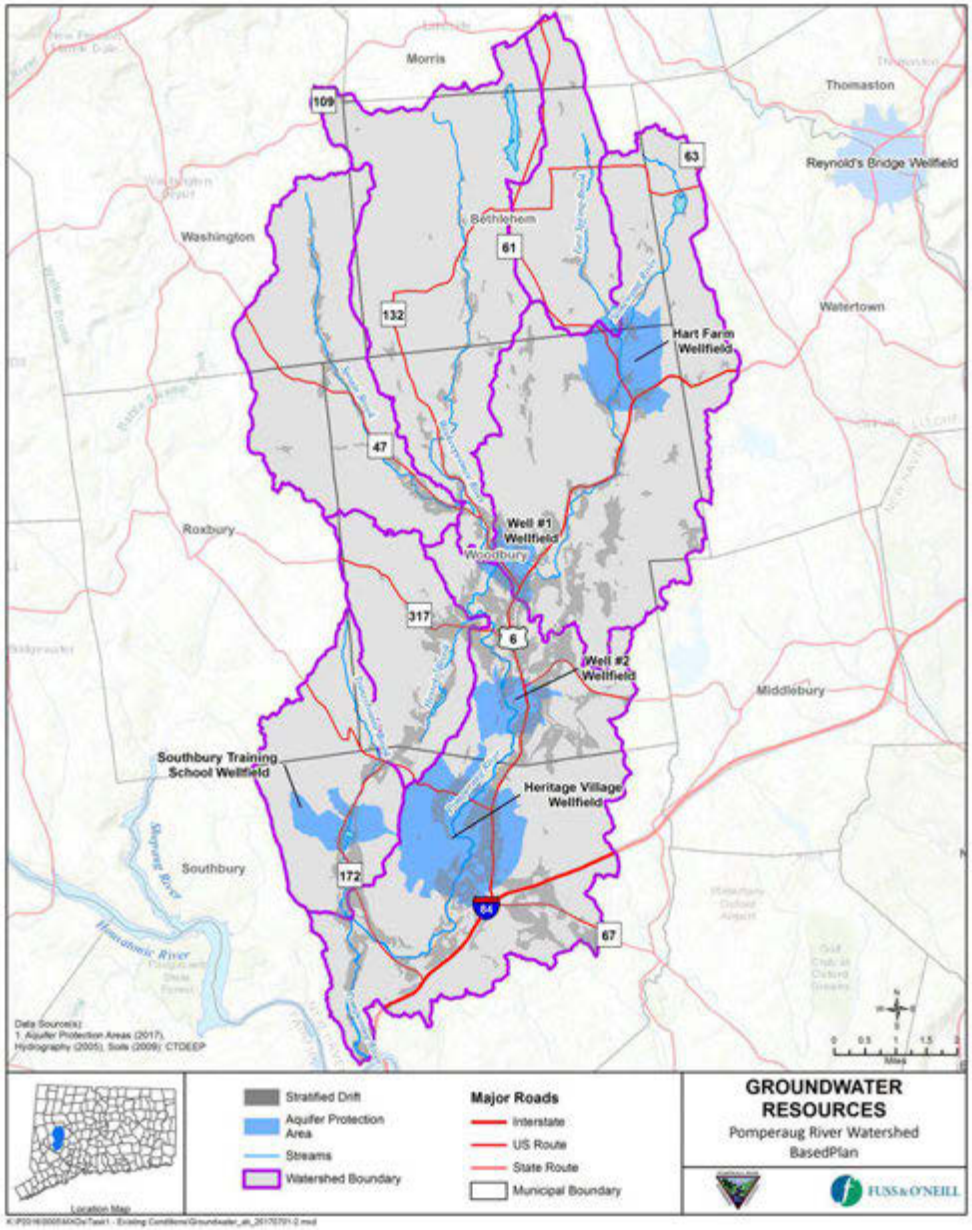
Groundwater Resources



- CTDEEP
  - Aquifer protection areas, 2017
  - Stratified drift soils, 2009
- Significant prior study of groundwater resources in the watershed

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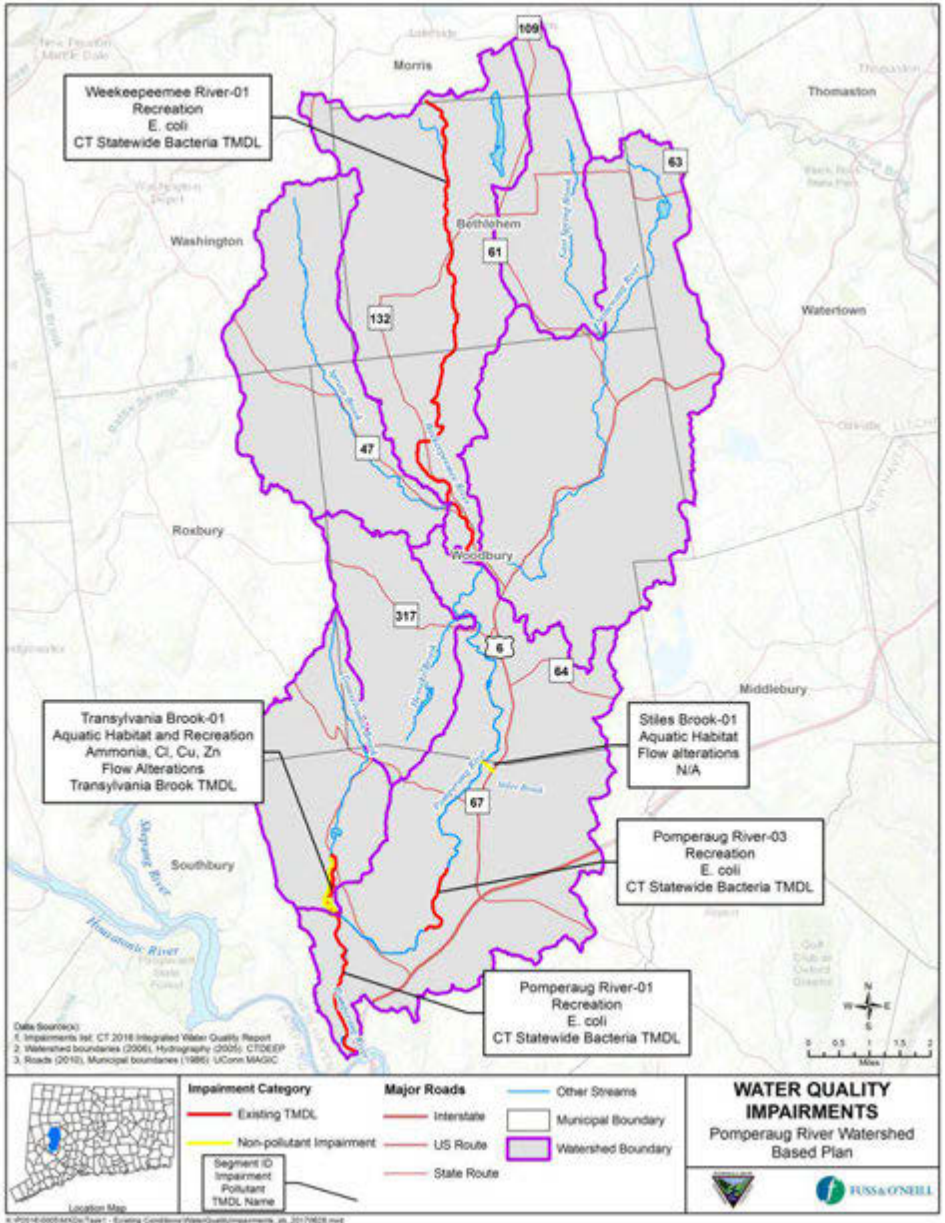
Water Quality Impairments



- CT 2016 Integrated Water Quality Report
- Designation based on impaired uses
  - Recreation (swimming and boating)
  - Aquatic habitat
  - Fish consumption
  - Drinking water supply

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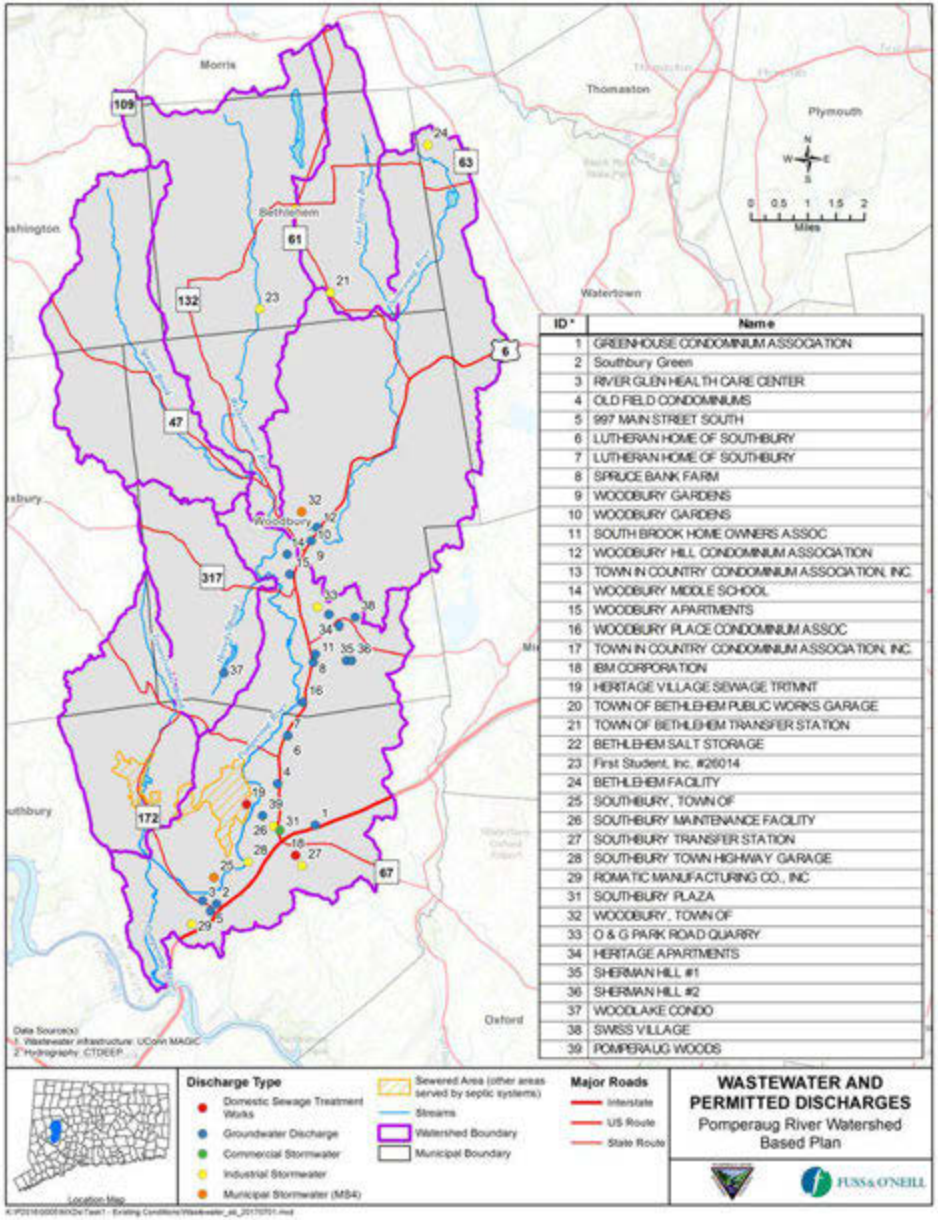
Water Quality Impairments

- Five impaired segments
  - Pomperaug River
  - Weekeepeemee River
  - Transylvania Brook (2)
  - Stiles Brook

- State-wide Bacteria TMDL
  - Pomperaug River
  - Weekeepeemee River
- Transylvania Brook TMDL
- Flow Alterations
  - Water withdrawals?

Impaired Water Body	Impairment	Pollutant of Concern	TMDL Name	Length (mi)
Pomperaug River-01	Recreation	E. coli	CT Statewide Bacteria TMDL	2.74
Pomperaug River-03	Recreation	E. coli	CT Statewide Bacteria TMDL	1.31
Stiles Brook-01	Aquatic Habitat	Flow alterations	TMDL not required	0.25
Weekeepeemee River-01	Recreation	E. coli	CT Statewide Bacteria TMDL	9.61
Transylvania Brook (Southbury)-01	Aquatic Habitat and Recreation	Ammonia, Cl, Cu, Zn	Transylvania Brook TMDL	1.6
Transylvania Brook (Southbury)-01	Aquatic Habitat and Recreation	Flow alterations	TMDL not required	1.6

Wastewater and Other Permitted Discharges



ID *	Name
1	GREENHOUSE CONDOMINIUM ASSOCIATION
2	Southbury Green
3	RIVER GLEN HEALTH CARE CENTER
4	OLD FIELD CONDOMINIUMS
5	997 MAIN STREET SOUTH
6	LUTHERAN HOME OF SOUTHBURY
7	LUTHERAN HOME OF SOUTHBURY
8	SPRUCE BANK FARM
9	WOODBURY GARDENS
10	WOODBURY GARDENS
11	SOUTH BROOK HOME OWNERS ASSOC
12	WOODBURY HILL CONDOMINIUM ASSOCIATION
13	TOWN IN COUNTRY CONDOMINIUM ASSOCIATION, INC.
14	WOODBURY MIDDLE SCHOOL
15	WOODBURY APARTMENTS
16	WOODBURY PLACE CONDOMINIUM ASSOC
17	TOWN IN COUNTRY CONDOMINIUM ASSOCIATION, INC.
18	IBM CORPORATION
19	HERITAGE VILLAGE SEWAGE TRTMNT
20	TOWN OF BETHLEHEM PUBLIC WORKS GARAGE
21	TOWN OF BETHLEHEM TRANSFER STATION
22	BETHLEHEM SALT STORAGE
23	First Student, Inc. #26014
24	BETHLEHEM FACILITY
25	SOUTHBURY, TOWN OF
26	SOUTHBURY MAINTENANCE FACILITY
27	SOUTHBURY TRANSFER STATION
28	SOUTHBURY TOWN HIGHWAY GARAGE
29	ROMATIC MANUFACTURING CO., INC
31	SOUTHBURY PLAZA
32	WOODBURY, TOWN OF
33	O & G PARK ROAD QUARRY
34	HERITAGE APARTMENTS
35	SHERMAN HILL #1
36	SHERMAN HILL #2
37	WOODLAKE CONDO
38	SWISS VILLAGE
39	POMPERAUG WOODS

- CTDEEP
  - Discharge permits database, 2016
  - Sewered area, 1997

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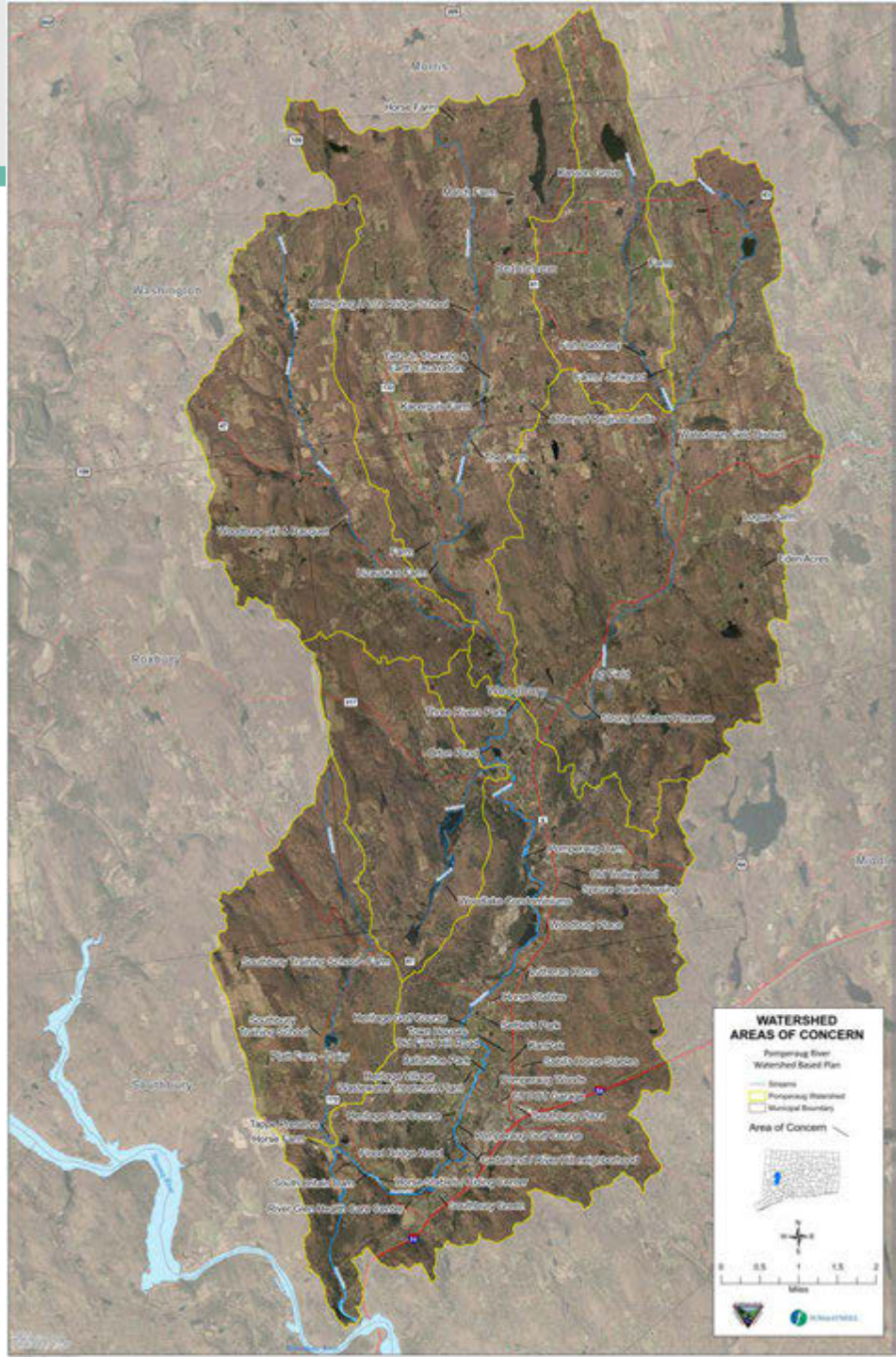
Wastewater and Other Permitted Discharges

- 39 permitted dischargers
  - Sewage treatment plants
  - Subsurface sewage disposal (septic) systems
  - Commercial, industrial, municipal stormwater discharges
- 2 sewage treatment plants
  - Heritage Village
  - IBM Campus
- Several apartments/condos with large septic systems
- Quarries

Pollution Hotspots/ Areas of Concern

- Identified by LUC and PRWC
- Roughly 60 sites identified (see board)
- Potential bacteria sources
  - Streambank erosion
  - Agricultural land adjacent to streams
  - Manure management
  - Septic system issues
  - Significant point discharges
  - Waterfowl, pet waste

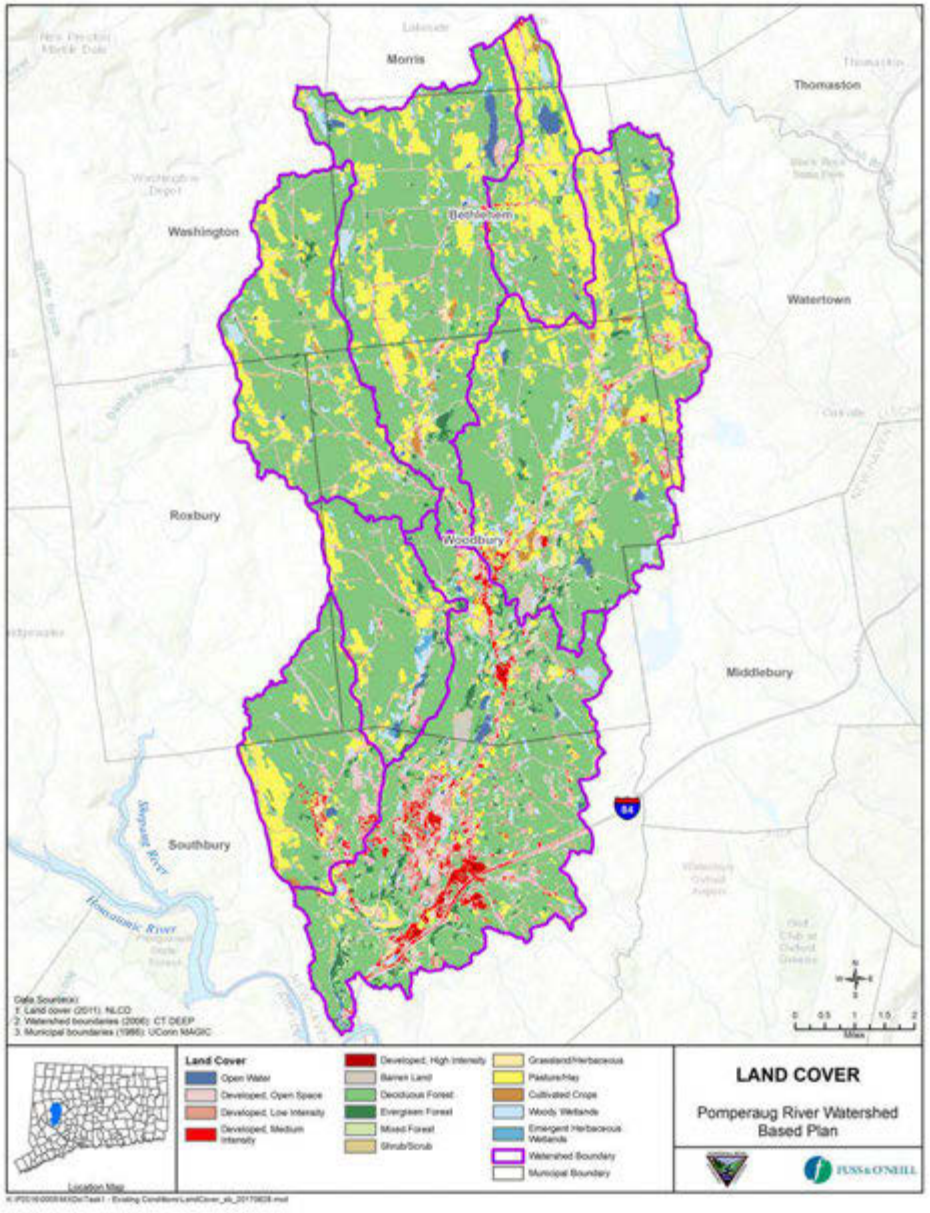


Watershed Assessments

- Pollutant Loading Model
- Riparian Cover Analysis
- Visual Field Assessments

Pollutant Loading Model

- Watershed Treatment Model (WTM) – surface runoff pollutant loads
- Annual loadings of bacteria, nutrients, and sediment
- Primary sources – land cover (NLCD, 2011)
- Secondary sources – point sources, septic systems, urban stream erosion, etc.
- Model development in progress



Visual Field Assessments

- Identify site-specific restoration, pollution prevention, and retrofit opportunities
- Prioritize locations for field assessments based on existing information and other watershed assessments
- 2-4 field days, using standardized protocols

