Rippowam/Mill River Watershed Study Annual Report

Introduction

During 2010, the City of Stamford has completed or partially completed plans to transform the Rippowam/Mill River corridor in the downtown area of the city into a world class urban space. Three projects are in various stages that will significantly promote those plans.

1. The US Army Corps of Engineers (USACE) removed the Main Street Dam in downtown Stamford and is completing the restoration the of over five miles of river and its shoreline to a more natural state

2. The Olin Partnership completed designs for the Mill River Park and Greenway Master Plan, which will create a premier urban park on the riverbanks, encompassing the USACE restoration project and other elements of the greenway in the downtown section of the river corridor.

The EPA STAG grant is funding the Rippowam/Mill River Watershed Management and Infrastructure Program (hereafter referred to as the Rippowam/Mill River Watershed Study) which is being conducted by CDM for Stamford Water Pollution Control Authority (SWPCA), and will provide the city the means to expand and improve on the significant work being performed in the downtown area by extending the study area to the entire watershed within the Stamford corporate boundaries.

The following provides a background of the project area, summary of scope of work for the Rippowam/Mill River Watershed Study, the status of the various tasks based on the work that has been completed to date, and deliverables to date.

Attached is the Comprehensive Characterization Report which details and documents all of the sampling and testing and interpretation of the results.

Project Background

The Rippowam/Mill River originates in southern New York State and western Connecticut and flows south through the City of Stamford, discharging into the waters of Long Island Sound. Figure 1 shows the Mill River watershed study area. The Rippowam/Mill River watershed covers a large portion of the City of Stamford, extending north into the bordering town of New Canaan, CT, New York State, and into Ridgefield, CT. The complete watershed area is approximately 37.5 square miles; approximately 18 square miles are within the City of Stamford. There are two major reservoirs within the upper portion of the study area, the Laurel Reservoir at 282 feet above mean sea level (ft-msl) and the North Stamford Reservoir at 194 ft-msl, both of which are impoundments of the Rippowam River. Four major tributaries are located within the study area downstream of the North Stamford Reservoir Dam – Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook. Two other major tributary flows are culverted discharges to the river – Toilsome Brook and the Washington Boulevard drain, which discharges at the Mill River Dam.

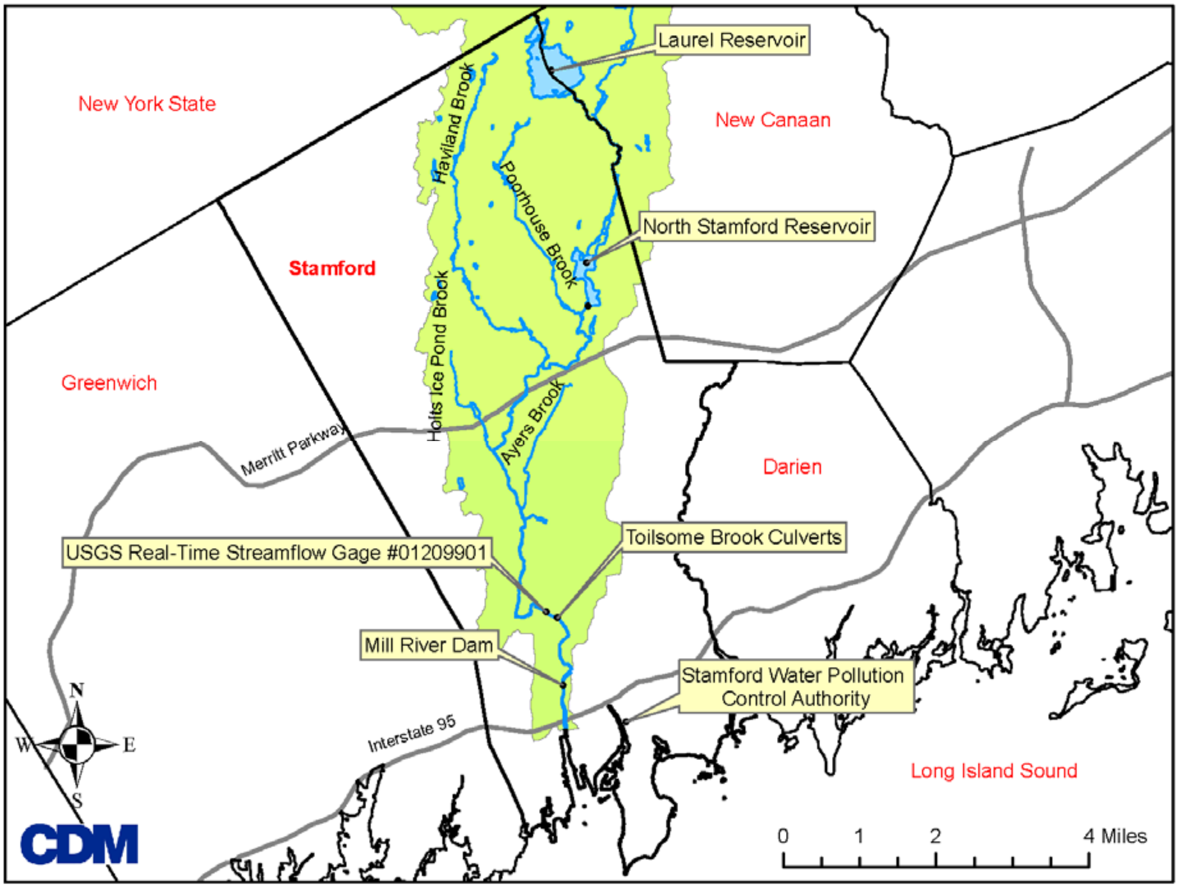
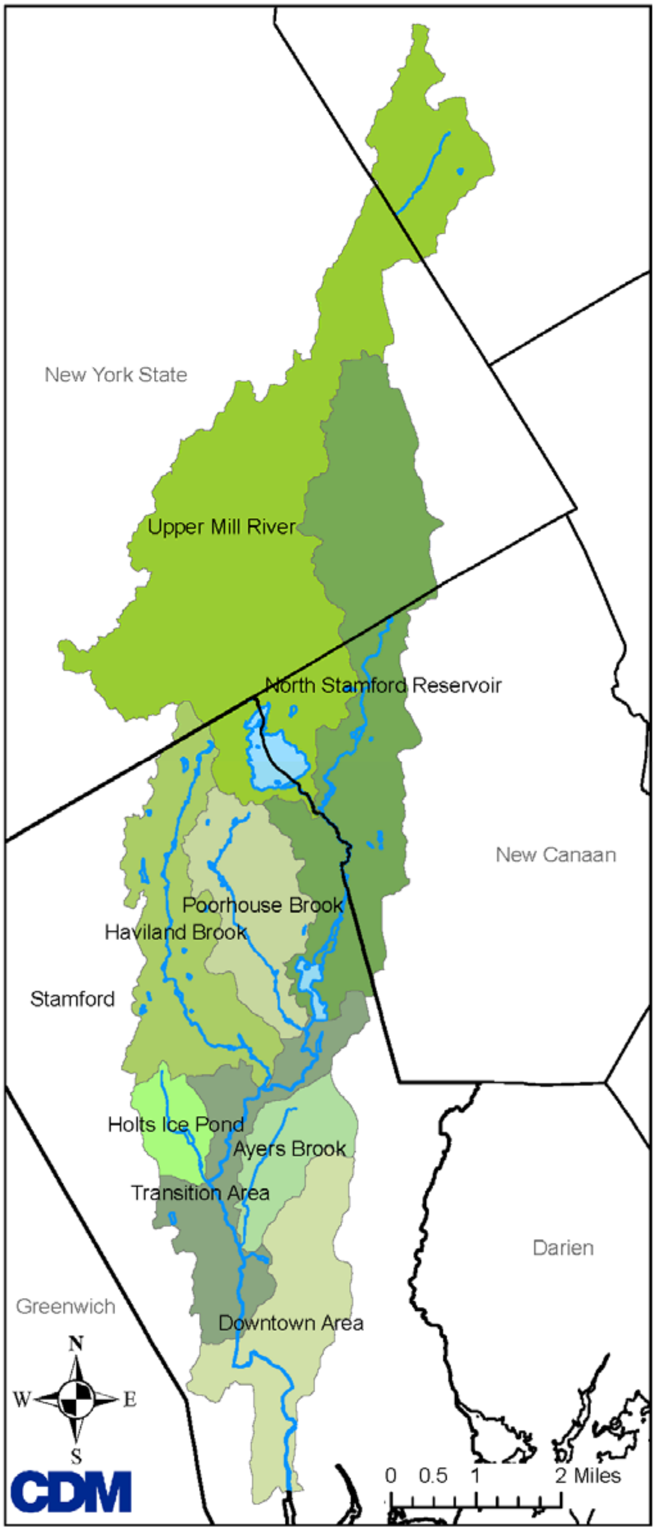


Figure 1: Mill River Watershed Study Area



From north to south, the watershed transitions from primarily forested 1-2 acre lots and detached single-family dwellings in North Stamford to a more developed, urban landscape as the river flows toward downtown Stamford and the Stamford Harbor. Some of the land surrounding the North Stamford Reservoir, which is located eight miles upstream of the harbor, is protected under the ownership of Aquarion Water Company. The Aquarion Water Company releases water from the North Stamford Dam to meet the minimum instream flow requirement at about 4 cubic feet per second, and water discharges over the reservoir spillway when the water level is high.