POMPERAUG RIVER WATERSHED COALITION

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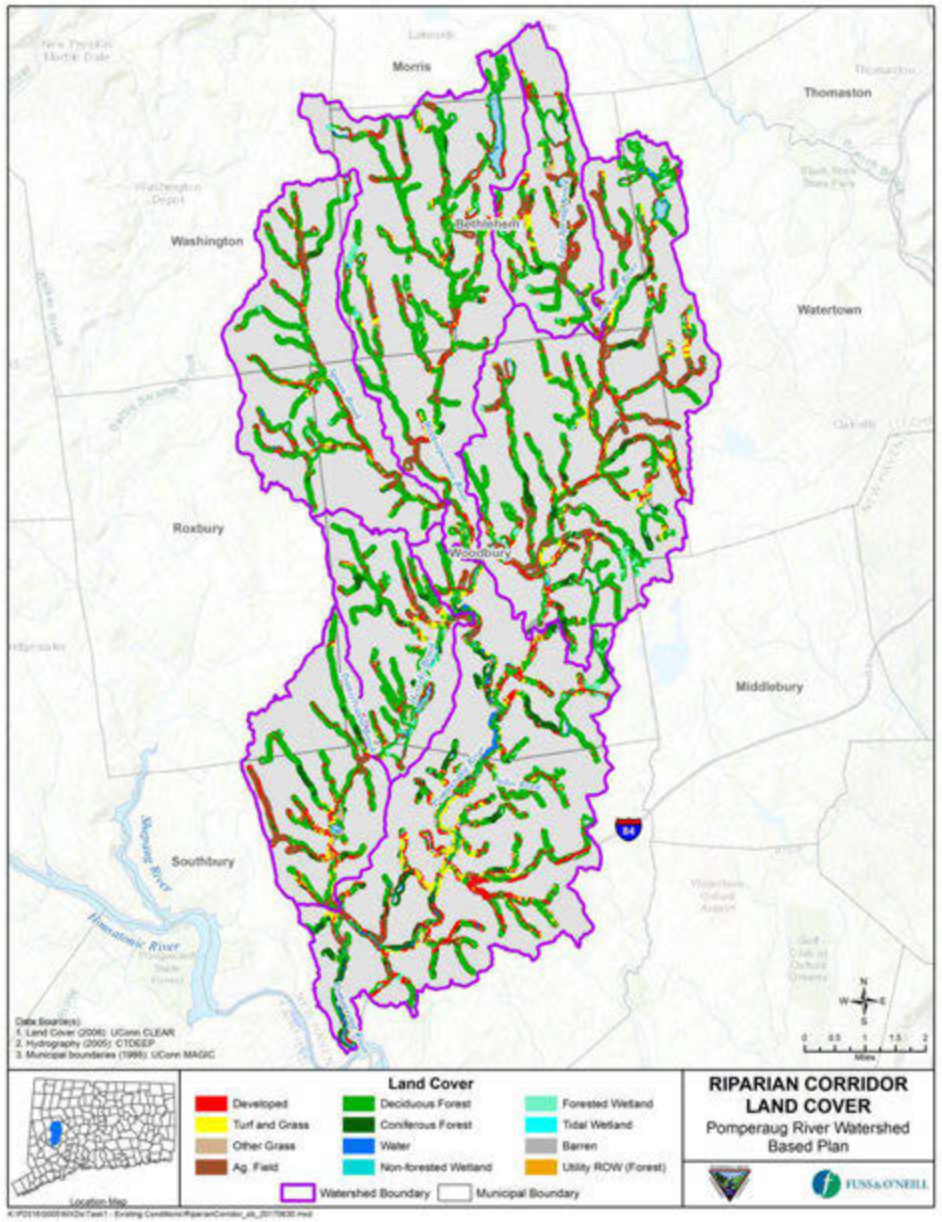
Riparian Cover Analysis

- Combine CLEAR riparian analysis with NVCOG parcels and protected open space
- Buffer restoration opportunities
- Additional land conservation opportunities



Next Steps

- July
  - Finalize watershed maps
  - Complete existing conditions pollutant load modeling
  - Complete riparian cover analysis
- July/August
  - Develop updated existing conditions narrative to support WBP
- August
  - Conduct visual field assessments

Additional Discussion/Questions

MEETING NOTES

PRWC Land Use Committee
Thursday, October 5, 2017
3:00 PM – 4:30 PM
Southbury Town Hall, Room 201
501 Main Street South, Southbury

Attendees: Carol Haskins, Len DeJong, Chris Wood, Gail McTaggart, Leslie Kane, Norma Carey, DeLoris Curtis, Arthur Milnor, Curtis Jones, Petra Volinski, Susan Peterson, Erik Mas, Bill Guenther

1. Introductions

2. Presentation by Fuss & O'Neill and Discussion

Watershed Mapping Updates Since Previous LUC Meeting

- Erik Mas reviewed watershed mapping updates that were completed based on comments received during and following LUC Meeting #2
- Additional CTDEEP water quality monitoring stations (if any) should be added to the Water Quality Impairments map, including fish survey and macroinvertebrate survey data, if available
- Susan Peterson and others discussed clarifying the Water Quality Impairments map to distinguish between waters that are supporting for some uses (e.g., aquatic habitat) and not assessed for others (e.g., recreation). There was also a suggestion to re-color the reaches (red, yellow green) to avoid confusion and to clarify the impairment status for a general audience. For example, green implies "good water quality," although some of the segments that are colored green on the map may be unassessed for recreation/bacteria and therefore could have similar bacteria issues as the assessed/impaired segments.

Pollutant Loading Model

- Erik Mas presented draft results of the pollutant loading model that was developed for the Pomperaug River watershed. A draft technical memorandum dated October 4, 2017 was distributed to the PRWC LUC prior to the meeting.
- There was discussion about the assumptions and results of the illicit discharge and septic system secondary pollutant source categories in the model.
- How are illicit discharges quantified in the model? The model assumes 1 illicit connection per 1,000 residences and 5% of businesses having illicit connections. These estimates may be conservatively high given the type of development and very limited area of sanitary sewers in the Pomperaug. The loads resulting from illicit connections are likely overstated and should be revisited based on additional input from the Southbury and Woodbury DPW and the regional health district.
- How are septic system failure/malfunction rates quantified in the model? The model assumes a 10% failure rate. This estimate may also be conservatively high and may not reflect actual septic system failure issues in the watershed. The model also assumes that 10% of septic systems are within 100 feet of a surface water body, which may be overly conservative considering that many septic systems in the watershed were constructed or replaced following the adoption of minimum setbacks for septic systems in the local land use regulations.

- PRWC will discuss these issues with the regional health district to provide some additional feedback on appropriate local values for illicit connection and septic system failure rates. Fuss & O'Neill will update the model accordingly.
- In the context of the pollutant loading model, make sure to refer to the modeled Pomperaug River subwatershed as the "Pomperaug Subregional Basin," consistent with CT DEEP terminology, to avoid confusion with the overall Pomperaug River watershed.

Field Assessments and Preliminary BMPs

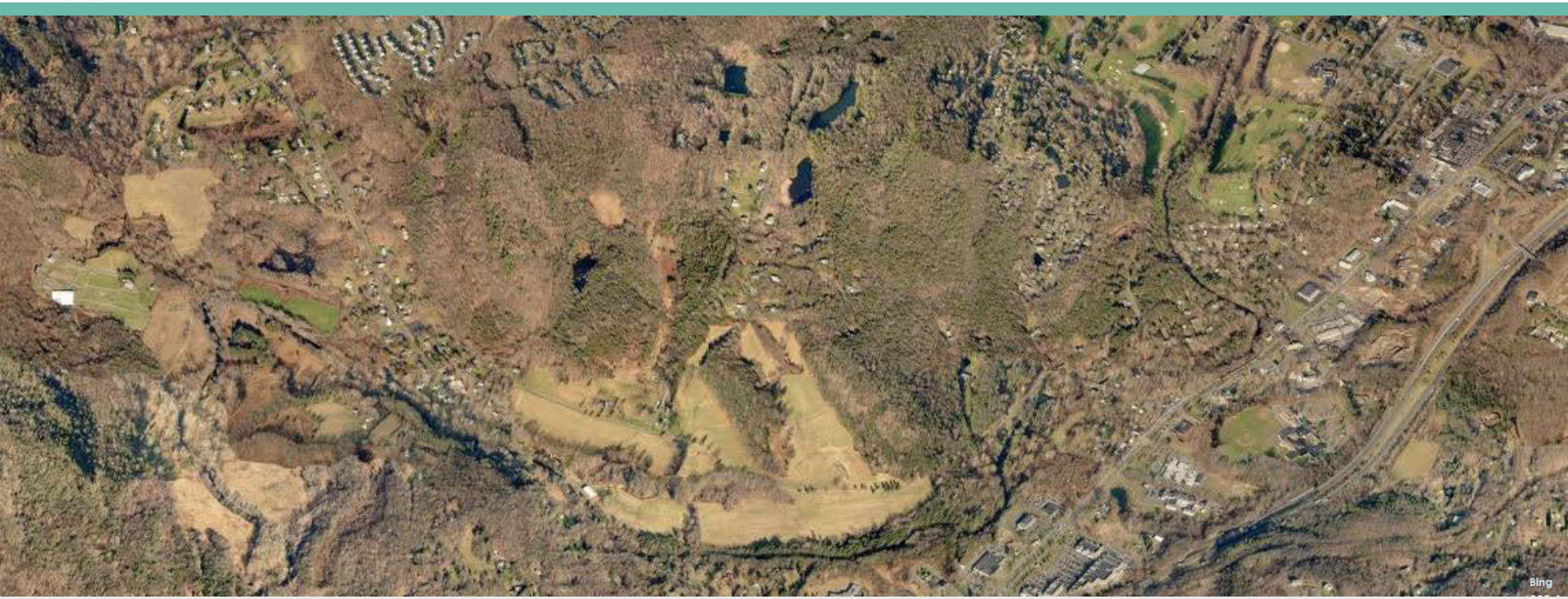
- Bill Guenther presented major findings from the watershed field assessments, including preliminary ideas for site-specific Best Management Practices to address observed issues relative to bacterial water quality impairments. A draft technical memorandum dated October 5, 2017 was distributed to the PRWC LUC prior to the meeting.
- Canada geese are an issue and source of bacteria in the watershed. Management of geese and other waterfowl populations is very challenging. The focus should be on resident as opposed to migratory geese. The close proximity of corn fields (food source), golf courses, other manicured lawns, and open water bodies are key ingredients that contribute to resident geese populations in the watershed. Golf courses typically discourage geese, although vegetated buffers may be in conflict with the use of the golf course. Southbury Training School and other municipal/state properties have issues with geese populations.
- Manure management, lack of vegetated buffers, and livestock access were identified as common issues at several of the farms that were assessed. Note, many farms observed during the field assessment survey were viewed from the road. There was discussion of how to raise site-specific issues with particular farms without "pointing fingers" unfairly at specific property owners, whose support and cooperation are critical for address water quality issues. The discussion also pointed out that many farmers may be more willing to pursue BMP implementation if there are additional local avenues to cost share or match federal funds. In some cases, farmers might like to pursue BMPs but may not have the funding or have it as a priority, or may not have the landowner rights (in the case of leased land) to make a long-term commitment to maintaining the BMP for its lifespan. Using riparian buffers to keep livestock out of streams was discussed, noting that while 200 foot widths are ideal, any buffer width is better than none given the perception challenges that such areas are removed from pasture land and or crop production land.
- Discussion of Berkshire Estates and the various issues associated with the "T lots" – particularly related to property lines, landownership, and how to proceed with developing BMP plans for this area that would be reasonably feasible to implement.
- Heritage Village was identified as a potential candidate for retrofitting existing connected impervious surfaces (i.e., roads, parking lots) with stormwater quality BMPs given the available land and limited, if any, existing stormwater quality BMPs. The Heritage Village housing units were the first condos developed in Connecticut (initially developed in 1966-1974), with later phases constructed in 1978 and 1982.
- There are several examples of Low Impact Development practices throughout the watershed. The watershed communities have promoted the use of LID for many years, although the municipal land use regulations may not require the use of LID and may need to be modified, either through compliance with the new MS4 Permit (Southbury and Woodbury) or separate land use regulatory updates by the non-MS4 communities in the watershed.

- New Morning Market and Prime Publishing are examples of recently installed pervious parking lots. The new movie theater that is under construction along Main Street South in Southbury is also implementing underground infiltration systems.
- Per recent feedback from EPA, CTDEEP indicated that watershed based plans should identify as many site-specific projects as possible, even if they are limited in their level of detail, to increase the chance of success with future grant applications. Inclusion of a table naming the site and most suitable BMP without detailed plans may be sufficient in this regard.

3. Next Steps

- PRWC will provide feedback from the LUC on both draft technical memoranda – pollutant loading model and watershed field assessments.
- Fuss & O'Neill will revise and finalize the pollutant loading model based on feedback from the LUC, town staff, and/or regional health district
- The next phase of work will focus on finalizing selection of BMPs, developing site-specific BMP concepts, and preparing the draft watershed based plan.

FUSS & O'NEILL



PRWC Land Use Committee Meeting

Pomperaug River Watershed Based Plan

October 5, 2017

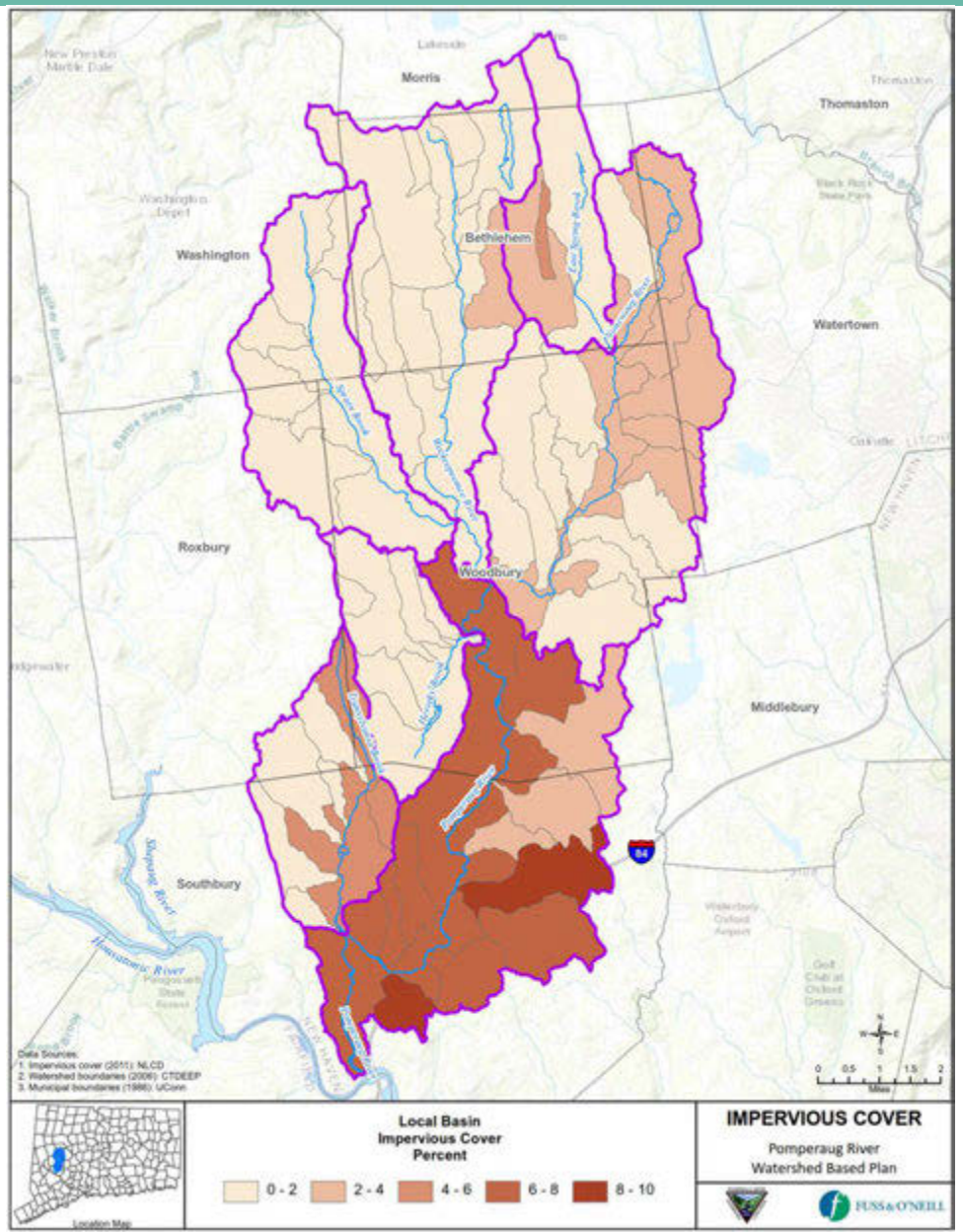
POMPERAUG RIVER WATERSHED COALITION

Meeting Agenda

1. Introductions
2. Updates from Previous LUC Meeting
3. Pollutant Loading Model
4. Field Assessments and Potential BMPs
5. Next Steps
6. Discussion

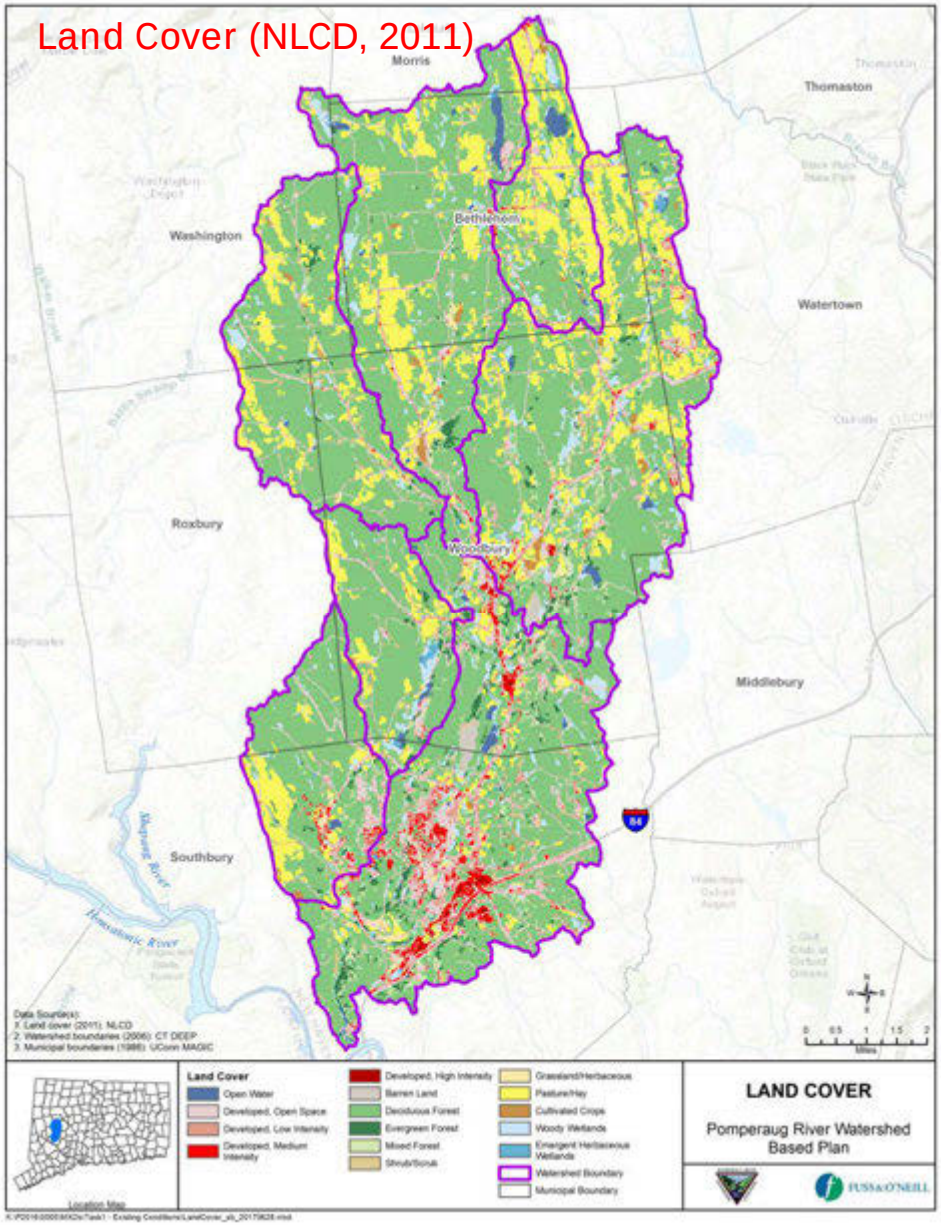
Mapping Updates

- Impervious Cover
  - CT Local Basins
  - All basins below 10% IC threshold
  - Most of Pomperaug basin in 6-10% range
  - Several Pomperaug sub-basins in 8-10% range



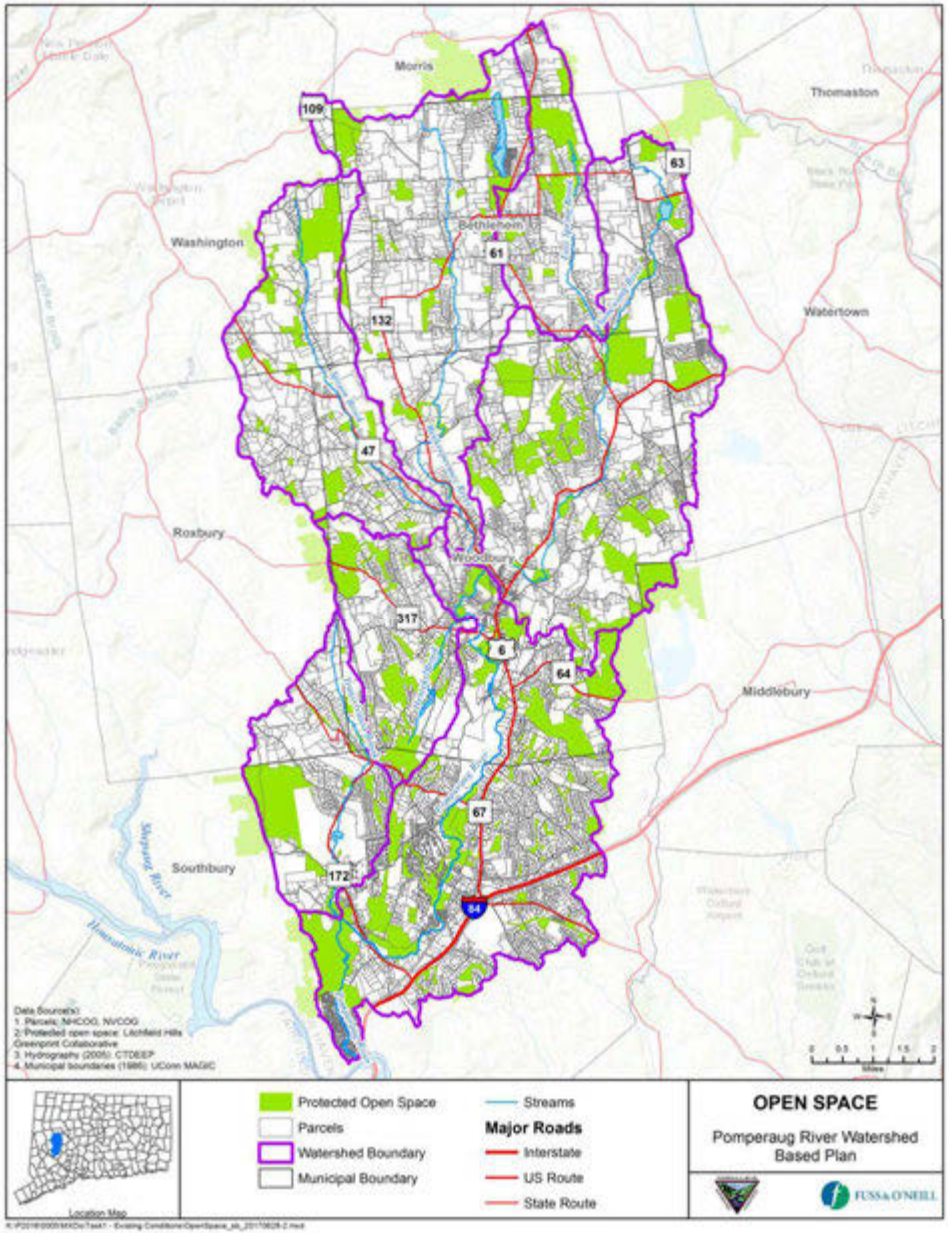
Mapping Updates

- **Land Cover**
  - CLEAR 2015 land cover (same classes as 2010 data)
  - Compared 2010 and 2015 CLEAR land cover data (no significant differences)
  - NLCD 2011 land cover still valid