Downstream of the reservoir, the Rippowam/Mill River flows through a residential area and remnants of forested land. Residential lawns line the river as it passes under several road crossings and meets with Poorhouse Brook and Haviland Brook. Before entering the mainstem Mill River, Poorhouse Brook flows through the Bartlett Arboretum Historic Preserve and Stamford Museum and Nature Center, approximately 200 acres of the watershed remaining protected from development. Notable in-stream features in this

Figure 2: Rippowam/Mill River Study Area Subbasins

reach of the river are the several low-head dams that impound the mainstem and tributaries. Six of these mainstem dams are reported and mapped, however more have been identified through field reconnaissance as part of the Mill River Watershed Study.

The watershed becomes increasingly developed south of the Merritt Parkway, where industrial and residential complexes and parking lots abut the river more frequently. At Cold Spring Road, land use abutting the river changes from mostly single-family residences to low-rise apartment complexes. Evidence of invasive species, household debris, and direct stormwater runoff from parking lots and roadways can be seen in lower reaches of the river. Toilsome Brook, an historic tributary that is now culverted and consists mainly of urban runoff, enters the mainstem at Scalzi Park, approximately two miles upstream of Stamford Harbor.

The Rippowam/Mill River was impounded by the Main Street Dam in downtown Stamford and lined with vertical concrete walls on both banks. The USACE recently removed the Main Street Dam and is currently completing the restoration of Mill Pond to a more natural stream. This portion of the watershed is highly urban, with a majority of impervious surfaces that contribute runoff directly to the river or to the storm drain network. Mill River Park lines the river on both sides just upstream of the dam and is the largest park in downtown Stamford. A multi-story housing development also abuts the river on the southeastern portion of Mill Pond and the dam.

The river becomes tidal about 900 feet downstream of the location of the old Main Street Dam; the South Arm of the Stamford Harbor has a mean tidal range of 7.2 feet. The watershed for this reach is a combination of residential, industrial, commercial, and city-owned parkland. Several road bridges, including the Interstate 95 Highway and a railroad bridge, span the river downstream of the Main Street Dam. The banks of the river are largely inaccessible downstream of the dam.

Project Scope of Work and Status

The scope of work for this project was divided into two phases: Phase 1 – Comprehensive Management Planning and Phase 2 – Basin Management Planning, consisting of five tasks as described in CDM's scope of work dated April 10, 2008. The majority of Phase I tasks are complete and the basin management plan is well underway. The following summarizes the five tasks and the completed tasks, as well as the deliverables associated with each task.

Phase 1 – Comprehensive Management Planning

Task1 – Reconnaissance, Data Collection and Gap Analysis

All of the tasks under Task 1 are complete including research and compilation of existing data, identification of data gaps, and updates to the City's GIS database. The deliverables associated with this task included:

- Technical memorandum summarizing the existing data.

- White Paper summarizing case studies on urban watershed restoration projects and landmark watershed studies.

- Technical memorandum that summarized available GIS data (final data transfer to occur with transmittal of basin management plan).

- Technical memorandum summarizing the findings of the windshield survey of the watershed.

Task 2 – Preliminary Goals and Problem Statement

Task 2 was completed and included conducting project Advisory Committee meetings, Working Group meetings, and early stages of public outreach activities, including other stakeholder (e.g. neighborhood groups) meetings. The outcome of this task is a list of goals and objectives for the basin management plan that was compiled using feedback obtained from the various levels of project stakeholders.

Task 3 – Monitoring and Assessment

This task included preparation of a project specific Field Sampling Plan (FSP) to perform a field monitoring program that included:

- **Stormwater Outfalls** – were sampled during dry weather on May 6 and September 2, 2009.

- **Dry Weather Flow and Water Quality Sampling** – four full dry-weather sampling rounds were conducted in November 2008, January 2009, May 2009 and August 2009; and two partial dry-weather rounds were conducted in July 2008 and August 2009.

- **Wet Weather Flow and Water Quality Sampling** – two rounds of wet weather sampling was conducted in June and October 2009

- **Sediment Sampling** – occurred on May 6, May 13, May 14 and September 22, 2009.

- **Physical Stream Characteristics Assessment** – occurred on April 4 – 5, April 15 – 17, and May 18-21, 2009.

- **Ecological Conditions Assessment** – occurred on May 18-20, 2009.

The monitoring and assessment of the watershed has been completed and the following deliverables were developed as part of this task to perform the assessment and summarize the results: Field Sampling Plan, Field Safety Plan, and Comprehensive Characterization Report. The final electronic data transfer will occur with transmittal of the Basin Management Plan.

Task 4 – Modeling and Analyses

Task 4 includes model development, verification/calibration of the models and utilization of the models to simulate various alternatives. Models include the following: HEC-RAS hydraulic model, HSPF hydrologic model and WMM pollutant loading model for the Rippowam/Mill River watershed. These models are currently being used to evaluate various stormwater best management practices (BMPs) to treat runoff and improve water quality within the Mill River, as well as other watershed management measures.

Phase 2 – Basin Management Planning

Task 1 – Basin Management Plan

This task is underway, with anticipated completion by September 2011. Completed tasks include: preliminary framework for the plan research and planning for the Basin Management Plan, problem statement development, and draft list of components for alternatives based on review of all project deliverables. Active tasks include performing the evaluation of BMPs to treat the pollutants of concern, and evaluation of other watershed management measures. The results from these subtasks will be summarized in the Basin Management Plan.

Project Meetings and Coordination

The following meetings, workshops and public coordination efforts have taken place throughout the project duration:

- Monthly progress meetings were held with SWPCA on the following dates:

2008	April 21, July 31, November 7 and December 2
2009	January 9, February 3, March 3, April 7, May 6, June 2, July 23, August 4, September 1, October 8, November 3 and December 2
2010	January 12, February 9 and April 6
2011	April 25

- The initial coordination meeting with the project team was held on April 21, 2008.
- A coordination and fact finding meeting was conducted with the US Army Corps of Engineers and the Mill River Collaborative on May 6, 2008.
- The project kick off meeting with the Advisory Committee was held on July 31, 2008.
- A project briefing meeting to neighborhood groups was also held on July 31, 2008 to introduce the project to the public.
- Coordination meeting with SWPCA and other interested parties on March 9, 2009 to provide overall program update, including summary of monitoring program results, update on modeling and next steps in the project.
- An Advisory Committee meeting was held on March 16, 2009.

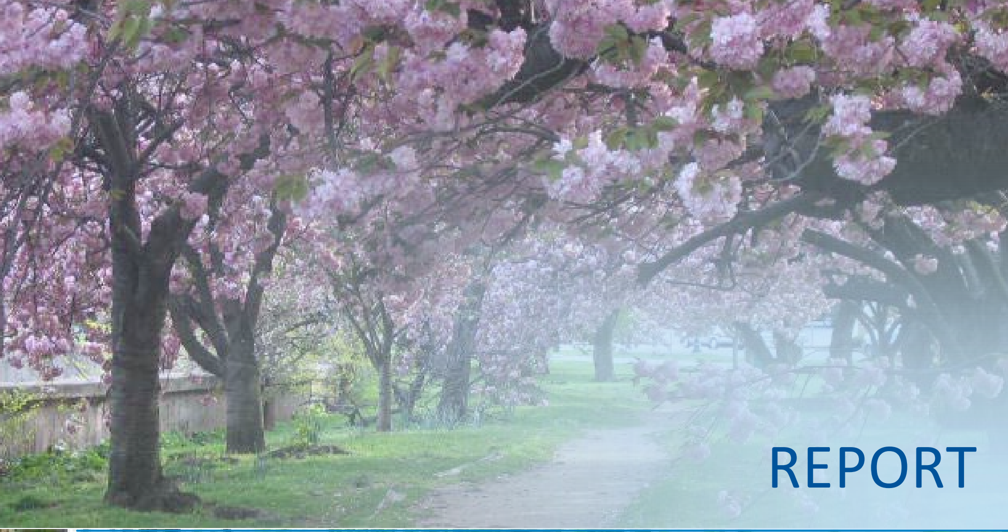
- Participated in the Stamford Sustainable Garden Expo, held on May 28, 2009.
- A Working Group meeting was held on June 25, 2009 at SWPCA.
- A public workshop was held on November 12, 2009 to solicit public input on issues and goals for the project.
- Attended Long Island Sound Study alewife fish release to the Rippowam River at Cloonan Middle School on April 20, 2010.
- A project planning session was held on April 20, 2010 with the project team.
- Attended LISS Green Cities/Blue Waters Citizens Summit on May 7, 2010 in Bridgeport.
- A project status meeting was held on April 25, 2011 with SWPCA and city staff.

Project Deliverables

The following reports and documents have been developed as part of this project in order to summarize the results of the various tasks described above.

Field Sampling Plan	November 4, 2008
Technical Memorandum – Project GIS Data	January 16, 2009
Technical Memorandum – Existing Conditions	February 3, 2009
White Paper of Urban Watershed Restoration/Revitalization	March 12, 2009
Working Group Meeting PowerPoint Presentation	June 24, 2009
Technical Memorandum – Windshield Survey	December 8, 2009
Draft Comprehensive Characterization Report	January 2010
Comprehensive Characterization Report A	

Jeanette A. Brown



REPORT

Comprehensive Characterization Report

Rippowam/Mill River Watershed Management and Infrastructure Program

City of Stamford, Connecticut

April 19, 2011

CDM

Rippowam/Mill River Watershed Management and Infrastructure Program Study
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Section 1
Introduction