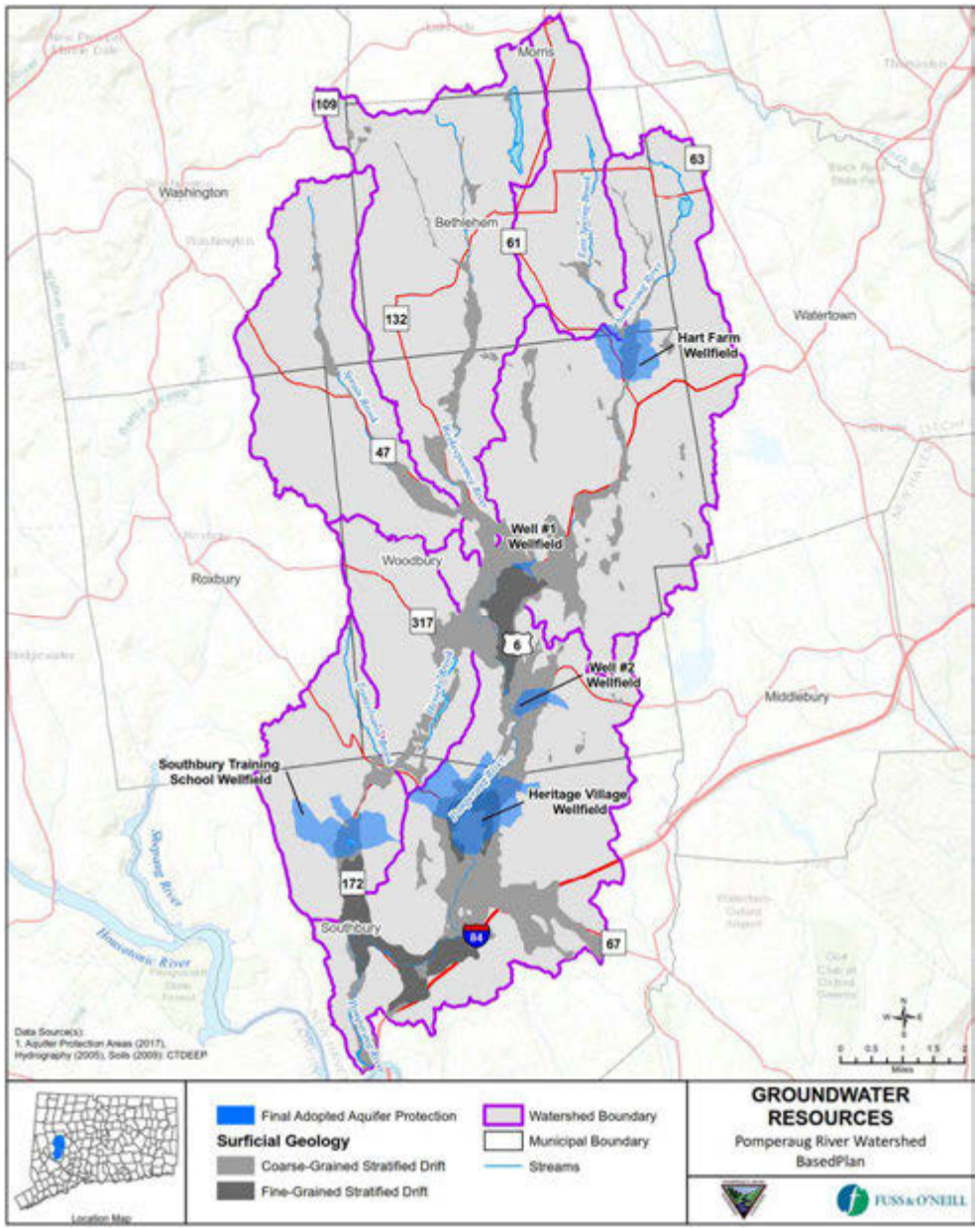
Mapping Updates

- **Committed Open Space**
  - Town owned parks, recreation areas, preserves
  - Land trust properties with legal protections
  - State of Connecticut properties that are undeveloped
  - Farms where the development rights have been acquired
  - Excludes Public Act 490 land
  - Class A water company property



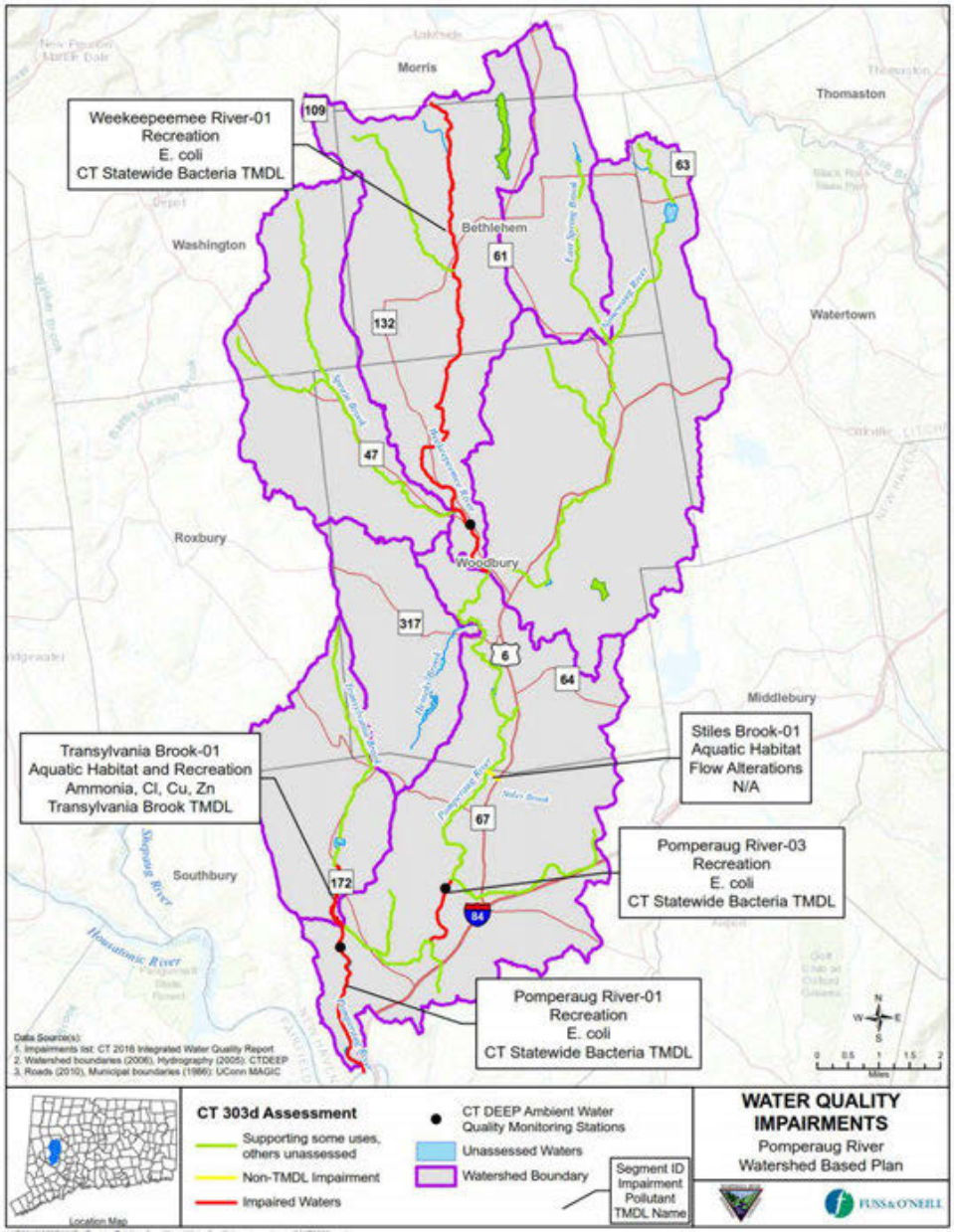
Mapping Updates

- **Groundwater Resources**
  - Final adopted Aquifer Protection Areas only
  - Surficial geology



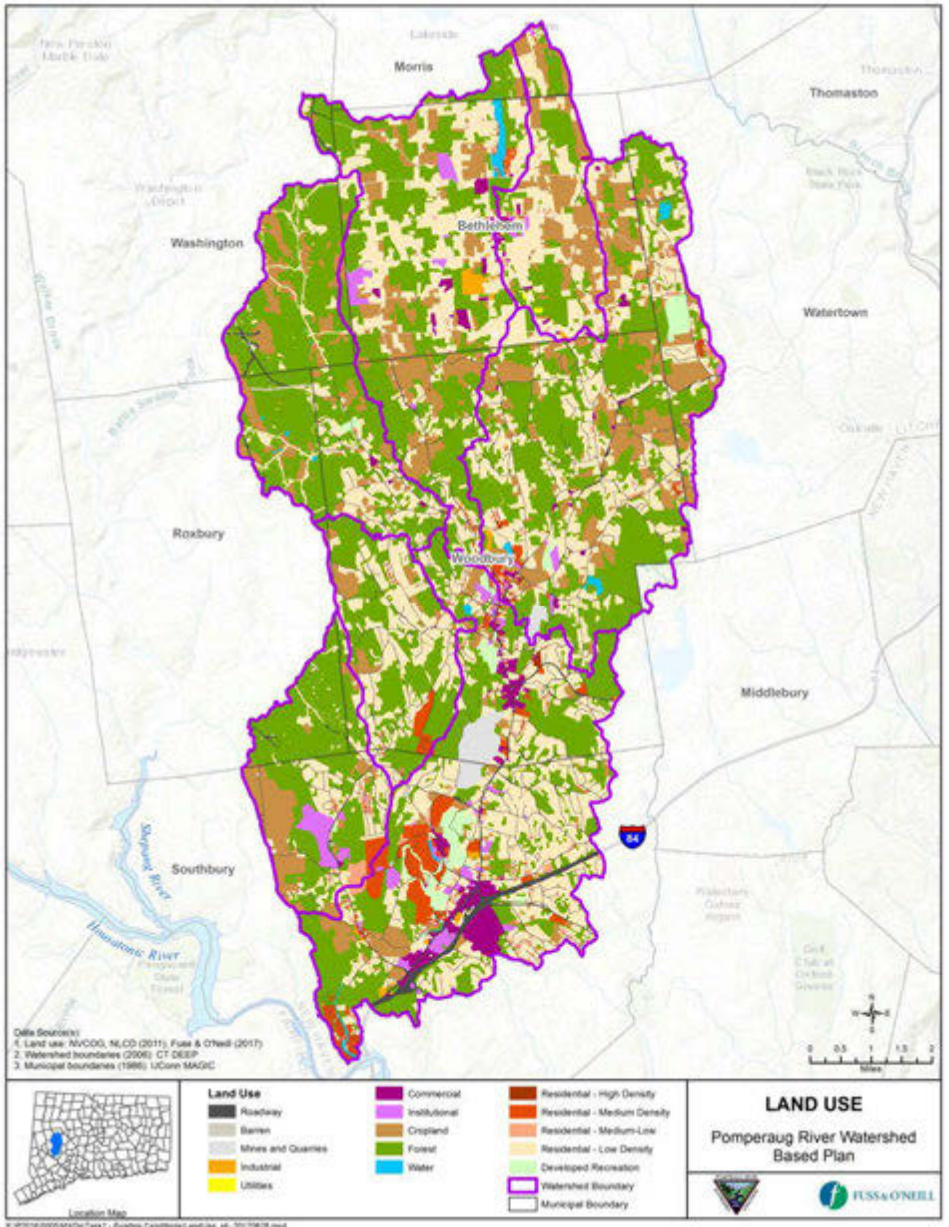
Mapping Updates

- **Water Quality Impairments**
  - Updated to show supporting and unassessed waters
  - CTDEEP ambient water quality monitoring locations added



Pollutant Loading Model

- Watershed Treatment Model (WTM) – surface runoff pollutant loads
- Annual loadings of bacteria, nutrients, and sediment to surface waters
- Primary sources – land use
- Secondary sources – point sources, septic systems, illicit discharges, etc.



Model Inputs

- Land Use and Impervious Cover
- Event Mean Concentrations (Developed Land Use)
- Export Coefficients (Rural Land Use)
- Annual Rainfall
- Hydrologic Soil Groups
- Runoff Coefficients
- Sewer Service Information
- Septic System Information
- Illicit Connections
- Road Sanding
- Livestock

Watershed Treatment Model (WTM)
2013 Documentation

Funding Provided By:
US EPA Office of Wetlands Oceans and Watersheds
Altria Foundation
Cooperative Institute for Coastal and Estuarine Environmental Technology

June, 2013
Deb Caraco, P.E.
Center for Watershed Protection, Inc.

CENTER FOR WATERSHED PROTECTION

SECONDARY SOURCES

General Sewage Use Data

Dwelling Units	611	Indi duals/Dwelling Unit	2.7
		Water Use (gpcd)	70
		Wastewater Characteristics	
		TN (mg/l)	60
		TP (mg/l)	10
		TSS (mg/l)	400
		FC (MPN/100 ml)	10,00

Nutrient Concentration in Stream Channels

	Concentration	Enrichment Factor
Soil P(%)	0.002%	2
Soil TN (%)	0.002%	2

On-Site Sewage Disposal Systems

Unsewered Dwelling Units(% of total)	100%	Failure Rates	10%		
% of Septic Systems <100' to waterway	10%				
			Normal	Adjacent to Waterway	
Soils	Clay/Mixed Soils	Bacteria decay	0.20%	13%	
		Delivery ratio	50%	100%	
			TN	TP	TSS	Bacteria (Billions)
Untreated Sewage Delivered to Septic Systems			21063	3511	140422	15936102

System Type	% of Systems	TN Efficiency	TP Efficiency	TSS Efficiency	Bacteria Log Reduction
Conventional	100%	28%	57%	72%	3.5
Intermittent Sand Filter		55%	80%	92%	3.2
Recirculating Sand Filter		64%	80%	90%	2.9
Water Separation System		83%	30%	60%	3.0
Other		0%	0%	0%	0.0
Combined Efficiency		28%	57%	72%	3.5
Adjusted Efficiency (density)		19%	38%	48%	2.5

Current Septic System Management	Medium. Inspection at installation, education to encourage ongoing maintenance				
Typical Separation from Groundwater	3-5 Feet				
Density (#/acre)	1-2/acre				
		TN	TP	TSS	Bacteria
Removal by soil below the leach field		10%	80%	100%	100%

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Event Mean Concentrations

- **Developed Land Use**

Land Use	WTM Default Values				Regional Values				Selected Values			
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC
Low Density Residential	2.1	0.31	49	20,000	3.18	0.27	34	2,950	3.18	0.27	34	2,950
Medium Density Residential	2.1	0.31	49	20,000	3.5	0.41	49	12,360	3.5	0.41	49	12,360
High Density Residential	2.1	0.31	49	20,000	3.81	0.64	102	16,901	3.81	0.64	102	16,901
Highway	-	-	-	-	2.65	0.43	141	600	2.65	0.43	141	600
Commercial	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Institutional	2.1	0.22	43	20,000	1.85	0.15	44	9,306	1.85	0.15	44	9,306
Industrial	2.2	0.25	81	20,000	4	0.11	42	1,467	4	0.11	42	1,467
Mining	-	-	-	-	1.18	0.15	94	300	1.18	0.15	94	300

Export Coefficients

- **Rural Land Use**

Land Use	WTM Default Values				Regional Values				Selected Values				Comments
	TN	TP	TSS	FC	TN	TP	TSS	FC	TN	TP	TSS	FC	
Forest	2.0	0.2	100	12	2.5	0.2	100	12	2.5	0.2	100	12	Selected regional values
Rural	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Power Lines	4.6	0.7	100	39	-	-	-	-	4.6	0.7	100	39	Selected WTM Default values
Open Water	12.8	0.5	155	-	0.4 (2)	0.03 (2)	2 (2)	0.4 (2)	0.4	0.03	2	0.4	Selected regional values
Cropland	-	-	-	-	Pasture 1.9 (2) 7.7 (3) 5.6 (4) Row Crops 14.4 (3) 15.7 (4)	Pasture 0.1 (2) 1.3 (3) 0.5 (4) Row Crops 4.0 (3) 0.94 (4)	Pasture 47 (2) 591 (4) Row Crops 1997 (4)	Pasture 7 (2) Row Crops -	10	0.8	300	39	Selected TN, TP, and TSS based on regional sources for pasture and row crops; FC assumed same as Rural land use

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Livestock Pollutant Source

- **Export Coefficients**

Livestock Type	Nitrogen[1] (lbs/animal/year)	Phosphorus[1] (lbs/animal/year)	E. coli (billion cfu/AU/year)
Cows	164	26	1,966
Horses	102	18	84
Sheep	18.5	3.2	7,165
Poultry	1.1	0.4	85

- **Estimated Number of Livestock**

Livestock Type	East Spring Brook	Hesseky Brook	Nonnewaug River	Pomperaug River	Sprain Brook	Transylvania Brook	Weekeepeemee River
Cows	20	175	450	100	15	40	150
Horses	60	40	50	100	15	25	40
Sheep	25	40	25	15	0	0	40
Poultry	30	75	50	50	250	25	50

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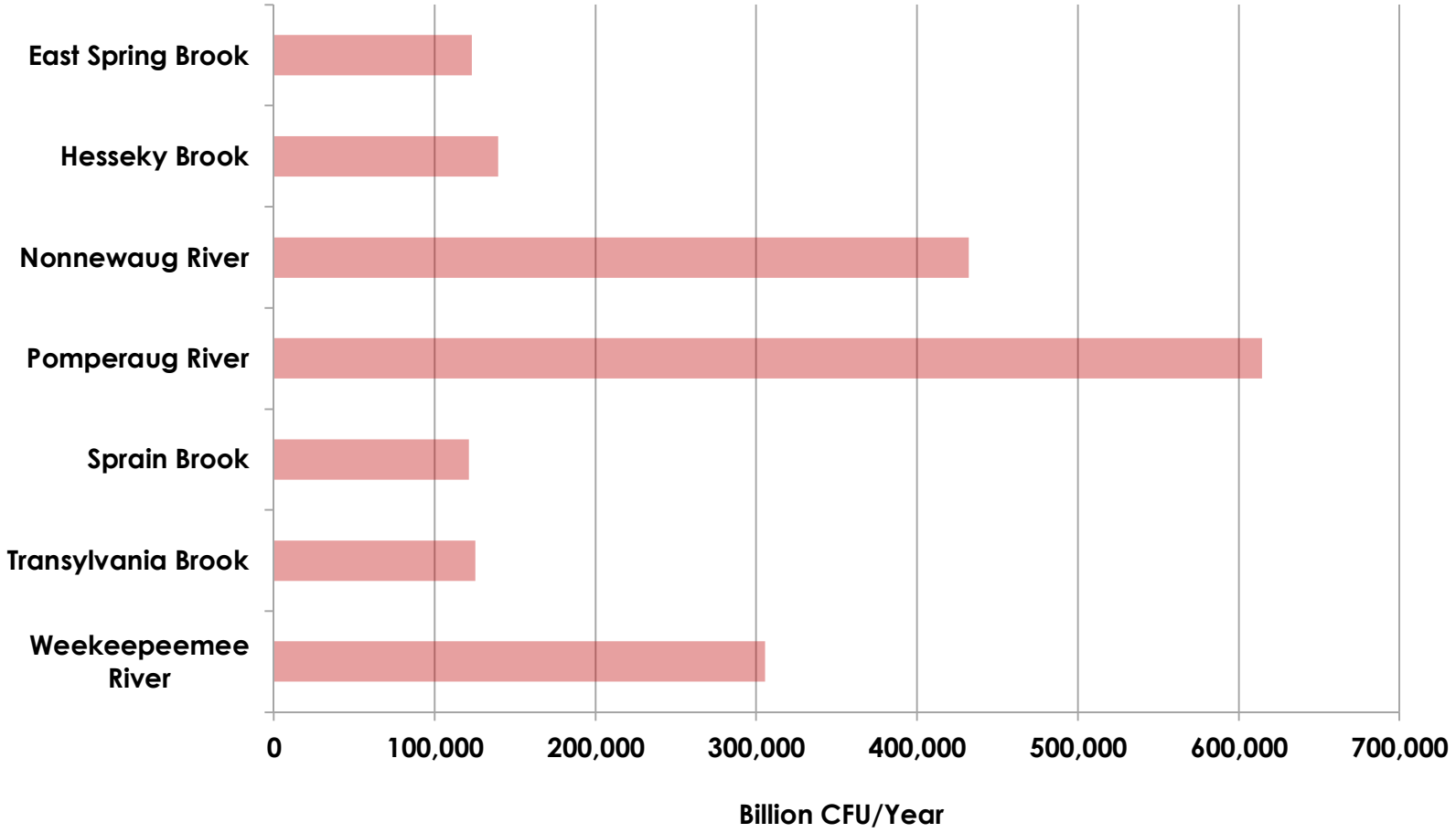
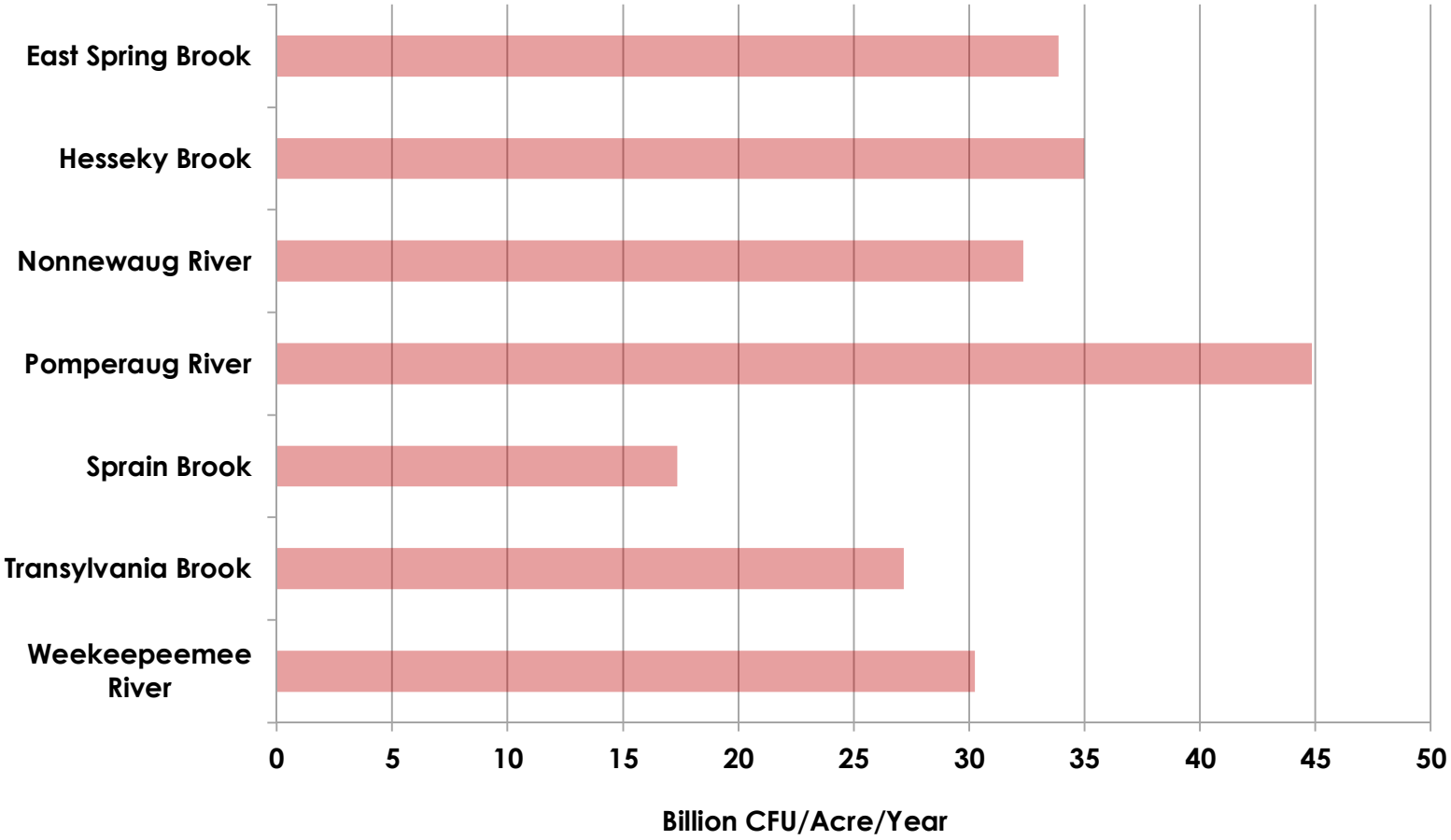
Model Results – Bacteria

- **Pollutant Loads**



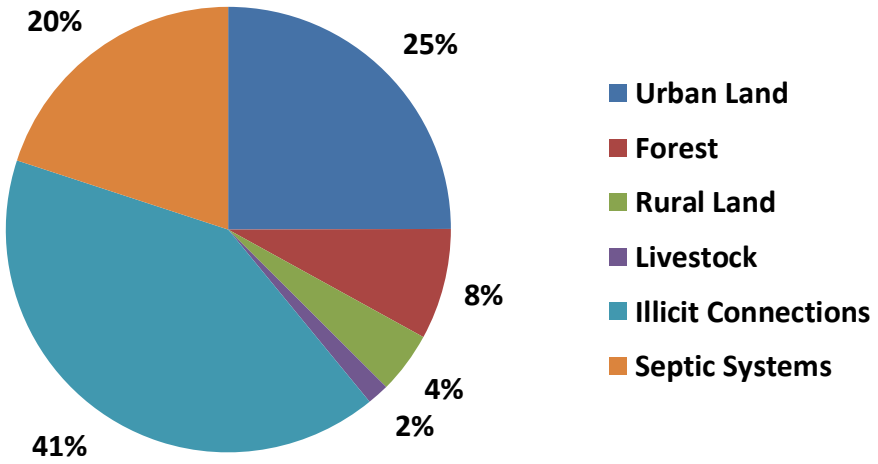
Model Results – Bacteria

- **Pollutant Yields**

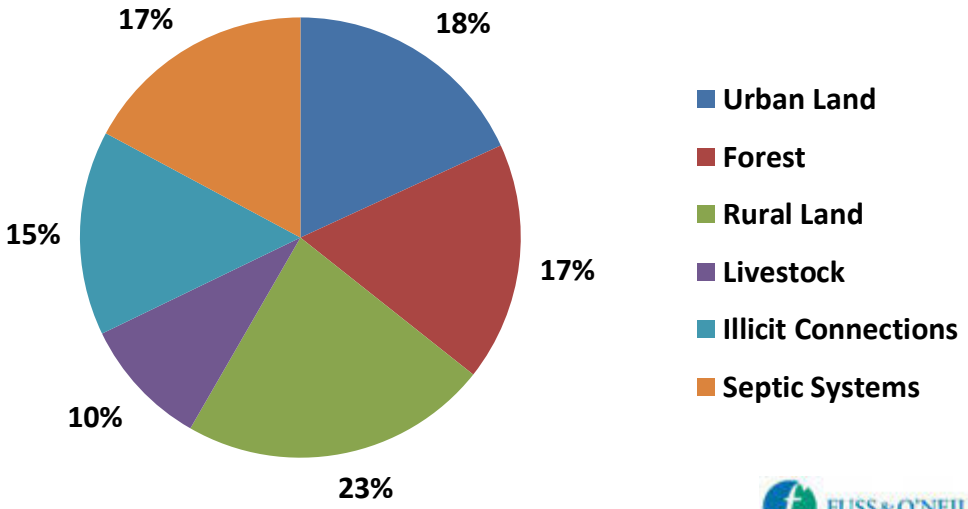


Relative Bacteria Sources

- **Pomperaug River Subwatershed**



- **Weekeepeemee River Subwatershed**



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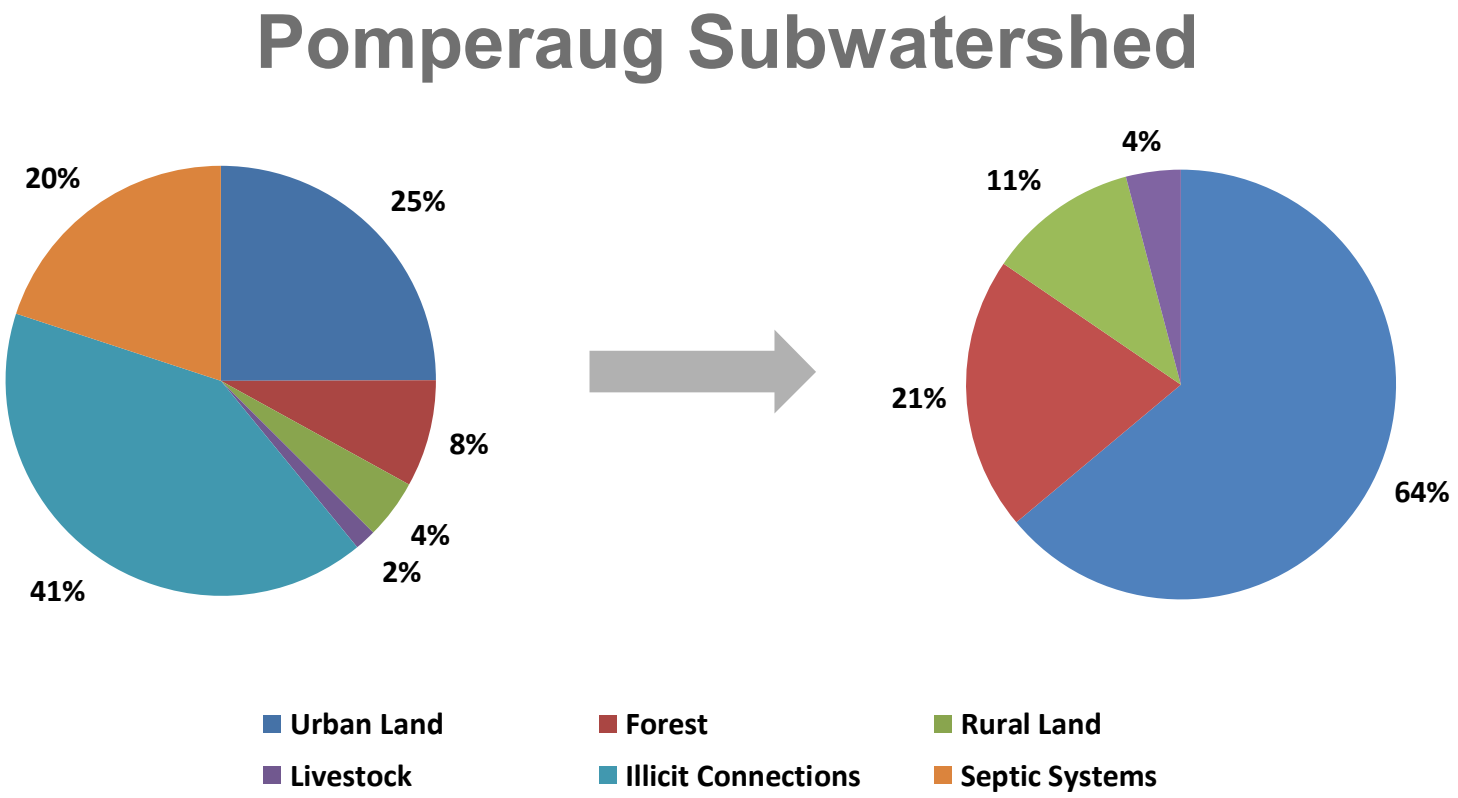
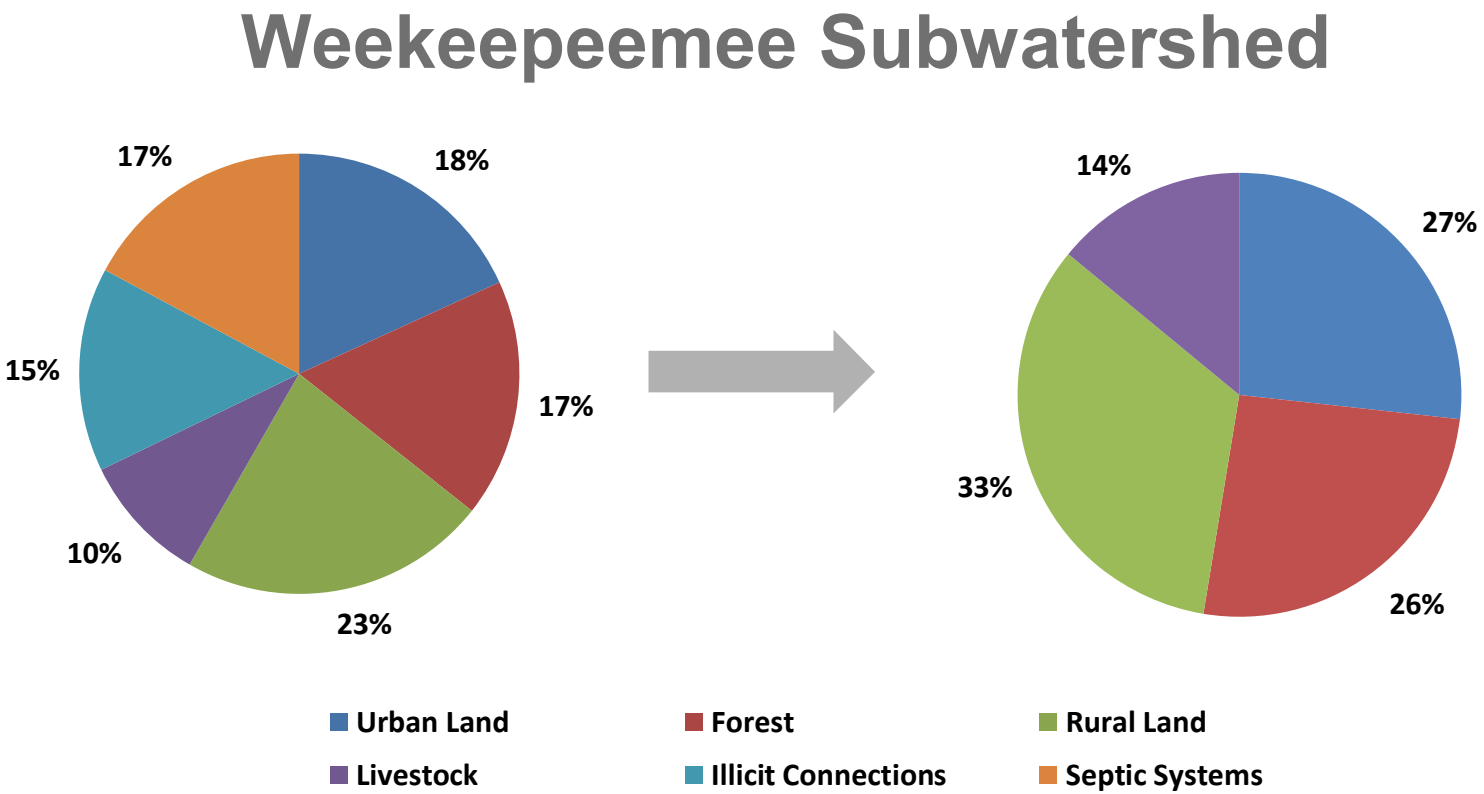
Relative Bacteria Sources

- **What if we could eliminate illicit discharges and septic system issues?**



Relative Bacteria Sources

- **What if we could eliminate illicit discharges and septic system issues?**

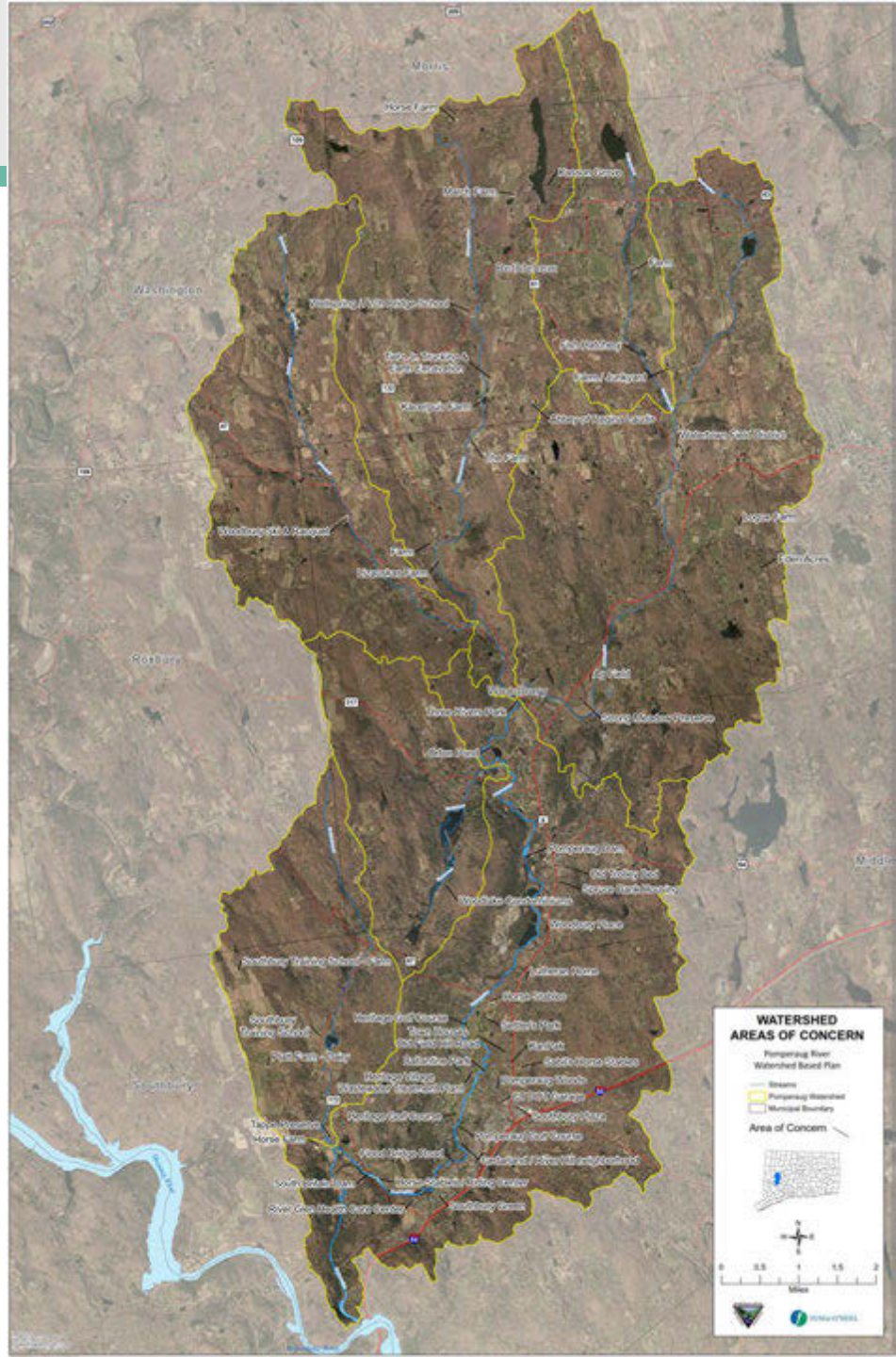


Visual Field Assessments

- Investigate suspected bacteria sources in areas with impairments
- Identify restoration, pollution prevention, and retrofit opportunities
- Standardized field protocols
  - Stream reaches
  - Neighborhoods
  - Hotspots

Pollution Hotspots/ Areas of Concern

- Identified by LUC and PRWC
- Roughly 60 sites identified
- Potential bacteria sources
  - Urban runoff
  - Agricultural land adjacent to streams
  - Manure management
  - Septic system issues
  - Point discharges
  - Waterfowl, pet waste
  - Streambank erosion

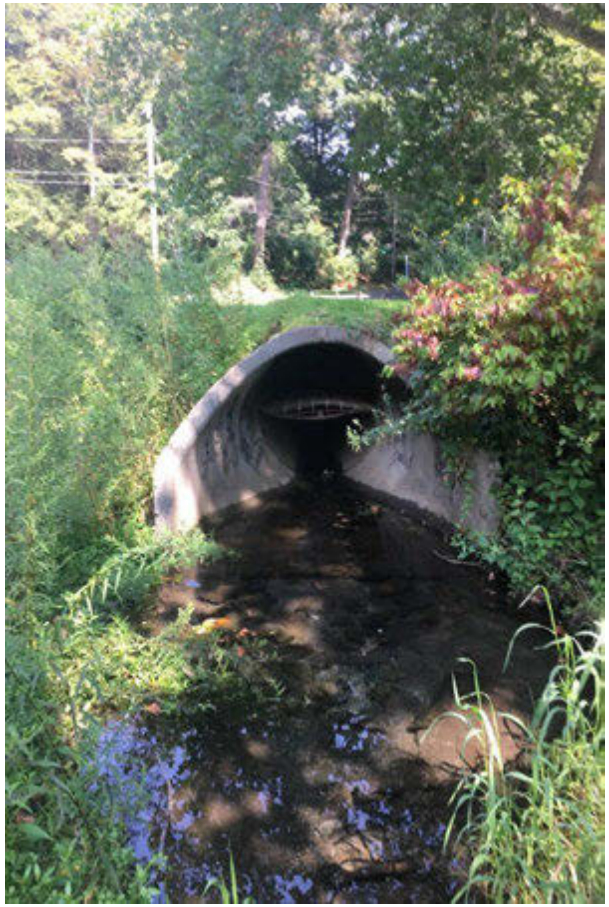


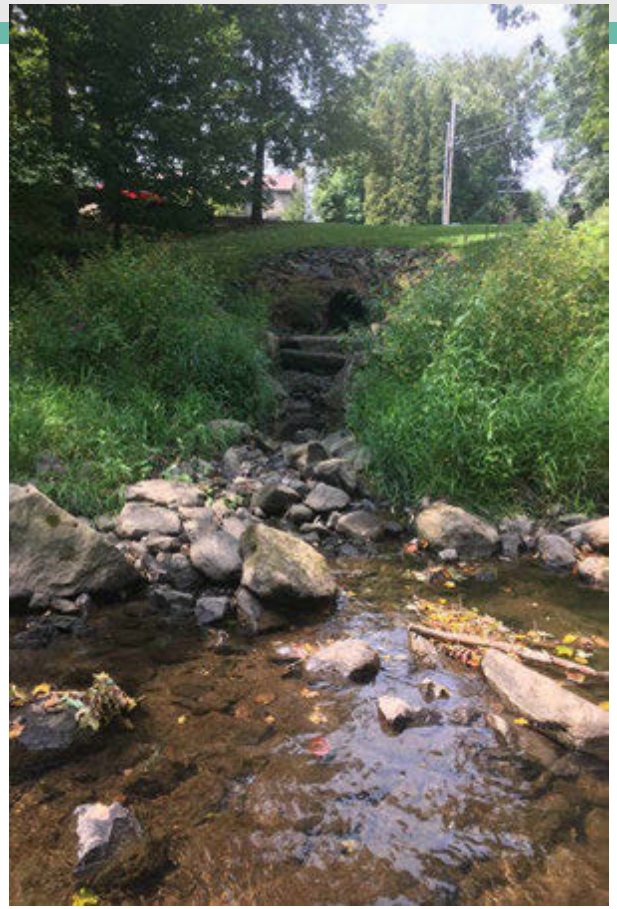
Reach Assessment Results

- **Pomperaug-01**
  - **Potential sources**
    - *Equestrian Center*
    - *Stormwater*

Reach Assessment Results

- **Pomperaug-03**
  - Potential sources
    - *Geese*
    - *Stormwater*
    - *WWTP*
    - *Septic*





Reach Assessment Results

- **Weekeepeemee-01**
  - Runoff from pastures and Paddocks

Neighborhood Assessment Results

- **Berkshire Estates/Oakdale Manor**
  - Stormwater
  - Septic

Neighborhood Assessment Results

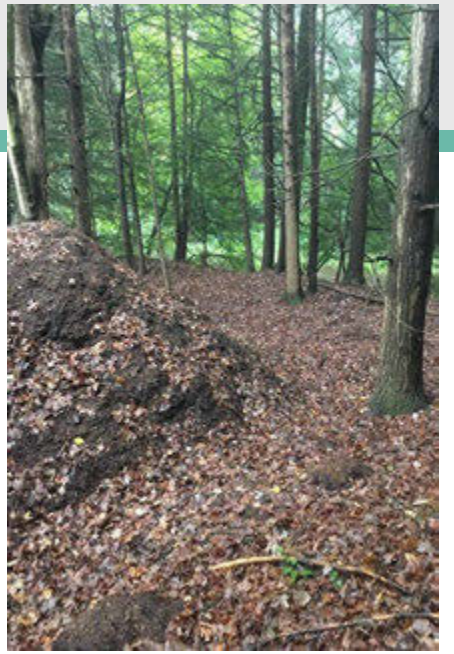
- **Heritage Village**
  - Stormwater
  - WWTP
  - Geese

Neighborhood Assessment Results

- **Heritage Village**
  - Stormwater
  - WWTP
  - Geese

Hotspot Assessment Results

- Stonecrest Farm
  - Manure piles
  - Front Paddock Area
  - Farm Pond



Hotspot Assessment Results

- **Stonecrest Farm**

Hotspot Assessment Results

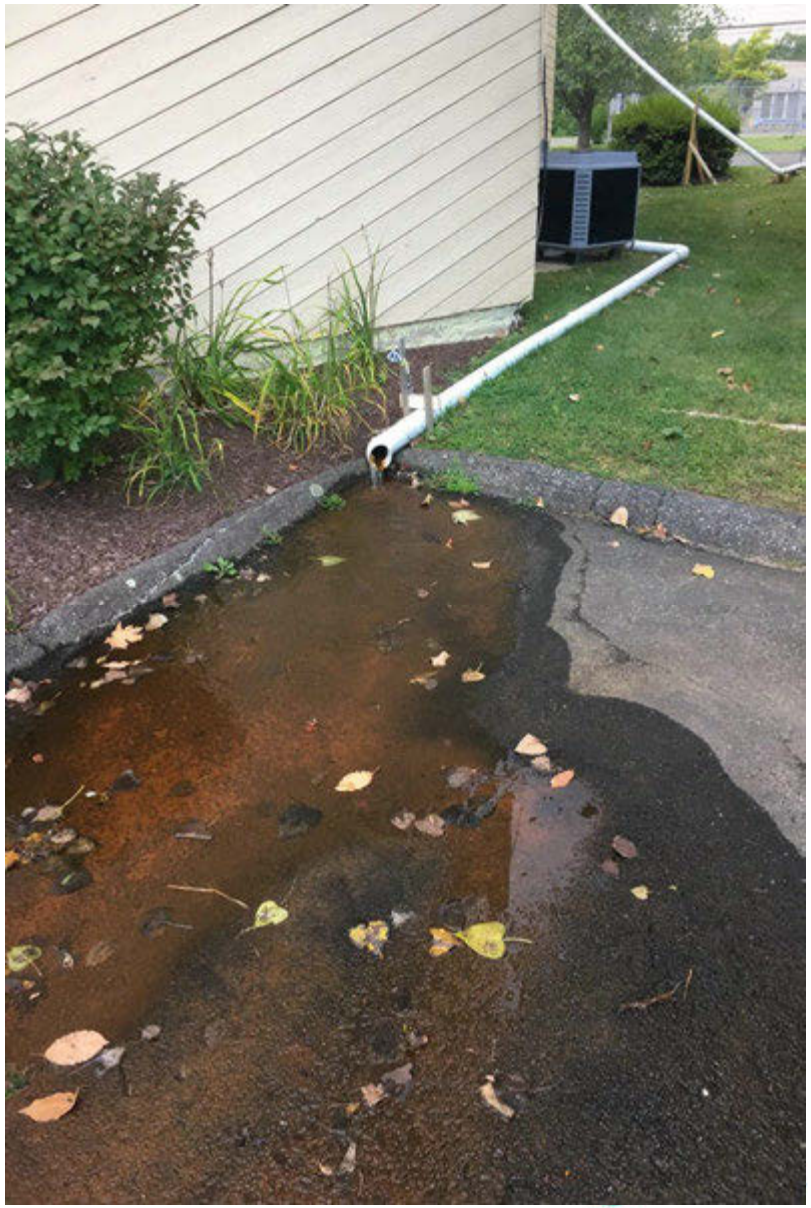
- Logue Farms
  - Direct livestock access to tributaries
  - Buffer
  - Manure handling