1.1 Study Overview

The City of Stamford has been advancing plans to transform the Rippowam/Mill River corridor in the downtown area of the city into a world class urban space. Two projects have recently been completed that will significantly promote those plans. First, the US Army Corps of Engineers (USACE) has finalized its design and started construction of the removal of the Rippowam/Mill River dam and the restoration of over five miles of the river and its shoreline to a more natural state. Secondly, the Olin Partnership completed designs for the Mill River Park and Greenway Master Plan, which will create a premier urban park on the riverbanks, encompassing the USACE restoration project and other elements of the greenway in the downtown section of the river corridor. This study, the Rippowam/Mill River Watershed Management and Infrastructure Program (hereafter referred to as the Mill River Watershed Program), will provide the city the means to expand and improve on the significant work being performed in the downtown area by extending the study area to the entire watershed within the Stamford corporate boundaries.

Phase I of the Mill River Watershed Program includes conducting multi-faceted water quality and ecological monitoring aimed at establishing baseline conditions in the river and river corridor. The data collected during the monitoring program will be used as the technical basis of modeling of the watershed and development of a comprehensive basin management plan to improve the water quality and flows in the river. Data collection plays a key role in understanding the problems and opportunities in the river and watershed, and in identifying the most cost-effective solutions. The surface water quality and flow data collected during the field programs will be used to develop simulation models of the Rippowam/Mill River.

Monitoring and modeling efforts in Phase I were designed to improve the understanding of the water quality and stream flows of the river during wet-weather and dry-weather conditions, as well as ecological conditions in the river. In Phase II of the study, a basin management plan will be developed, which will establish an initial set of actions to improve the water quality, structure and ecological function of the Rippowam/Mill River and its watershed. The understanding of the behavior of the watershed achieved in Phase I will be used to identify implementable alternatives for watershed restoration efforts to be considered for the basin management plan.

Study Area

The Rippowam/Mill River[1] originates in southern New York State and western Connecticut, and flows south through the City of Stamford, discharging into the water of Long Island Sound.

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[1] There is no spatial distinction between the names "Rippowam River" and "Mill River"; therefore to maintain consistency, the study reach will hereafter be referred to as the Mill River.

The Mill River watershed covers a large portion of the City of Stamford, extending into the bordering town of New Canaan, CT and into New York. The complete watershed area is approximately 37.5 square miles, with approximately 18 square miles within the City of Stamford.

For the purposes of the monitoring program, the study area was defined as the mainstem portion of the Mill River and its major tributaries within the City of Stamford from the New York State line to the mouth of the river in Long Island Sound. The study area is depicted in **Figure 1-1**. There are two major reservoirs within the upper portion of the study area, the Laurel Reservoir and the North Stamford Reservoir, which are impoundments of the Mill River. Water resources of these reservoirs are managed and operated by the Aquarion Water Company for water supply. As a result, the focus of this study will be the portion of the Mill River corridor downstream of the North Stamford Dam.

Land uses within the Mill River watershed are urban and suburban. Much of the Mill River watershed is highly developed and urbanized, resulting in high wet-weather flows and impaired water quality during dry-weather conditions. In 2002, the Mill River was added to the "Impaired Waters List" by the CT DEP according to the requirements of Section 303(d) of the Federal Clean Water Act (CT DEP 1998 and 2002). Land use within the watershed north of the Merritt Parkway is primarily suburban. There are a number of small, low-head dams (less than 2 feet) creating numerous small impoundments of the river and its tributaries. Most of the homes in the watershed north of the Merritt Parkway have onsite wastewater disposal (septic systems). In contrast, the land use south of the Merritt Parkway is densely suburban and urban, with the most highly urban and industrialized areas located near downtown Stamford. Many tributaries of the Mill River are contained in culverts and function primarily for stormwater drainage.

Four major tributaries are located within the study area downstream of the North Stamford Dam. These are the Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook. Two other major tributary flows are culverted discharges to the river: Toilsome Brook culverts near Scalzi Park and Washington Boulevard drain that empties into the Mill River. Impacts of the major tributary sub-watersheds on the Mill River have been evaluated as part of this field sampling program by collection of water quality samples at the mouths of these key tributaries and stormwater outfalls.