Hotspot Assessment Results

- Logue Farms
  - Direct livestock access to tributaries
  - Buffer
  - Manure handling

Hotspot Assessment Results

- **Medical Office Building**
  - Dry weather flows



Best Management Practices (BMPs)

- Filter berms
- Increased riparian buffer
- Structural stormwater BMPs
  - Infiltration systems
  - Bioretention systems
  - Underground solutions
- Non-structural BMPs
  - Goose abatement
  - Septic system management and outreach
  - Illicit discharge detection and elimination (IDDE)
  - Manure/nutrient management
  - Land use regulatory controls

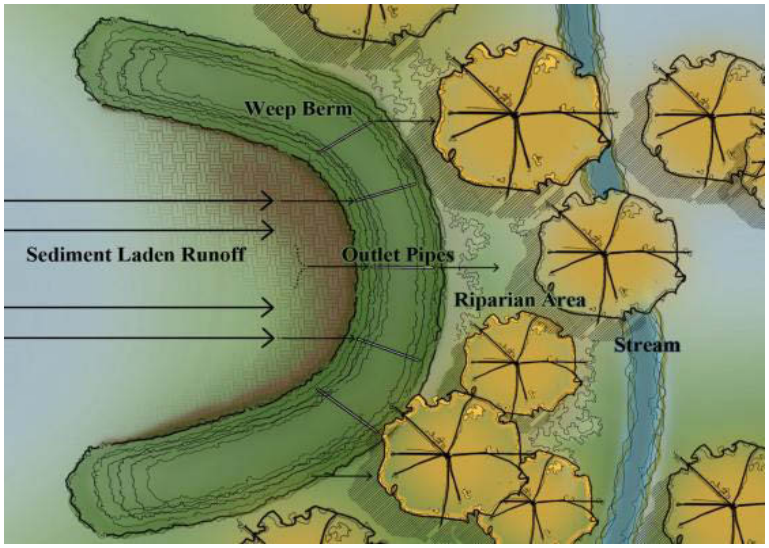
Illicit Discharge Detection and Elimination (IDDE)

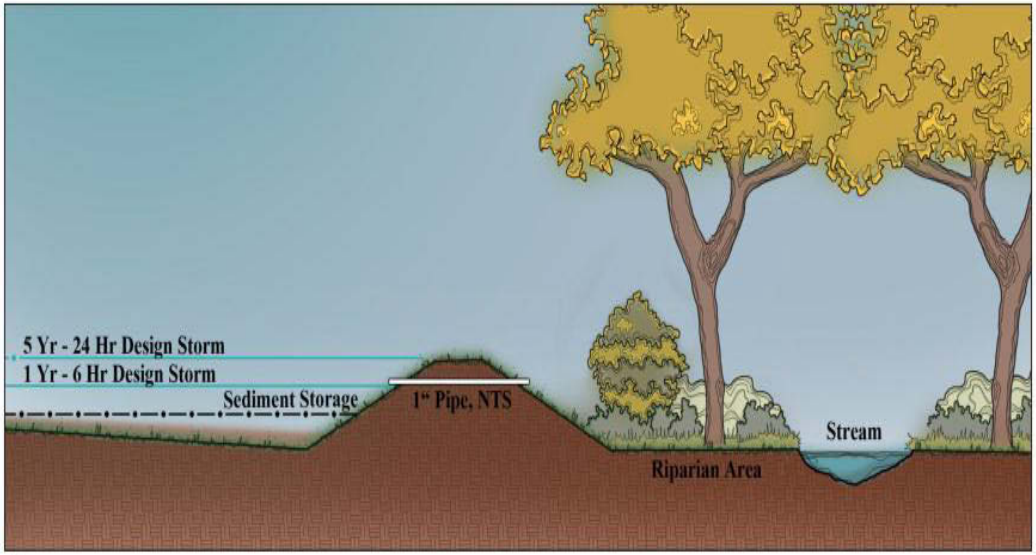
- Requirements for MS4 regulated communities
- Encourage IDDE program implementation outside of regulated areas and in unregulated communities
- “Priority Areas” should include discharges to impaired segments

Manure Management

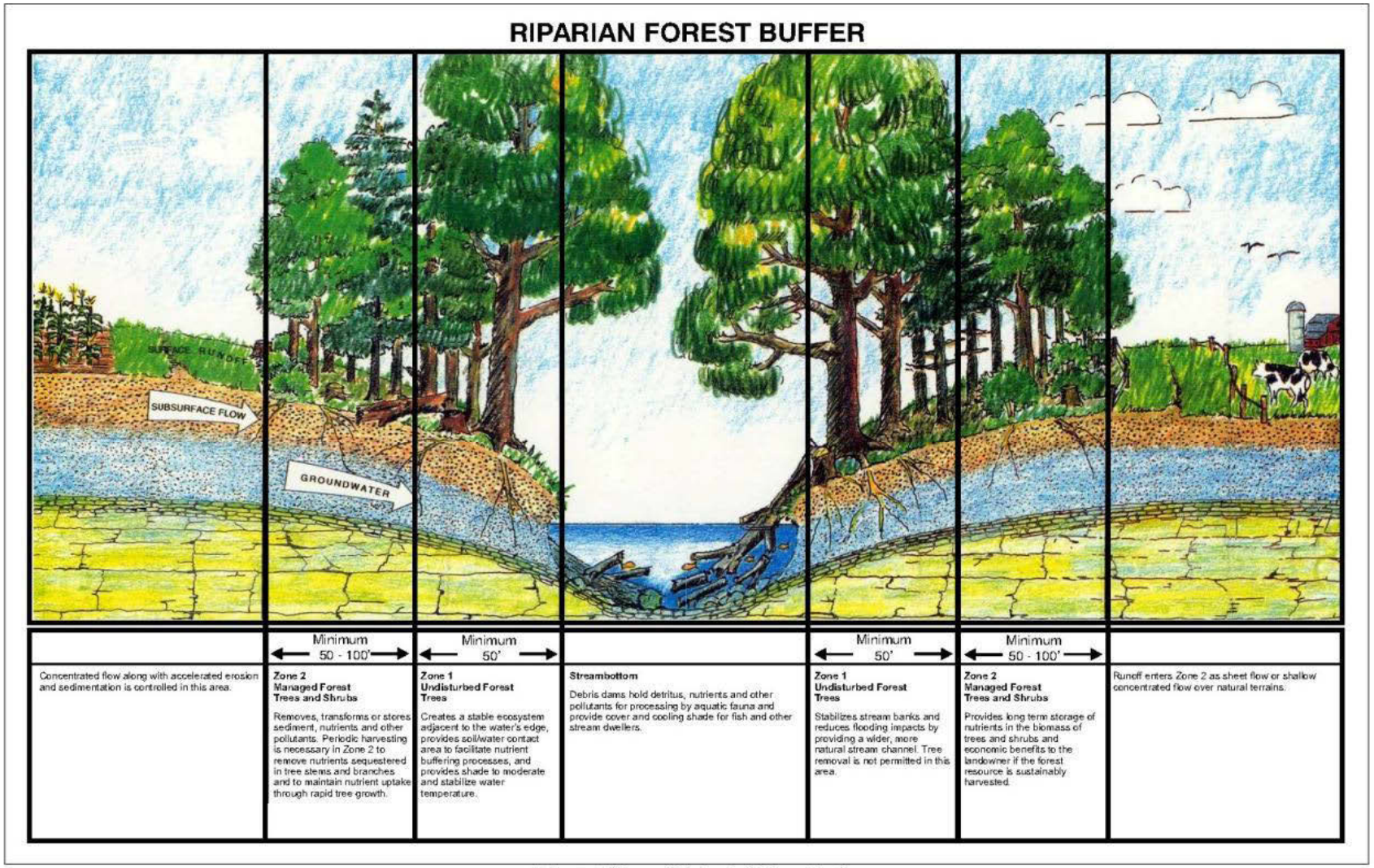
- Target equestrian facilities and livestock owners
  - Many likely doing a good job but could be better
- Focus on pastures as well as paddocks, barns, and storage areas

Filter Berms





Increased Riparian Buffer



Adapted from Welsch (*Riparian*)

FUSS & O'NEILL

Structural Stormwater BMPs

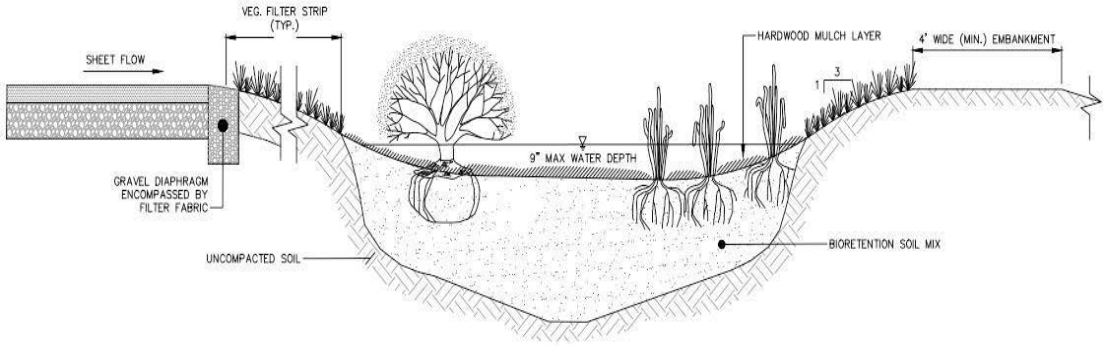
- Permeable Pavers EM2

Slide 36

EM2 Somewhere in these stormwater BMP slides, discuss the potential for stormwater retrofits at Southbury Plaza (recall our discussion with Carol and Chris?) and Heritage Village.
Erik Mas, 10/4/2017

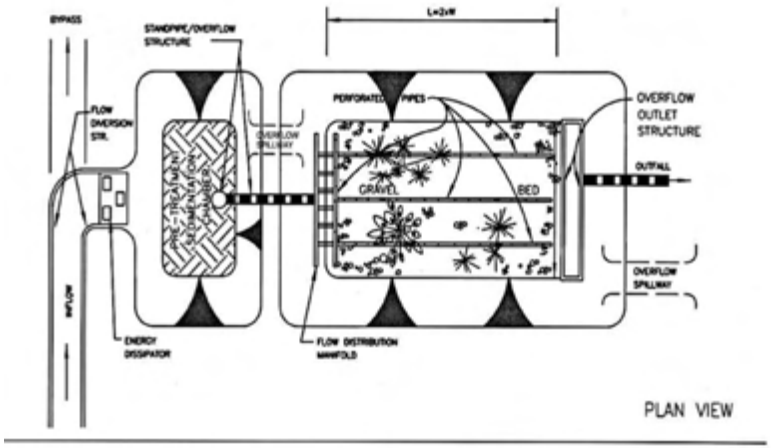
Structural Stormwater BMPs

- **Bioretention/Infiltration**



Structural Stormwater BMPs

- WVTS



Structural Stormwater BMPs

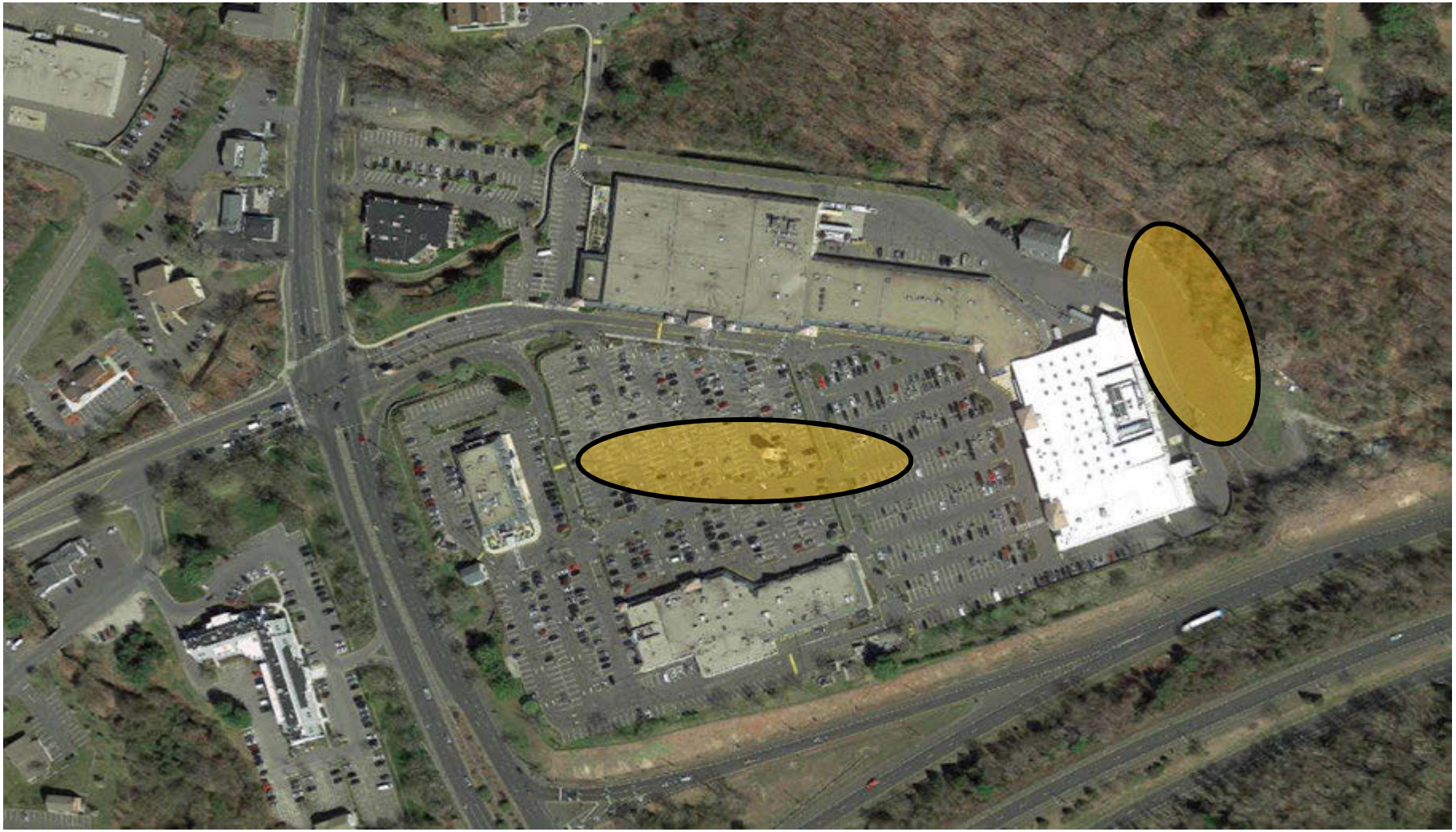
- **Underground solutions**
  - Parking lots
  - Public right-of-way

Structural BMP Opportunities

- Southbury Plaza
- Heritage Village

Southbury Plaza

Southbury Plaza cont.



Heritage Village

Heritage Village cont.

Next Steps

- BMP site selection and prioritization
- BMP concept designs
- Public meetings
- Draft and final watershed plan

Discussion/Questions

Pomperaug River Watershed Coalition
Land Use Committee Meeting
June 12, 2018 from 3:00 PM – 5:00 PM
Shove Building, Municipal Office Complex, Woodbury

AGENDA

1. Revisit pollutant loading model results

2. Revisit field assessment survey findings

3. Revisit general recommendations for structural and non-structural BMPs

4. Review BMP Matrix for site specific BMP recommendations
    a. Add/subtract and make corrections to list

5. Prioritize projects/sites from BMP matrix for conceptual project design development
    a. Select 5 large projects for conceptual project design development
    b. Select 10 small projects for conceptual project design development

6. Review and revise draft outline for Watershed Based Plan document

7. Next steps

Pomperaug River Watershed Coalition
Land Use Committee Meeting
June 12, 2018 from 3:00 PM – 5:00 PM
Shove Building, Municipal Office Complex, Woodbury

Meeting Notes

Attendees: Neil Lustig, Amy Fisher, Erik Mas, Susan Peterson, Chris Wood, Maryellen Edwards, Janel Chap, Carol Haskins, Norma Carey, Curt Jones, Gail McTaggart, Aaron Budris

1. **Revisit pollutant loading model results**
   Erik Mas (Fuss & O'Neill) presented slides previously shared at the Land Use Committee (LUC) meeting in October to refresh the committee's memory of the pollutant load modeling results. He began by sharing the water quality impairment map that highlights the locations of the stream reaches that are listed as impaired for elevated levels of bacteria, which are the focus of the Watershed Based Plan development. Viewing the pie charts of the relative sources of bacteria loading model, the following land cover types were noted as the main contributing sources in their respective subwatershed areas:
   A. Pomperaug Subwatershed
      - Primary: Runoff from the urbanized area (i.e. stormwater input)
      - Secondary: Illicit Discharges (not necessarily a large number of these discharges, but a few could count account for a large contribution of bacteria from residential, commercial, or other land uses).
      - Priority Area for Load Reduction: Mitigating stormwater runoff through implementation of LID and BMP practices on new and redevelopment projects; conducting illicit discharge detection and elimination surveys (requirement of MS4 permit in Southbury and Woodbury)

   B. Weekeepeemee Subwatershed – almost the inverse of the Pomperaug as the relative bacteria sources go
      - Primary: Rural land cover and livestock
      - Secondary: Urban and forested land cover areas
      - Priority Areas for Load Reduction: Manage for agricultural inputs associated with livestock near waterways

   C. Transylvania Subwatershed
      - Modeled bacteria inputs are a mix of those reflected in the Pomperaug and Weekeepeemee Subwatersheds and the reductions priorities should be a mix of urban and rural
      - Question raised about the geese population on Southbury Training School site and their contribution to the bacteria load

2. **Revisit field assessment survey findings**

   Erik continued his slide presentation to highlight the findings of the Field Assessment Surveys, showing slides shared previously at the October 2017 meeting. He reminded the committee that about 35 sites were visited of the list of sixty or more identified as potential areas of concern by the Land Use Committee. The sites visited represented a mix of public and private residential, municipal, agricultural, and commercial activities. The field team looked at equestrian facilities, farms with other livestock, urban and rural residential areas, roads, storm drains, paddocks, manure management practices, and more. The field investigations were intended to serve as a way to ground-truth the types of potential concerns and to identify areas where LID retrofits and other BMPs could potentially be implemented.

3. **Revisit general recommendations for structural and non-structural BMPs**

   Based on the observations made during the field assessment surveys, Erik's team generated a broad list of BMP types that may be suitable for reducing bacteria inputs to the Pomperaug and Weekeepeemee Rivers and Transylvania Brook.

   A. BMPs include filter berms, increased buffer widths, structural stormwater BMPs (infiltration systems, bio-retention); non-structural BMPs (education, geese deterrents); livestock fencing, and more with the main focus generally being practices that will infiltrate runoff into the soil for natural filtration. Additional notes for specific BMP types are as follows:
      - Stormwater reductions – already focus via MS4 – IDDE (big bang for the buck)
      - Manure Management – generally cost effective, but could be challenging in working with private landowners
      - Filter Berms – structural element to filter overland flow around paddocks and manure storage areas (materials, soils w/ amendments)
      - Riparian Buffers – farms especially; barrier to livestock access to water
      - Permeable Pavers – low traffic, low volume overflow parking
      - Bioretention – permeable soils make Pomp Watershed generally viable for rain gardens, linear bioswales, infiltration and/or underdrain systems
      - WVTS – Wet vegetated treatment systems
      - Underground solutions – parking lots and public right of ways
   B. Sites highlighted as opportunities for structural BMP retrofits included –
      - Southbury Plaza – areas for infiltration, need to design around existing septic systems below parking lot
      - Main Street South – Exit 15 end – office buildings and retail areas
      - Main Street South – Exit 14 end – town offices, Southbury Green, Sacred Heart Church
      - Heritage Village – potential parking areas and roadway areas

4. **Review BMP Matrix for site specific BMP recommendations; add/subtract and make corrections to list**

Erik passed out copies of the BMP Matrix along with maps of the subwatershed areas showing the potential areas of concern for reference. He walked the committee through the data captured in the matrix and how it is presented while noting the breakdown of subwatersheds, the area of concern, notes regarding the potential for bacteria input, potential BMPs for the specific site along with associated project scale, relative costs, maintenance requirements, whether a field visit was conducted, and a recommendation if a BMP conceptual plan should be developed for that site.

In reviewing this document, the committee flagged a key question related to the datasets and thresholds used to identify the impaired stream segments and how that factors into understanding potential bacteria sources contributing to those stream segments. In the discussion that followed, the committee recognized the limitation of the dataset and that further temporal and spatial data collection is needed to refine our understanding of the extent of the impaired areas and that this is something that should be included among the non-structural BMP recommendations in the draft Watershed Based Plan. Carol noted that she would follow-up with CT DEEP's Monitoring & Assessment Division staff to learn more about the scope of data needed to have an impaired stream segment removed from EPA' 303(d) impaired waters list (established based on finding of DEEP's monitoring and assessment work).

A couple of questions were raised about the inclusion of a couple of sites that have already made modifications that would alleviate bacteria inputs. These included Pomperaug Woods having connected to the Heritage Village Wastewater Treatment Plant and Wellspring installing a new septic system. The committee was asked to look carefully through the list to see if there are other sites that should be taken out and to share that feedback with Carol by June 20, 2018. Similarly, are there any sites that should be added to the list?

In regards to residential septic concerns in certain neighborhoods, we recognized that staffing availability of the local health department currently precludes neighborhood-wide track down surveys to identify specific instances of failure based on unsolicited reports. We also recognized that seeking funding for additional staffing or interns to aide in this type of activity could be considered as a non-structural BMP recommendation to include in the WBP.

A question was also raised regarding the facility discharge from the Heritage Village Wastewater Treatment Plant as it relates to the volume of wastewater they are treating compared to their overall capacity. Carol seemed to recall their influent volume is only about half of their full capacity of 750,000 gallons per day. As for the quality of the effluent, Erik noted his team did use the plants quarterly reporting data submitted to DEEP in the pollutant loading model. Thus, that wedge of the pie in the relative bacteria sources chart reflects the actual discharge from the plant.

In consideration for manure management practices, Amy suggested that livestock fencing and buffer practices be used for keeping livestock away from stream areas if that is a component of the bacteria concern. She noted the strict technical guidelines NRCS has for other manure containment measures when funded through their agency. Amy also noted that her program is non-regulatory in nature and focuses heavily on sharing innovated practices and providing technical assistance to help farmers implement BMPs; but again underscored that certain programs and funding mechanisms through the agency have strict technical guidelines for certain BMPs. This lead the LUC to consider more educational outreach based approaches for working with smaller farming operations (hobby farms) on topics of manure management and livestock containment as a non-structural BMP recommendation for inclusion in the WBP.