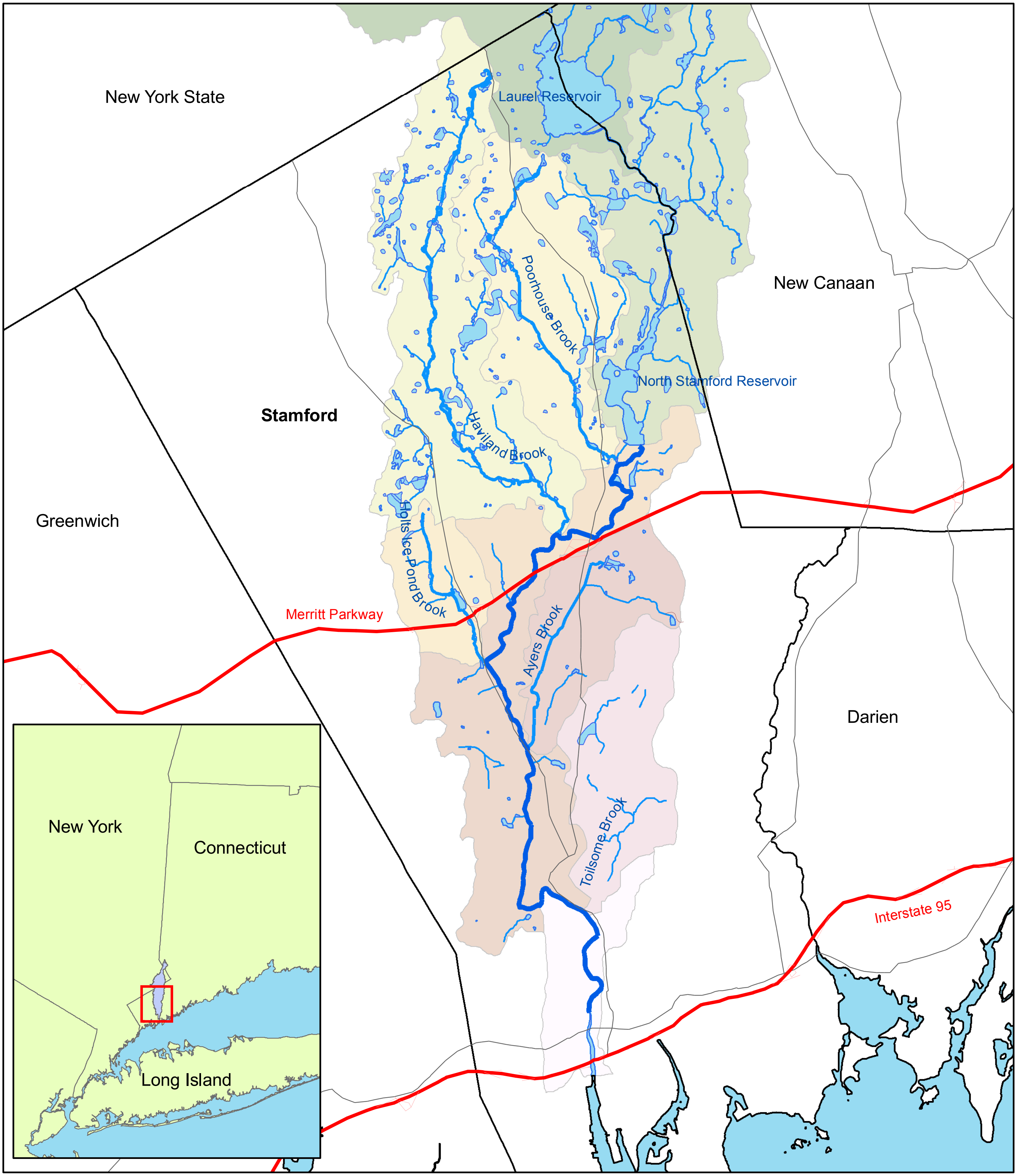
1.2 Monitoring Program Overview

This report presents and summarizes the data collected between July 2008 and December 2009 as part of the Mill River Watershed Program. The objectives of the monitoring program are as follows:

- Collect water quality, flow and ecological data to gain an understanding of the river system under various conditions (various seasons and dry and wet weather)
- Provide input for the simulation models, which will provide an assessment of baseline conditions and will be used to evaluate alternatives for river and watershed improvements.

Phase I monitoring includes site reconnaissance and gathering of existing data from the watershed, identification of data gaps, and conducting the following sampling events:

- 4 rounds of wet-weather water quality sampling (1 round per season)
- 4 rounds of dry-weather water quality sampling (1 round per season)
- 2 rounds of partial (*in situ* only) dry-weather water quality measurements



Watershed and River Study Area
Mill River Watershed Study

Subbasins

- Laurel Reservoir
- North Stamford Reservoir
- Haviland Brook
- Poorhouse Brook
- Holts Ice Pond
- Direct Drainage - Upper
- Direct Drainage - Middle
- Ayers Brook
- Toilsome Brook
- Direct Drainage - Lower

1 inch equals 1 miles

Figure 1-1

- 1 round of sediment sampling representative of each geomorphic reach
- Stream geomorphology study (geomorphic assessment)
- Ecological assessment (benthic macroinvertebrate survey) and physical habitat study
- Flow monitoring at tributary locations and major storm water outfalls

1.2.1 Diversions from Program Plan

Wet Weather Sampling

Two rounds of wet weather sampling were conducted, in June and October 2009. Four rounds were originally planned for, but weather conditions and laboratory restrictions limited the number of wet weather events.

Sediment Sampling

Sediment sampling locations were identified during the river walk and geomorphological survey. Due to scheduling of other field activities, sampling at each of the locations was done on three separate dates in May and September 2009.

1.2.2 Quality Assurance

The quality assurance provisions for this monitoring program are specified in the Quality Assurance Project Plan (QAPP), dated December 2008. The quality assurance program included field and equipment blanks, sample duplicates, and data validation and evaluation. With few exceptions, the data collected and presented in this report are deemed acceptable for use with respect to the stated program objectives.

Data that did not satisfy quality assurance requirements were flagged as specified in the QAPP. The majority of the data is usable, and can be used to calibrate and validate the simulation models being developed under separate task orders, and to help determine relative likelihood that the river satisfies state water quality standards.

Based on a review of the data quality, the collected water quality and streamflow data appears to be of sufficient quality to meet the monitoring programs objectives.

1.3 Data Transfer to Stamford WPCA

Following completion of this study, the City will be provided with an electronic access database and GIS layers containing all relevant information for reference.

Section 2
River Walk

2.1 Overview of River Walk

The entire river corridor included in the study was walked by a field team. An inventory of generalized geomorphic characteristics was conducted using Vermont Agency of Natural Resources Rapid Stream Assessment field protocols (VT ANR, May 2007). This inventory outlined anomalies in the channel form and function, and provided information on each reach to determine a representative segment for a more detailed study, including a physical habitat assessment and benthic macroinvertebrate survey. One representative segment was selected for each of the 15 reaches of the river corridor. These representative segments were measured in longitudinal profile and cross-section, which allowed for evaluation of fundamental channel form components.

In addition to surveying the geomorphic characteristics of the river, the field crew identified human impacts to the river and river corridor. This included identifying areas of bank armoring, locating in-stream structures, measuring over stream structures (bridges and culverts), locating water intakes, collecting qualitative observations on a sample of stormwater outfalls, and identifying outfalls with dry weather flow.

2.2 Results and Findings

The main stem of the Mill River has been significantly altered throughout the area covered by the river walk. In general, the river corridor is less developed in the upper portion of the study area with increased development moving downstream, as shown in the photographs presented in **Appendix A**.

The following primary observations were made during the river walk:

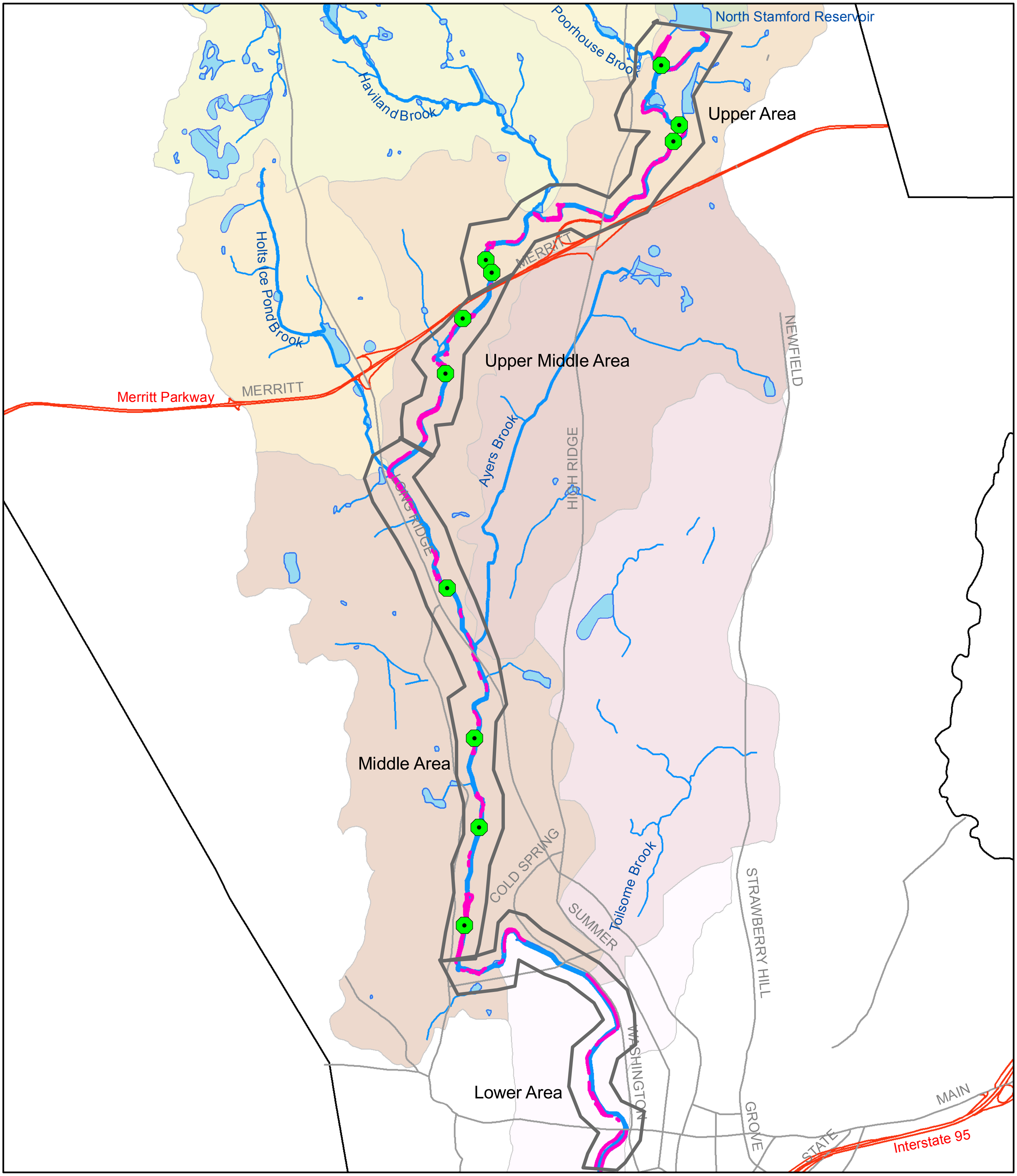
- The river along the study reach appears to be in a state of disequilibrium.
    - *Much of the banks are armored (see Figure 2-1, approximately 60% of the river is armored on at least one side) or has evidence of erosion.*
    - *In many places, the river is disconnected from its floodplain, mostly due to bank armoring and development up to the river bank, resulting in a very rectangular and wide river bed.*
    - *The channel bed consists primarily of sand and gravel/boulders with very little fine materials; there are channel bars in several locations, a sign that the river is out of equilibrium and that sediment transport is occurring.*
- There are many structures in the river, many of which are legacy structures that are no longer functional (many small dams, a number of which are breached).