5. **Prioritize projects/sites from BMP matrix for conceptual project design development**
   Taking the above discussion into consideration, the committee members were asked to more closely review the BMP matrix and to provide input back to Carol by June 20, 2018. PRWC is looking for input specific to:
   - verification (addition / subtraction) of sites on the list
   - flagging sites deemed as "low-hanging fruit" for BMP implementation
     - basis of project scale and/or willingness of landowner to support a project
     - basis of project type; ability to replicate at other sites
   - Goal is to collectively select 5 large projects and 10 small projects for conceptual project design and then to identify approximate project cost and potential funding sources and a timeline for implementation.

6. **Review and revise draft outline for Watershed Based Plan document**
   Erik provided a draft outline for the Watershed Based Plan. Upon review, committee suggestions were:
   - Include discussion of the limited datasets that were used in establishing the "impaired" rankings in the Introduction section.
   - Include examples of sites where BMPs and LID practices have already been implemented in the watershed
   - Include a glossary of acronyms and definitions of technical terms
   - Include additional monitoring needs within the Management Recommendations section
   - Call out / reference the EPA's required 9-elements within the table of contents to ease DEEP and EPA review and approval of the document

7. **Next steps**
   A. Carol will collect LUC input on BMP prioritization and draft outline for the Watershed Based Plan. Please share input with Carol by Wednesday June 20, 2018.
   B. Fuss & O'Neill will then begin drafting conceptual BMP plans
   C. In the meantime, Fuss & O'Neill will also begin drafting sections of the Watershed Based Plan document

D. Public information sessions still need to be held in Southbury, Woodbury, and Bethlehem to capture community input. Timing = July
    a. After the meeting, Carol and Erik identified July 18 & 19 as dates for these sessions pending availability of meeting space.
E. After the draft plan is completed and reviewed, a final presentation of the Watershed Based Plan will be held somewhere central in the watershed. Timing = August
F. After the meeting, Carol and Erik identified August 15 or August 22 as possible dates for the final presentation pending availability of meeting space and completeness of the Plan.
G. The Final Draft of the Watershed Based Plan needs to be submitted by August 31 to ensure adequate time for DEEP and EPA review/approval of the document before the grant contract expires.

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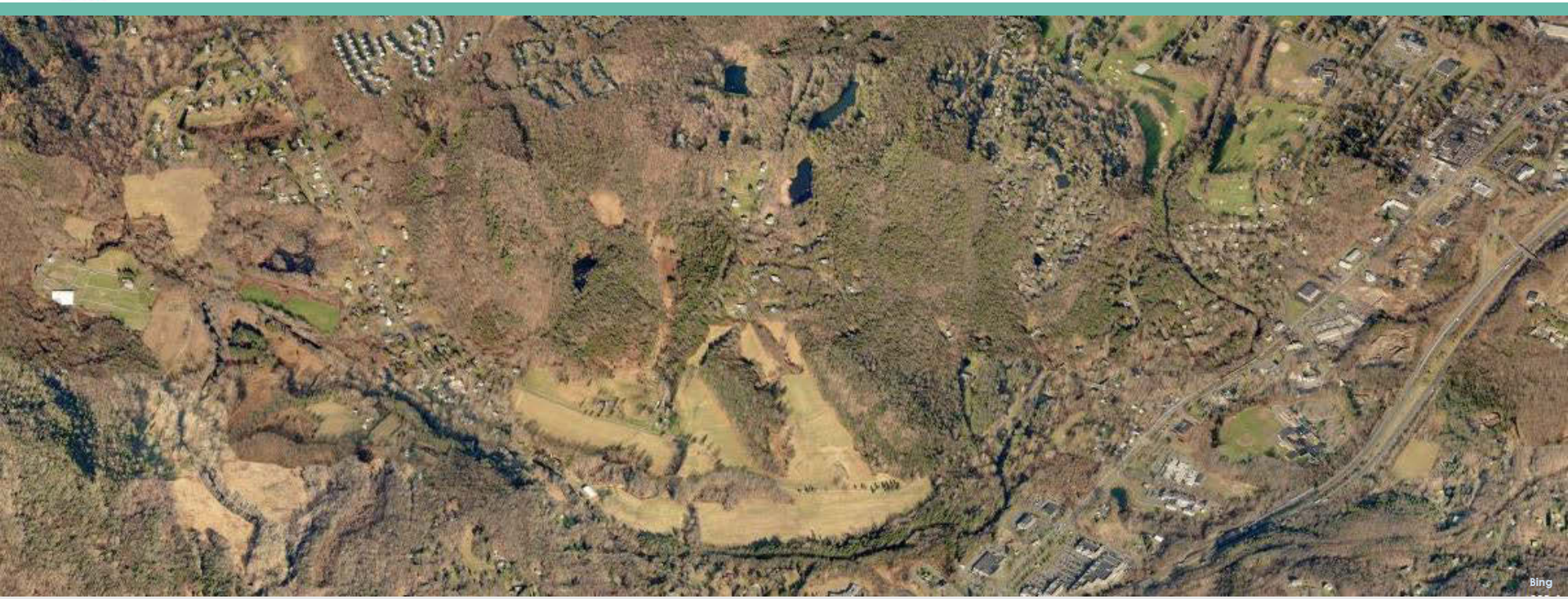


PRWC Land Use Committee Meeting

Pomperaug River Watershed Based Plan

June 12, 2018

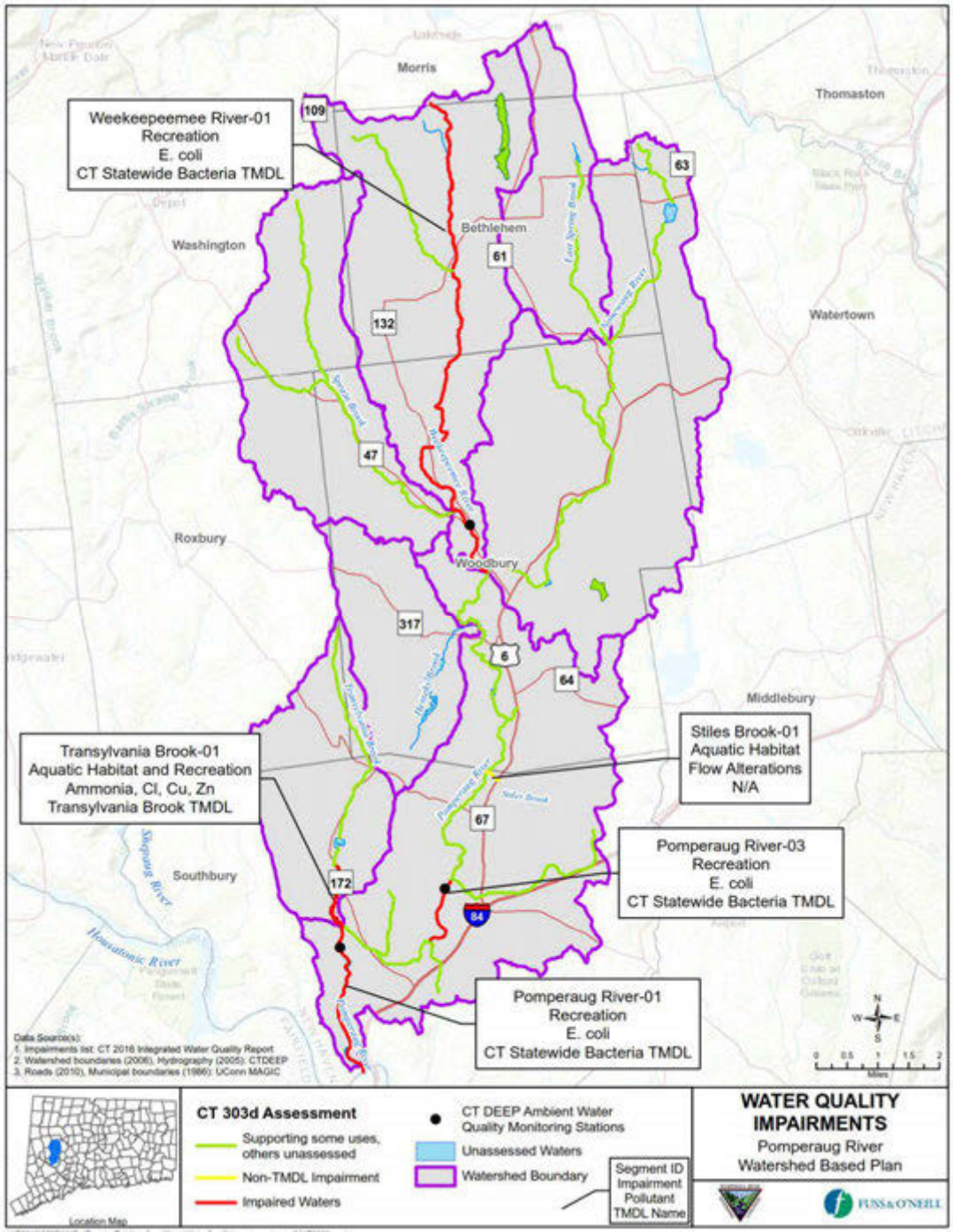
POMPERAUG RIVER WATERSHED COALITION

Meeting Agenda

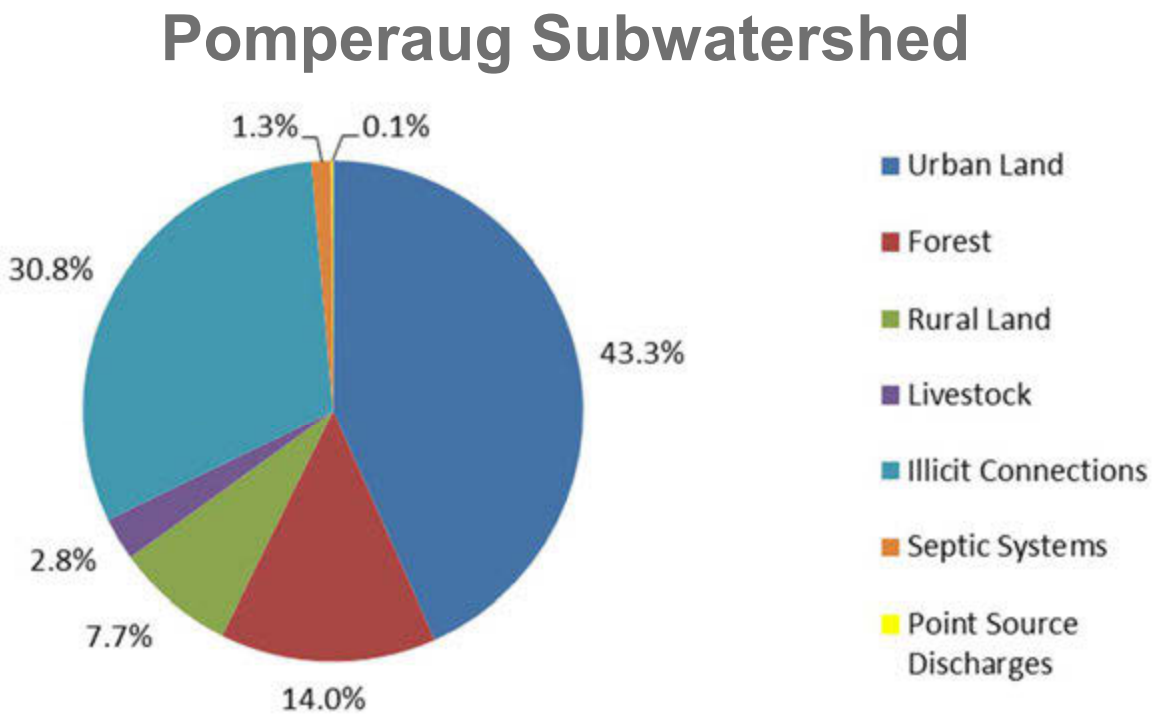
1. Introductions
2. Summary of Findings from Previous LUC Meeting
   - Pollutant Loading Model
   - Field Assessments and Potential BMPs
3. BMP Project Selection
4. Next Steps
5. Discussion

Impairments

- Pomperaug River
- Weekeepeemee River
- Transylvania Brook



Modeled Relative Bacteria Sources



- Stormwater runoff from developed land
- Illicit connections from residential and commercial land use
- Source controls, structural stormwater BMPs, education and outreach, illicit discharge detection and elimination

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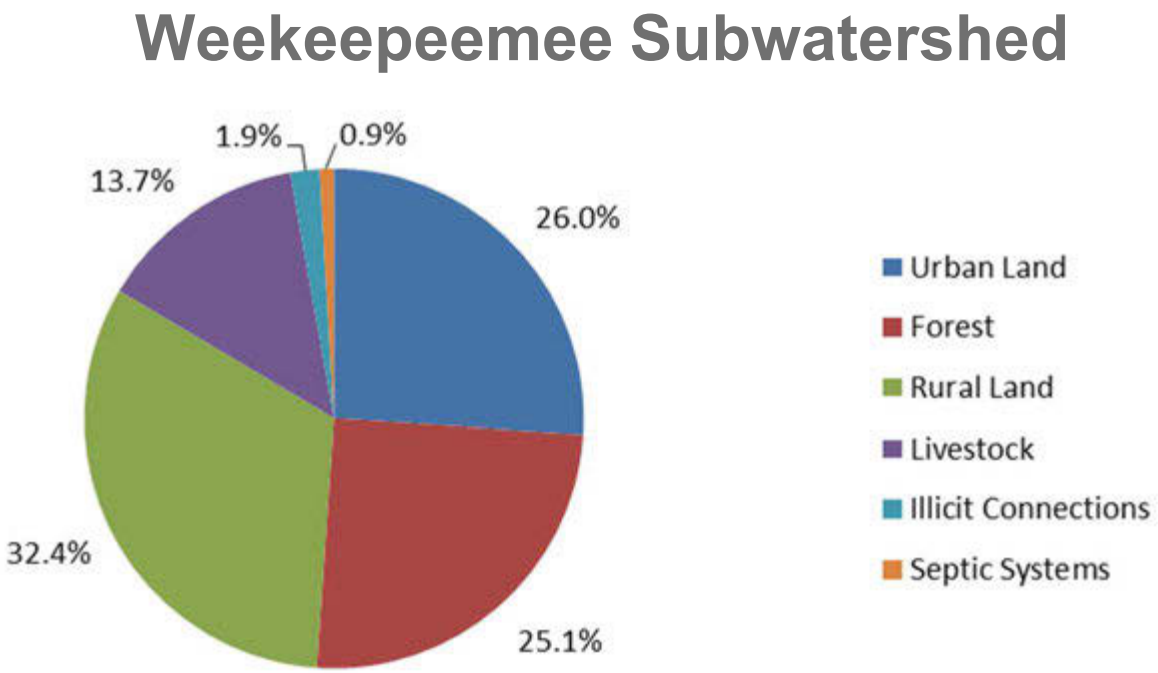
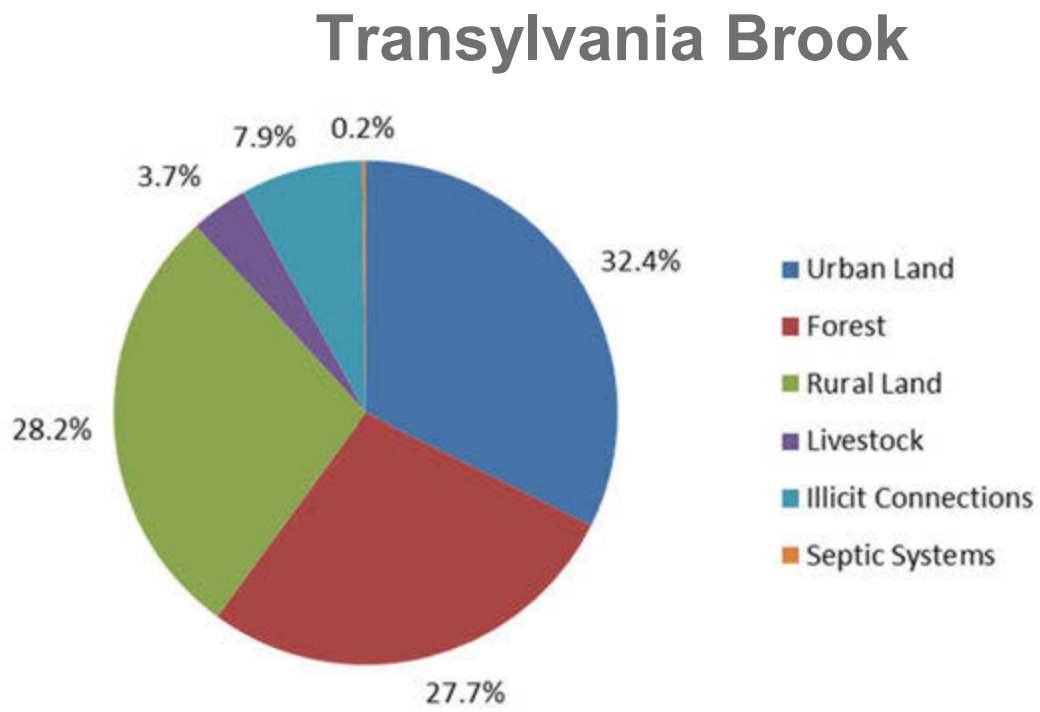
Modeled Relative Bacteria Sources



- Stormwater runoff from agricultural land use and some developed land use
- Agricultural BMPs (livestock and manure management)

Modeled Relative Bacteria Sources



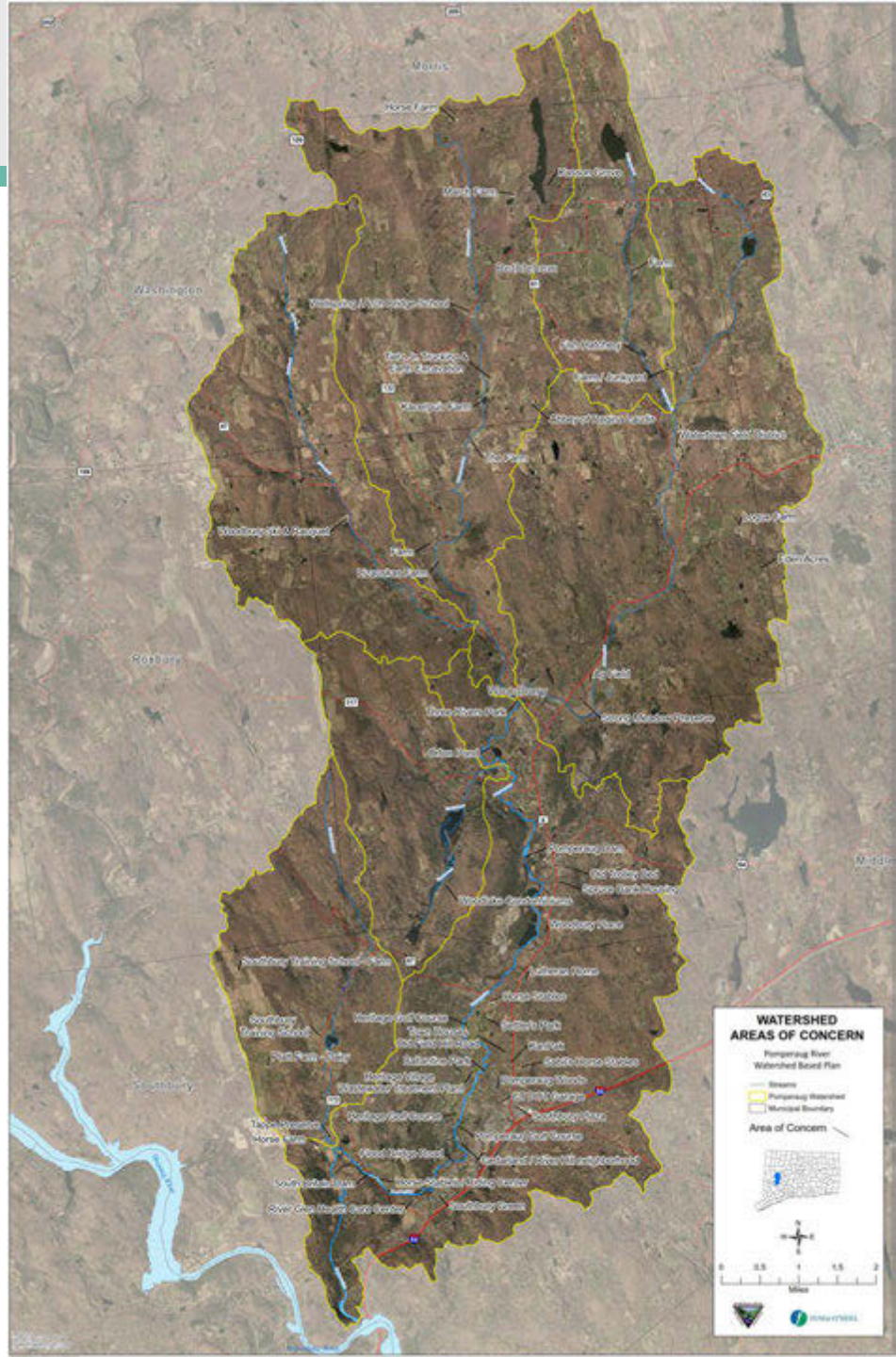
- Stormwater runoff from mix of agricultural and developed land uses

Visual Field Assessments

- Investigate suspected bacteria sources in areas with impairments
- Identify restoration, pollution prevention, and retrofit opportunities
- Standardized field protocols
  - Stream reaches
  - Neighborhoods
  - Hotspots

Pollution Hotspots/ Areas of Concern

- Identified by LUC and PRWC
- Roughly 60 sites identified
- Potential bacteria sources
  - Urban runoff
  - Agricultural land adjacent to streams
  - Manure management
  - Septic system issues
  - Point discharges
  - Waterfowl, pet waste
  - Streambank erosion

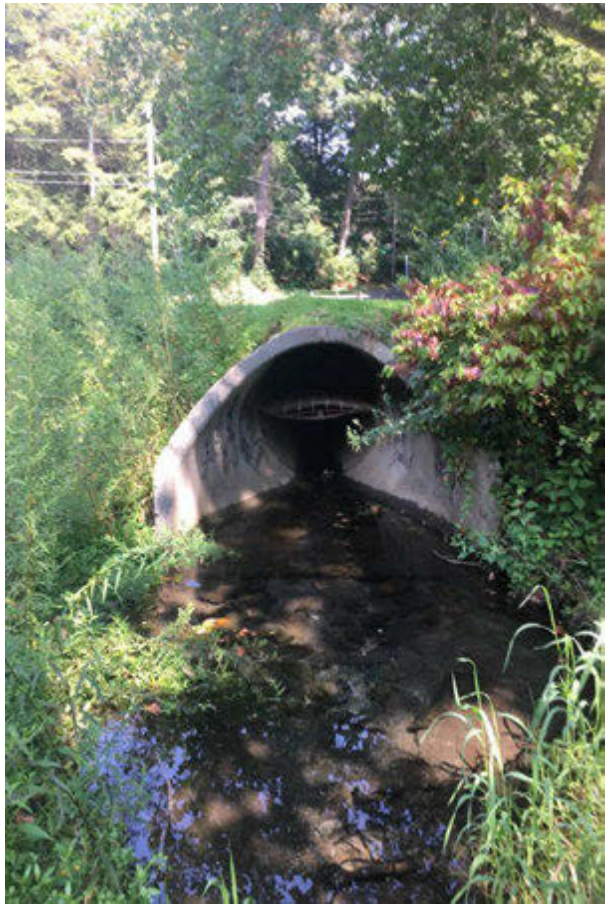


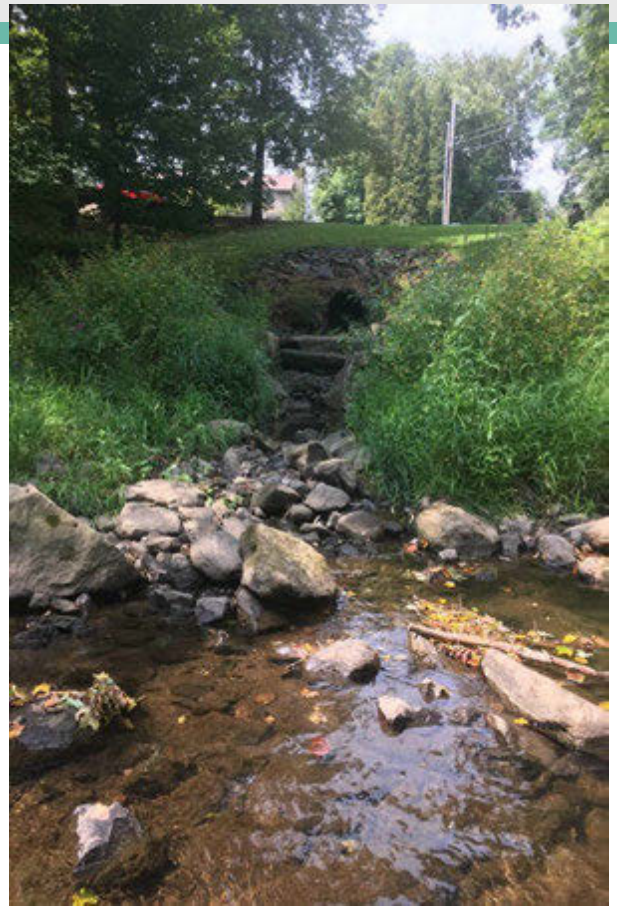
Reach Assessment Results

- **Pomperaug-01**
  - **Potential sources**
    - *Equestrian Center*
    - *Stormwater*

Reach Assessment Results

- **Pomperaug-03**
  - Potential sources
    - *Geese*
    - *Stormwater*
    - *WWTP*
    - *Septic*





Reach Assessment Results

- **Weekeepeemee-01**
  - Runoff from pastures and Paddocks

Neighborhood Assessment Results

- **Berkshire Estates/Oakdale Manor**
  - Stormwater
  - Septic

Neighborhood Assessment Results

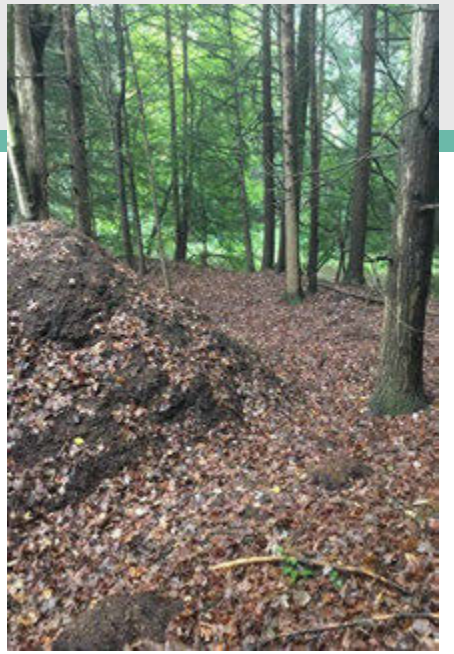
- **Heritage Village**
  - Stormwater
  - WWTP
  - Geese

Neighborhood Assessment Results

- **Heritage Village**
  - Stormwater
  - WWTP
  - Geese

Hotspot Assessment Results

- Stonecrest Farm
  - Manure piles
  - Front Paddock Area
  - Farm Pond



Hotspot Assessment Results

- **Stonecrest Farm**

Hotspot Assessment Results

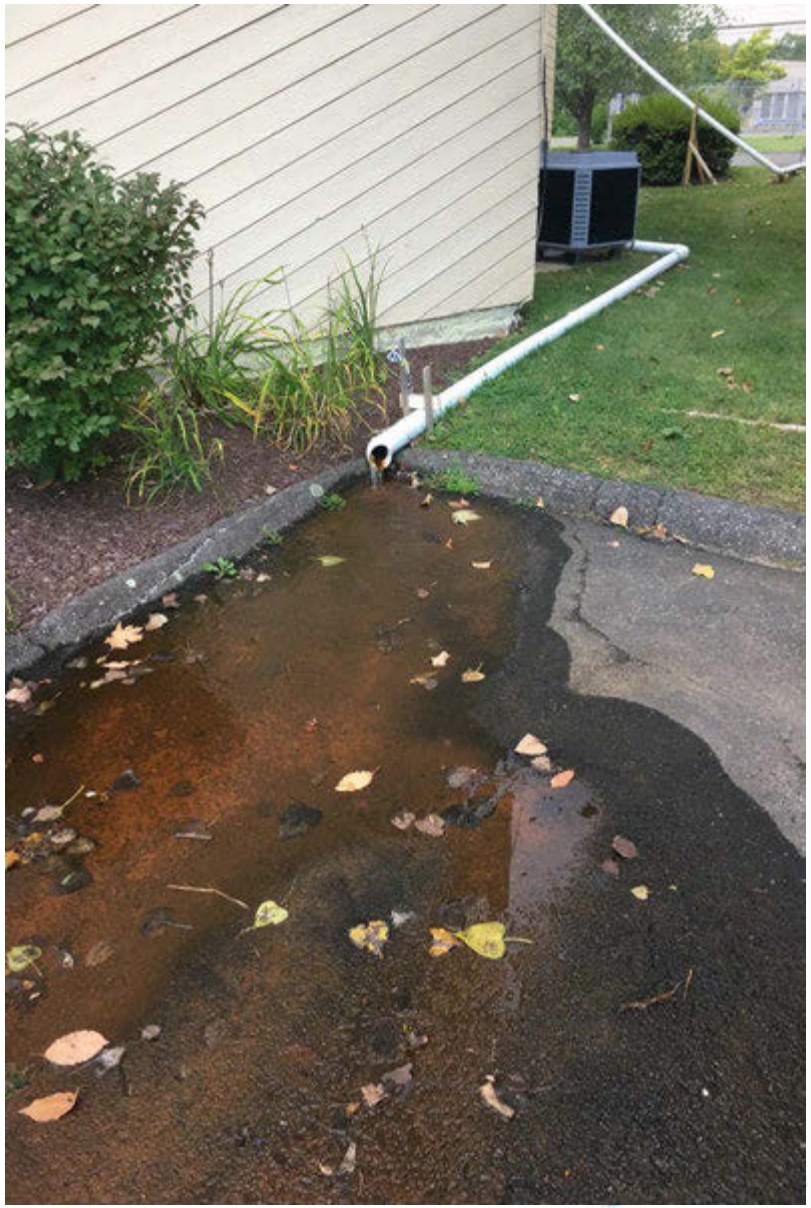
- Logue Farms
  - Direct livestock access to tributaries
  - Buffer
  - Manure handling

Hotspot Assessment Results

- Logue Farms
  - Direct livestock access to tributaries
  - Buffer
  - Manure handling

Hotspot Assessment Results

- **Medical Office Building**
  - Dry weather flows



Best Management Practices (BMPs)

- Filter berms
- Increased riparian buffer
- Structural stormwater BMPs
  - Infiltration systems
  - Bioretention systems
  - Underground solutions
- Non-structural BMPs
  - Goose abatement
  - Septic system management and outreach
  - Illicit discharge detection and elimination (IDDE)
  - Manure/nutrient management
  - Land use regulatory controls

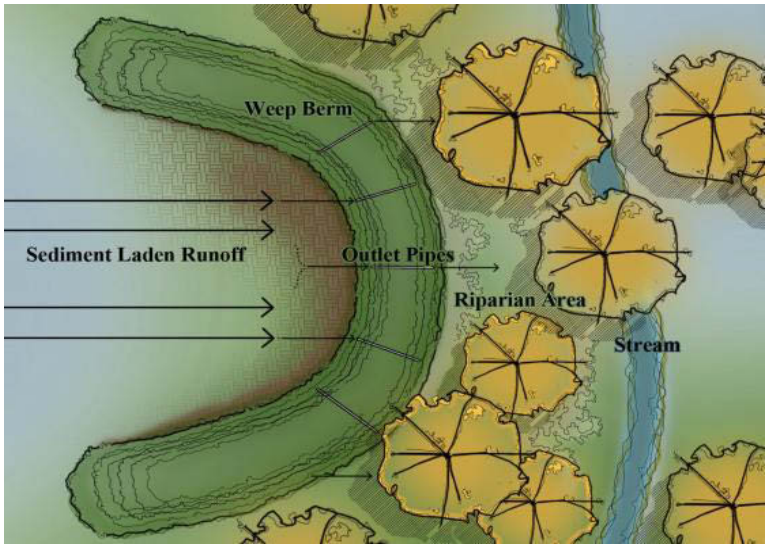
Illicit Discharge Detection and Elimination (IDDE)

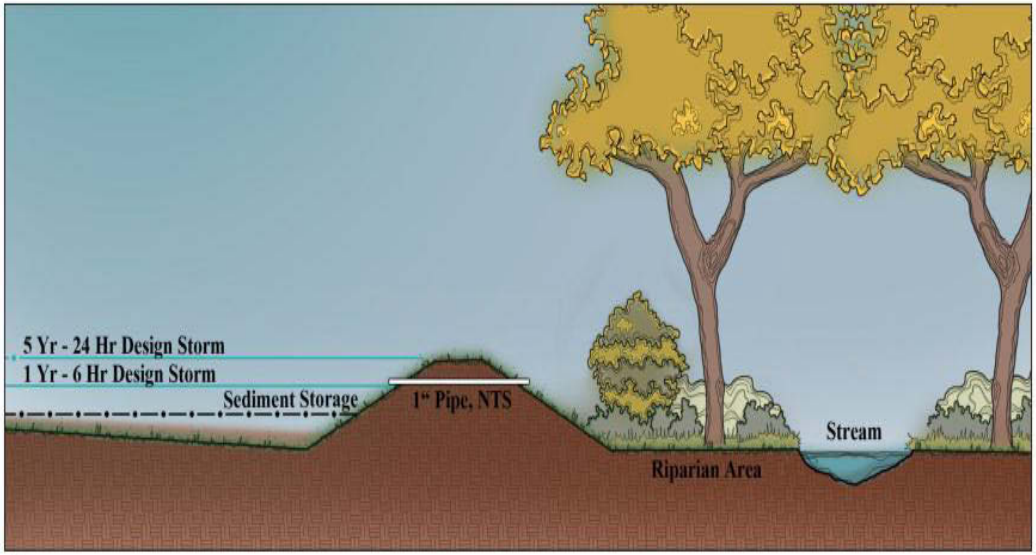
- Requirements for MS4 regulated communities
- Encourage IDDE program implementation outside of regulated areas and in unregulated communities
- “Priority Areas” should include discharges to impaired segments

Manure Management

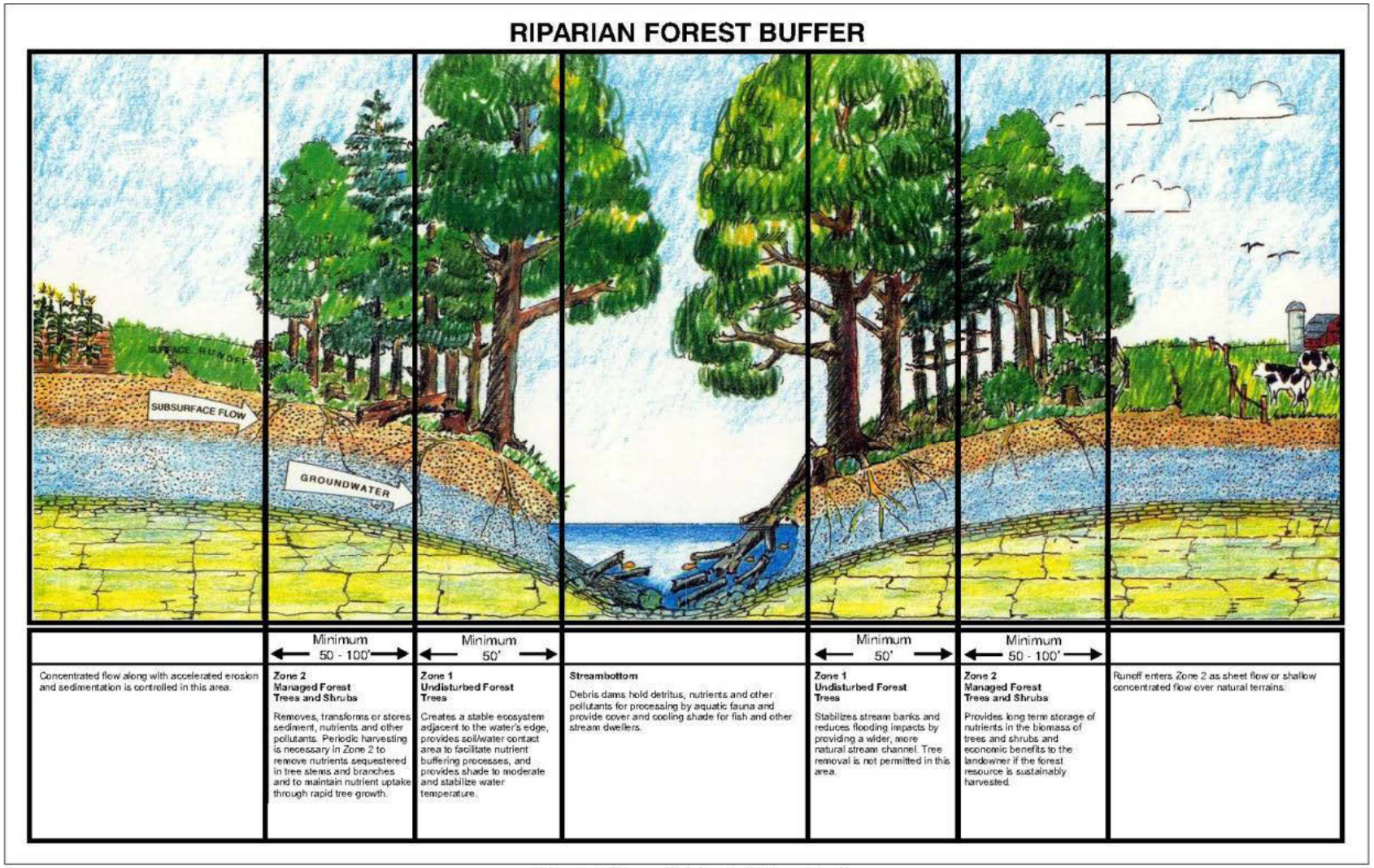
- Target equestrian facilities and livestock owners
  - Many likely doing a good job but could be better
- Focus on pastures as well as paddocks, barns, and storage areas

Filter Berms





Increased Riparian Buffer



Adapted from Welsch (*Riparian*)

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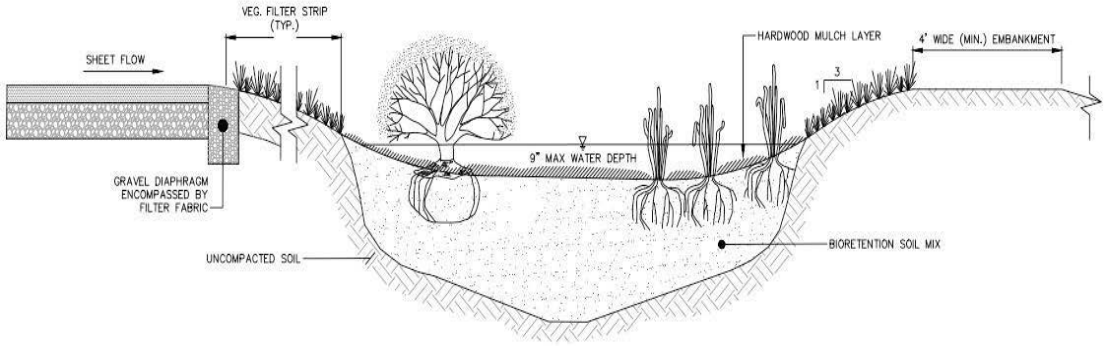
Structural Stormwater BMPs

- Permeable Pavers EM2

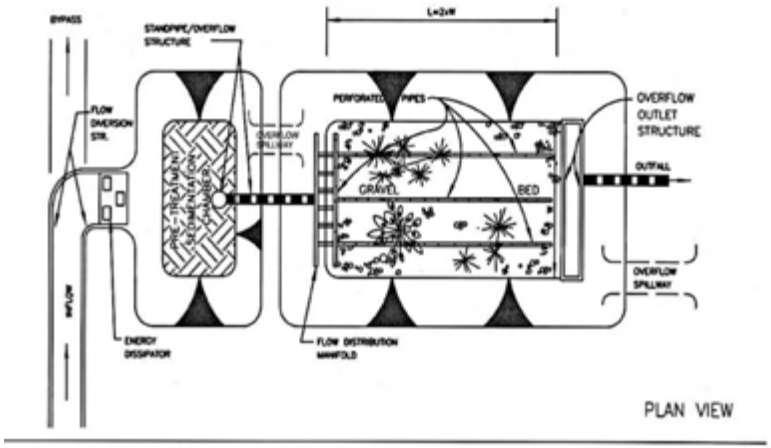
Structural Stormwater BMPs

- **Bioretention/Infiltration**



Structural Stormwater BMPs

- WVTS



Structural Stormwater BMPs

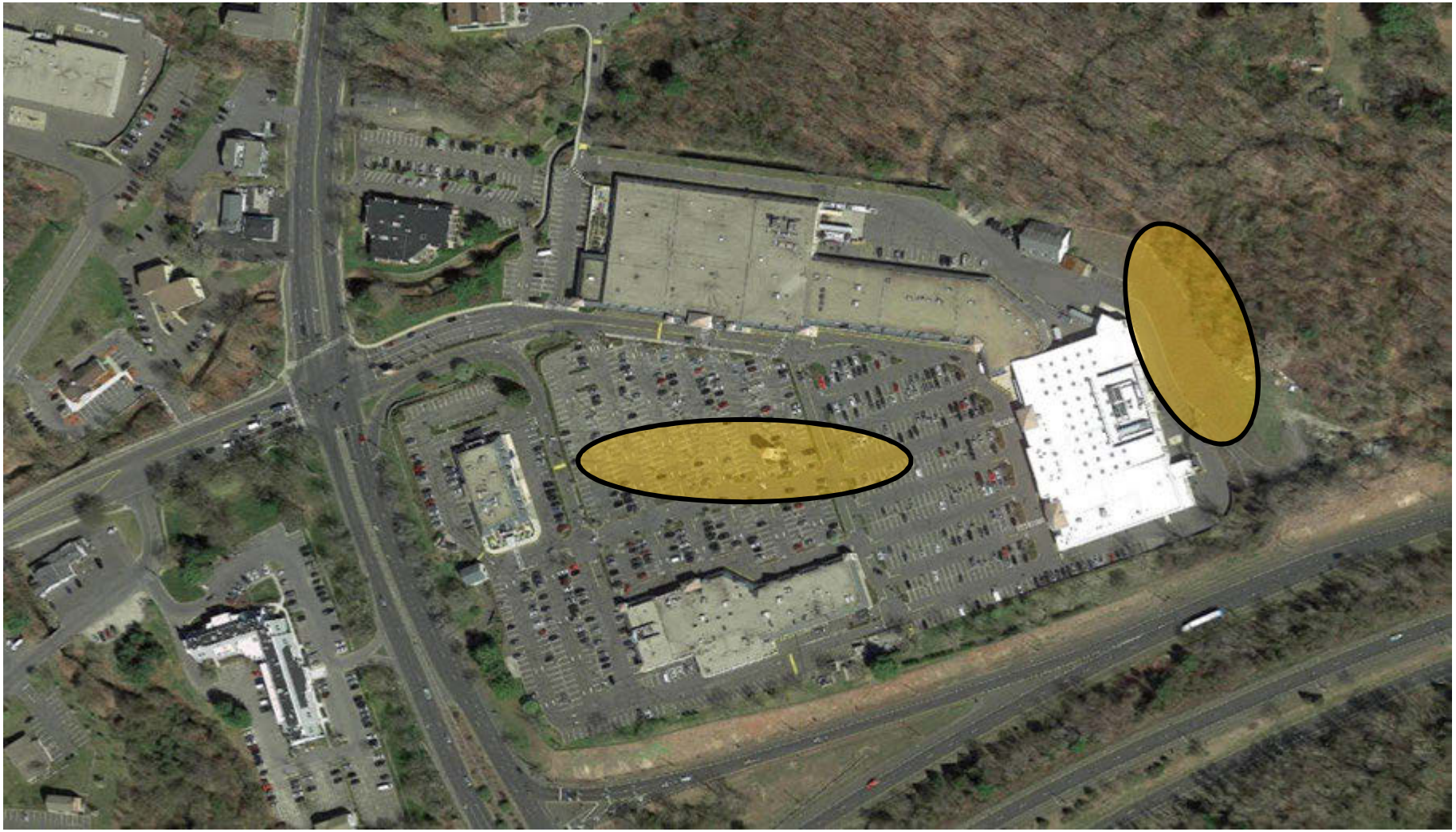
- **Underground solutions**
  - Parking lots
  - Public right-of-way

Structural BMP Opportunities

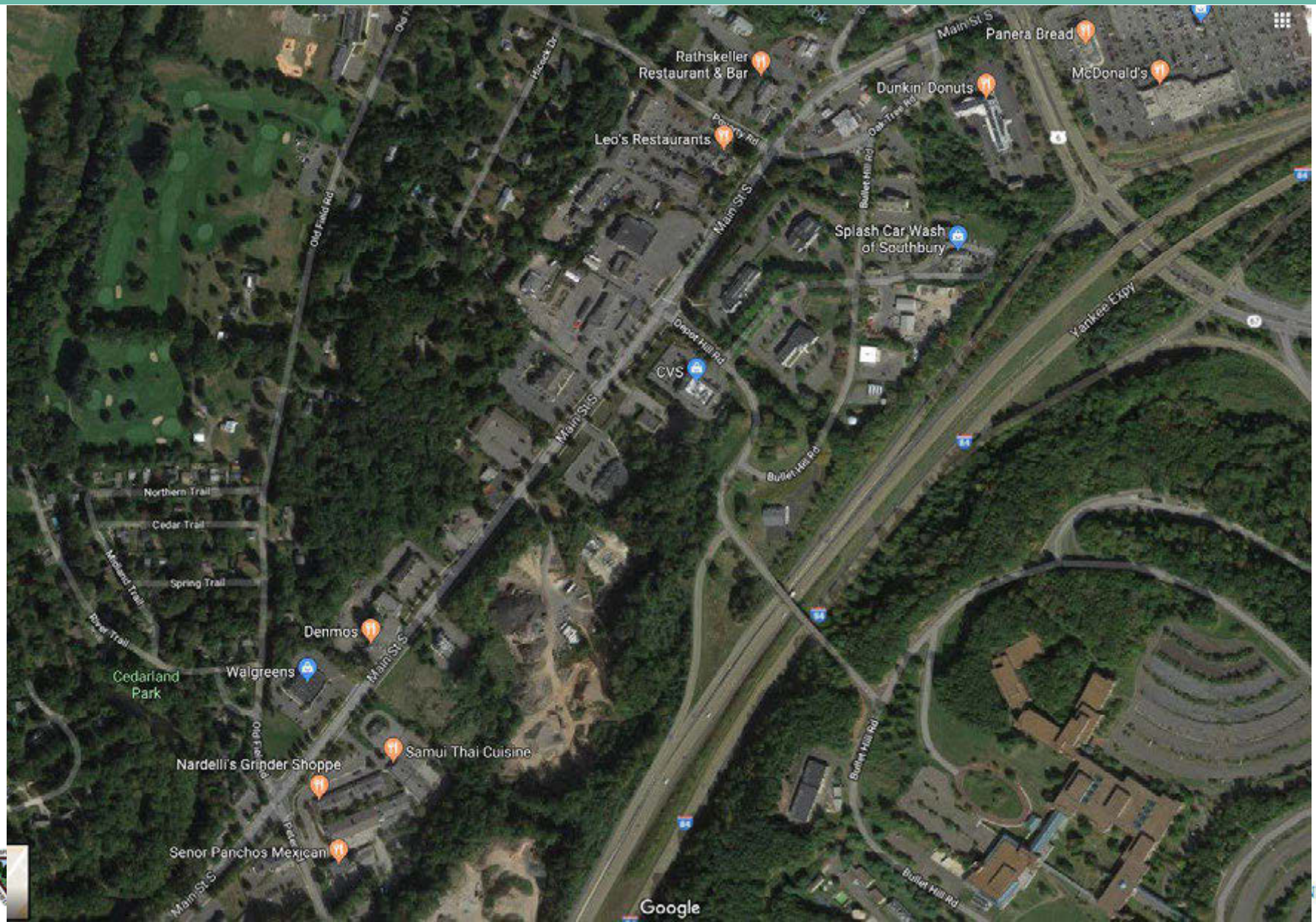
- Southbury Plaza
- Heritage Village
- Main Street South Corridor, Southbury

Southbury Plaza

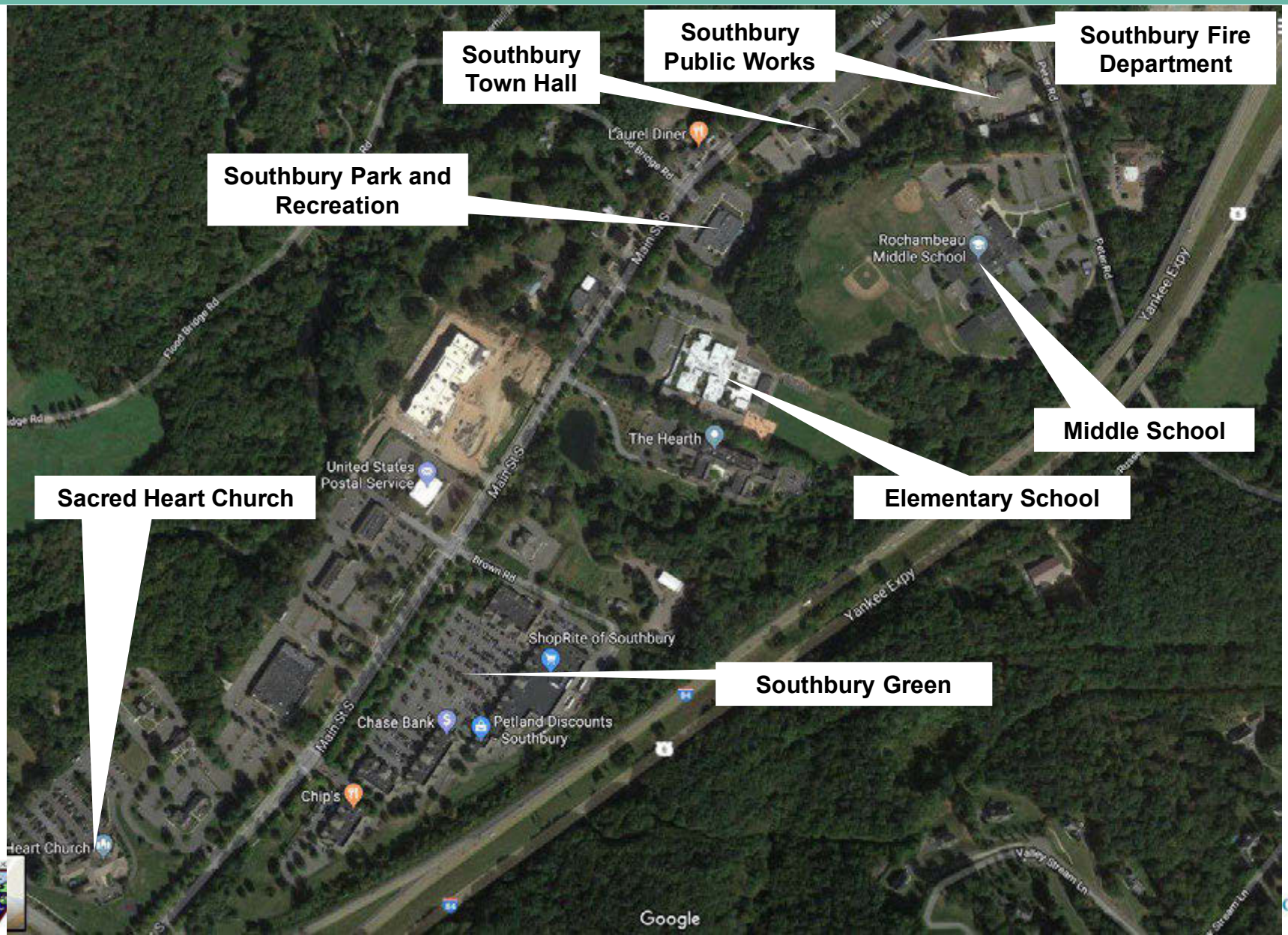
Southbury Plaza cont.



Main Street South Corridor – North



Main Street South Corridor – South



Heritage Village

Heritage Village cont.

Site-Specific BMP Project Selection

- 10 small BMP projects
- 5 large BMP projects
- See BMP Prioritization Matrix
  - Relative bacteria removal
  - Relative cost
  - Level of maintenance required

Next Steps

- Develop BMP project concepts – June/July
- Hold 2 public meetings – July
- Prepare watershed plan – July/August

Discussion/Questions

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Appendix H

Potential Funding Sources, Technical Assistance, and Other Resources

Pomperaug River Watershed Based Plan

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Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
Federal Sources		
EPA and WEF National Municipal Stormwater and Green Infrastructure Awards Program	The National Municipal Stormwater and Green Infrastructure Awards program, led by the Water Environment Federation (WEF) through a cooperative agreement with the U.S. Environmental Protection Agency (EPA), has been established to recognize high-performing regulated Municipal Separate Stormwater Sewer Programs (MS4s). The objective of the program is to inspire MS4 program leaders to seek new and innovative ways to meet and exceed regulatory requirements in a manner that is both technically effective as well as financially efficient. Recognition of innovative approaches is also a highlight of this program.	http://www.wef.org/ms4awards/
EPA Healthy Communities Grant Program	EPA New England's main competitive grant program to work directly with communities to reduce environmental risks to protect and improve human health and the quality of life.	http://www.epa.gov/region1/eco/uep/hcgp.html
EPA Environmental Education Grants	The Grants Program sponsored by EPA's Office of Environmental Education (OEE), Office of External Affairs and Environmental Education, supports environmental education projects that enhance the public's awareness, knowledge, and skills to help people make informed decisions that affect environmental quality.	https://www.epa.gov/education/environmental-education-ee-grants
FEMA (Federal Emergency Management Agency) Preparedness (Non-Disaster) Grants	FEMA provides state and local governments with preparedness program funding to enhance the capacity of their emergency responders to prevent, respond to, and recover from a range of hazards.	https://www.fema.gov/non-disaster-grants-management-system
EPA Smart Growth	EPA helps communities improve their development practices and get the type of development they want. EPA works with local, state, and national experts to discover and encourage development strategies that protect human health and the environment, create economic opportunities, and provide attractive and affordable neighborhoods for people of all income levels.	https://www.epa.gov/smartgrowth/epa-smart-growth-grants-and-other-funding

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Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
FEMA Hazard Mitigation Assistance	FEMA's Hazard Mitigation Assistance grant programs provide funding to protect life and property from future natural disasters. • Hazard Mitigation Grant Program (HMGP) assists in implementing long-term hazard mitigation measures following a major disaster. • Pre-Disaster Mitigation (PDM) provides funds for hazard mitigation planning and projects on an annual basis. • Flood Mitigation Assistance (FMA) provides funds for projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis.	http://www.fema.gov/hazard-mitigation-assistance
US Forest Service Land and Water Conservation Fund	The Land and Water Conservation Fund (LWCF) provides money to federal, state and local governments to purchase land, water and wetlands for the benefit of all Americans.	https://www.fs.fed.us/land/staff/LWCF/
United States Fish and Wildlife Service (USFWS)	The USFWS administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals.	http://www.fws.gov/grants/
USFWS North American Wetlands Conservation Act (NAWCA)	NAWCA provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.	https://www.fws.gov/birds/grants/north-american-wetland-conservation-act/how-to-apply-for-a-nawca-grant.php
USFWS National Coastal Wetlands Conservation Grant Program (NCWCGP)	The NCWCGP provides States with financial assistance to protect and restore these valuable resources. Projects can include (1) acquisition of a real property interest (e.g., conservation easement or fee title) in coastal lands or waters (coastal wetlands ecosystems) from willing sellers or partners for long-term conservation or (2) restoration, enhancement, or management of coastal wetlands ecosystems. All projects must ensure long-term conservation.	http://www.fws.gov/coastal/coastalgrants/

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Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
USFWS Partners for Fish and Wildlife Program	The Partners Program provides technical and financial assistance to private landowners and Tribes who are willing to work with USFWS and other partners on a voluntary basis to help meet the habitat needs of Federal Trust Species. The Partners Program can assist with projects in all habitat types which conserve or restore native vegetation, hydrology, and soils associated with imperiled ecosystems such as longleaf pine, bottomland hardwoods, tropical forests, native prairies, marshes, rivers and streams, or otherwise provide an important habitat requisite for a rare, declining or protected species.	http://www.fws.gov/partners/
National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience Grants Program	This competitive grant program funds projects that are helping coastal communities and ecosystems prepare for and recover from extreme weather events, climate hazards, and changing ocean conditions.	http://www.coast.noaa.gov/resilience-grant
NRCS Conservation Reserve Program	The Conservation Reserve Program (CRP) pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality.	https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index
NRCS Environmental Quality Incentives Program (EQIP)	For implementation of conservation measures on agricultural lands.	https://www.nrcs.usda.gov/wps/portal/nrcs/main/ct/programs/financial/eqip/
NRCS Emergency Watershed Protection (EWP) Program	The Emergency Watershed Protection (EWP) Program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, wind-storms, and other natural occurrences. EWP is an emergency recovery program, which responds to emergencies created by natural disasters. It is not necessary for a national emergency to be declared for an area to be eligible for assistance. EWP is designed for installation of recovery measures. Activities include providing financial and technical assistance to remove debris from stream channels, road culverts, and bridges, reshape and protect eroded banks, correct damaged drainage facilities, establish cover on critically eroding lands, repair levees and structures, and repair conservation practices.	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/

Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
NRCS Floodplain Easement Program	The Emergency Watershed Protection - Floodplain Easement Program (EWP-FPE) provides an alternative measure to traditional EWP recovery, where it is determined that acquiring an easement in lieu of recovery measures is the more economical and prudent approach to reducing a threat to life or property. The easement area will be restored to the maximum extent practicable to its natural condition. Restoration utilizes structural and nonstructural practices to restore the flood storage and flow, erosion control, and improve the practical management of the easement. Floodplain easements restore, protect, maintain and enhance the functions of floodplains while conserving their natural values such as fish and wildlife habitat, water quality, flood water retention and ground water recharge. Structures, including buildings, within the floodplain easement must be demolished and removed, or relocated outside the 100-year floodplain or dam breach inundation area.	https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/programs/financial/ewp/?cid=stelprdb1244478
NRCS Healthy Forests Reserve Program	Helps landowners restore, enhance and protect forestland resources on private lands through easements and financial assistance.	http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html
U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant Program	The Community Development Block Grant (CDBG) program is a flexible program that works to ensure decent affordable housing, provide services to the most vulnerable in our communities, and create jobs through the expansion and retention of businesses. CDBG-financed projects could incorporate green infrastructure into their design and construction. The Disaster Relief Appropriations Act of 2013 (Pub. L. 113–2) allocated $5,400,000,000 of Community Development Block Grant disaster recovery (CDBG–DR) funds for the purpose of assisting recovery in the most impacted and distressed areas declared a major disaster due to Superstorm Sandy.	https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs

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Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
State Sources		
CT Department of Agriculture (CT DOAG) Farmland Restoration Program (FLRP)	The main objective of this voluntary program is to increase the State's resource base for food and fiber production agriculture focusing primarily on prime and important farmland soils.	http://www.ct.gov/doag/cwp/view.asp?a=3260&Q=498322
CTDEEP Section 319 Grant Program	Federal Clean Water Act Section 319 funds, administered by CTDEEP, are intended to effectively and efficiently address nonpoint source pollution are available to municipalities, nonprofit environmental organizations, regional water authorities/planning agencies, and watershed associations. Section 319 funds may be used for watershed based plans implementation projects, watershed based plan development, implementation of non-structural BMPs, and other related activities.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325594&deepNav_GID=1654
CTDEEP Connecticut Clean Water Fund	The Connecticut Clean Water Fund (CWF) is the state's environmental infrastructure assistance program. The fund was established in 1986 to provide financial assistance to municipalities for planning, design and construction of wastewater collection and treatment projects. This program was developed to replace state and federal grant programs that had existed since the 1950s. The 1987 amendments to the Federal Clean Water Act required that states establish a revolving loan program by 1989. The fund was modified in 1996 to include the Drinking Water State Revolving Fund (DWSRF) to assist water companies in complying with the Safe Drinking Water Act by providing low cost financing. The CWSRF currently includes set-asides or reserves categories for green infrastructure, river restoration and small community wastewater (including decentralized) systems.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325576&deepNav_GID=1654%20
Long Island Sound Study - Long Island Sound Research Grant Program	To support research that will enhance scientific understanding of Long Island Sound, and provide information needed by managers to protect and effectively manage the Sound and its valuable resources. Available to Connecticut academic institutions.	http://longislandsoundstudy.net/research-monitoring/lis-research-grant-program/

Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
CTDEEP Recreational Trails Grants Program	Since 2015, CTDEEP's recreational trails program has provided funding to non-profits, municipalities, state departments and tribal governments in support of trail construction and/or restoration projects, accessibility improvements, purchase of trail maintenance equipment, land acquisition, and educational programs. Requests should be under $1million, and a 20% match is required.	http://www.ct.gov/deep/cwp/view.asp?a=2707&q=513740&deepNav_GID=1650
CTDEEP Long Island Sound License Plate Program	Section 14-21e of the Connecticut General Statutes (CGS) authorizes the issuance of the Long Island Sound license plate by the Department of Motor Vehicles, while CGS Section 22a-27k establishes the Long Island Sound Fund to be administered by the Department of Energy and Environmental Protection into which proceeds from the sale of the plates are deposited.	http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635
CTDEEP Open Space and Watershed Land Acquisition	The Open Space and Watershed Land Acquisition (OSWA) Grant Program provides financial assistance to municipalities and nonprofit land conservation organizations to acquire land for open space and to water companies to acquire land to be classified as Class I or Class II water supply property.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641
CTDEEP Recreation and Natural Heritage Trust Program	The Recreation and Natural Heritage Trust program was created by the Legislature in 1986 in order to help preserve Connecticut's natural heritage. It is the CTDEEP's primary program for acquiring land to expand the state's system of parks, forests, wildlife, and other natural open spaces.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641
CTDEEP Urban Forestry Grant Programs	America the Beautiful Urban Forestry Grants: Grants of up to $12,000 are available to assist municipalities and non-profits in local urban forestry efforts. Urban Forestry Outreach Grant: Grants for non-profit organizations in urbanized areas to foster outreach in these areas.	http://www.ct.gov/dep/cwp/view.asp?a=2697&q=322872&depNav_GID=1631&depNav=|

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Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
Connecticut Institute for Resilience and Climate Adaptation (CIRCA) – Municipal Resilience Grant Program and Matching Funds Program	The Municipal Resilience Grant Program is for municipal governments and councils of government for initiatives that advance resilience, including the creation of conceptual design, construction (demonstration projects or other) of structures, or the design of practices and policies that increase their resilience to climate change and severe weather. The Matching Funds Grant Program is applicable to municipalities, institutions, universities, foundations, and other non-governmental organizations for matching funds for projects that address the mission of CIRCA. As of June 1, 2017, CIRCA is currently not accepting applications for the Municipal Resilience Grant Program or Matching Funds Program.	https://circa.uconn.edu/
CTDEEP Supplemental Environmental Project (SEP) Funds	In the settlement of an environmental enforcement case, CTDEEP will require the alleged violator to achieve and maintain compliance with State environmental laws and regulations and to pay a civil penalty. To further CTDEEP's goals to protect and enhance public health and the environment, in certain instances one or more environmentally beneficial projects, or Supplemental Environmental Projects, may be included in the settlement.	https://www.ct.gov/deep/lib/deep/enforcement/policies/seppolicy.pdf
CT Office of Policy and Management (OPM) Small Town Economic Assistance Program (STEAP)	Funds economic development, community conservation and quality of life projects for localities that are ineligible to receive Urban Action (CGS Section 4-66c) bonds. This program is administered by the Office of Policy and Management. STEAP funds are issued by the State Bond Commission and can only be used for capital projects. Eligible projects include projects involving environmental protection.	http://www.ct.gov/opm/cwp/view.asp?Q=382970
Connecticut In-Lieu Fee Program	The National Audubon Society, Inc., through its Connecticut program (Audubon Connecticut) is the sponsor of an In-Lieu Fee Program for aquatic resource compensatory mitigation required by Department of the Army authorizations. Audubon Connecticut administers a competitive grant funding program, soliciting proposals for wetland and waters restoration, enhancement, creation and/or preservation.	http://ct.audubon.org/conservation/in-lieu-fee-program http://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/CT/

Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
Other Sources		
Private Foundations	Connecticut Community Foundation, Southbury Community Trust Fund, Ion Bank Foundation, Thomaston Savings Bank Foundation, The Watertown Foundation, Argall Hull Foundation, Kresge Foundation	https://conncf.org/ https://ionbank.com/about-us/foundation/ https://www.thomastonsavingsbank.com/foundation https://www.watertownfoundation.com/ www.kresge.org/programs/environment
NOAA Community-Based Restoration Program Partnership	These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.	https://www.fisheries.noaa.gov/national/habitat-conservation/strategic-habitat-restoration
FishAmerica Foundation Conservation Grants	FishAmerica, in partnership with the NOAA Restoration Center, awards grants to local communities and government agencies to restore habitat for marine and anadromous fish species. Successful proposals have community-based restoration efforts with outreach to the local communities.	https://www.fishamerica.org/grants/
National Fish and Wildlife Foundation (NFWF) Five Star and Urban Waters Restoration Grant Program	The Five Star and Urban Waters Restoration Program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country.	http://www.nfwf.org/fivestar/Pages/home.aspx
NFWF Long Island Sound Futures Fund	The Long Island Sound Futures Fund supports projects in local communities that aim to protect and restore Long Island Sound. It unites federal and state agencies, foundations and corporations to achieve high-priority conservation objectives. Funded activities demonstrate a real, on-the-ground commitment to securing a healthy future for the Long Island Sound.	http://longislandsoundstudy.net/about/grants/lis-futures-fund/
National Forest Foundation	Through its on-the-ground conservation programs, the National Forest Foundation supports action-oriented projects that directly enhance the health and well-being of America's National Forests and Grasslands and that engage the public in stewardship.	https://www.nationalforests.org/grant-programs

Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Funding Source	Description	Reference
Corporate Wetlands Restoration Partnership (CWRP)	The Corporate Wetlands Restoration Partnership (CWRP) is an innovative private-public initiative aimed at preserving, restoring, enhancing and protecting aquatic habitats throughout the United States. Bringing together corporations, federal and state agencies, non-profit organizations and academia, the CWRP allows members to contribute in a fundamental way to crucial projects involving America's coastal and inland aquatic resources and support related education programs. Since its inception in 1999, CWRP has aided in the restoration of more than 64,000 acres and 1,050 stream miles through the monetary donations and in-kind services of its corporate partners.	http://www.cwrp.org/
Trout Unlimited Embrace A Stream	Embrace-A-Stream (EAS) is a matching grant program administered by TU that awards funds to TU chapters and councils for coldwater fisheries conservation.	http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream
Wildlife Conservation Society Climate Adaptation Fund	Provides $2.5 million in funding annually, with awards ranging from $50,000 to $250,000. The program focuses on projects that promote functionality of ecosystems, long-term conservation impact, and landscape-scale impacts. All projects must conduct on-the-ground implementation; research and planning are not funded.	https://www.wcsclimateadaptationfund.org/program-information/

Note: Some grant programs, particularly federally-funded grant programs, may not allow the use of funds for projects/actions that are required as part of State or federal permit or enforcement-related actions. For example, projects intended to meet mandated requirements of the MS4 General Permit are not eligible for Section 319 NPS grants. However, Section 319 NPS grant proposals that provide stormwater mitigation above and beyond permit requirements may be considered.

Pomperaug River Watershed Based Plan - Potential Funding Sources, Technical Assistance, and Other Resources

Grant Search Resources

Please also see the following grant search resources for assistance in finding additional state, federal, local, and private sources of funding related to nonpoint source pollution management:

- Grants.gov
  http://grants.gov/
- Federal Assistance Listings
  https://www.cfda.gov/
- CTDEEP Watershed and Stormwater Funding Website
  http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1
- EPA Funding Sources for Watershed Protection and Restoration
  https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration
- EPA Watershed Funding
  http://water.epa.gov/aboutow/owow/funding.cfm
- EPA Water Infrastructure and Community Resiliency Finance Center
  https://www.epa.gov/waterfinancecenter
- EPA Green Infrastructure Funding Website
  https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities
- Foundation Center: Philanthropy News Digest
  http://philanthropynewsdigest.org/rfps/(search)/?tags_interest[]=environment
- USDA National Agriculture Library: Water Quality Information Center
  https://www.nal.usda.gov/waic/water-quality#quicktabs-waic_water_quality=2

Other Nonpoint Source Funding Opportunities

Congressional Appropriation - Direct Federal Funding
State Appropriations - Direct State Funding
Membership Drives Membership drives can provide a stable source of income to support watershed management programs.
Donations Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of ways.
User Fees, Taxes, and Assessments Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.
Rates and Charges State law authorizes some public utilities to collect rates and charges for the services they provide.
Stormwater Utility A stormwater utility operates much like an electric or drinking water utility. Fees collected from property owners go into a dedicated fund to pay specifically for the work of operating, maintaining, and improving stormwater infrastructure.
Impact Fees Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.
Special Assessments Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.
Property Tax These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.

Other Nonpoint Source Funding Opportunities

Excise Taxes These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.
Bonds and Loans Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects. **Green Bonds** are a growing mechanism for funding green projects, including green infrastructure and flood resilience projects. Green bonds are debt instruments issued to finance environmental projects focused on climate change initiatives. The identification and labeling of a green bond is typically based on a set of voluntary standards drafted by a consortium of investment banks that outlines the process for issuers to designate specific green projects. The guidelines specify that a bond issue qualifies as green if the issuer uses the proceeds solely for capital expenditures associated with green or climate-related environmental benefits in accordance with certain standards.
Investment Income Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.
Emerging Opportunities for Program Support for Water Quality Trading Allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.
Mitigation and Conservation Banks Created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the "bankers" get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.

Other Nonpoint Source Funding Opportunities

Public Private Partnerships (P3s)

Innovative financing mechanisms are being explored at the national level, particularly tapping into the resources of the private sector through public–private partnerships (P3s). Traditionally, water and wastewater infrastructure has been funded through municipal bonds, with help from EPA State Revolving Loan funds, while stormwater is typically funded either through its limited share of local general funds or stormwater utilities. The Chesapeake Bay states are exploring P3s to meet TMDL obligations for nutrients and sediment. A P3 is an arrangement between government and the private sector in which the private sector assumes a large share of the risk in terms of financing, constructing, and maintaining the infrastructure. Government repays the private sector over the long term if the infrastructure is built and maintained according to specifications. Prince George's County, Maryland is implementing a P3 program to retrofit 2,000 acres of impervious surfaces in the public right of way. Private funds will finance 30% to 40% of the program costs upfront, enabling project construction to begin sooner and proceed more quickly. This program is part of the County's Watershed Protection and Restoration Program.