- The stream channel has been modified in many places with diversions and constrictions, and even in areas that are more pristine, significant landscaping has altered the river and its floodplain.
- A total of 11 water withdrawal points were noted along the study reach, some were significant and others were private use intakes. These withdrawals may be minor during wet months but could have a significant effect on flow conditions during dry and summer months (see **Figure 2-1**).
- The river exhibits evidence of being very flashy with reduced low flows and increased high flows as a result of development and water withdrawals.
- Evidence was noted of the gradual change in land use with time from agricultural to residential.
- Periphyton and attached growth were observed in many places.
- The riverine habitat varies from North to South, degrading as you travel downstream. A night heron and nest was observed just above the Merritt and local residents reported the presence of river otters. In the lower portion of the study reach, habitat is degraded. There are many invasive plant species and there is very little to no natural river bank, with concrete retaining walls constraining the river.
- Litter and trash were not prevalent, except in the lower portion of the watershed. However, leaves and grass clippings in the river were observed throughout the study reach.

Based on the river walk findings and other assessments to date, land use and level of development, as well as restoration opportunities, the Mill River was broken down into the following four segments:

- Upper area – from the North Stamford Reservoir outlet to the Merritt Parkway
- Upper middle area – from the Merritt Parkway down to the GE Money Facility (ending approximately 1,000 feet above the Holts Ice Pond Brook confluence)
- Middle area – from the GE Money Facility to Cold Spring Road
- Lower area – from Cold Spring Road to Stamford Harbor

Figure 2-1 on the following page shows observation locations covered during the river walk, identifying river segments, bank armoring and water intakes.



River Walk Observations
Mill River Watershed Study

- Mill River
- Bank Armoring
- Water Intake
- Segmentation based on river walk findings

1 inch equals 1 miles

Subbasins

- Laurel Reservoir
- North Stamford Reservoir
- Haviland Brook
- Poorhouse Brook
- Holts Ice Pond
- Direct Drainage - Upper
- Direct Drainage - Middle
- Ayers Brook
- Toilsome Brook
- Direct Drainage - Lower

CDM

Figure 2-1

Section 3
Water Quality Sampling

3.1 Overview of Water Quality Sampling Program

The water quality monitoring program consisted of the following:

Dry Weather Sampling:

- Four full sampling rounds with one round collected at each season: Fall (November) 2008, Winter (January) 2009, Spring (May) 2009 and Summer (August) 2009; and ‘
- Two partial rounds with one each collected in Summer (July) 2008 and Summer (August) 2009

Wet Weather Sampling:

- Two rounds of wet weather sampling collected in June and October 2009.

Twelve sample sites were located on the mainstem Mill River, between the New York State line and the Interstate-95 crossing where the stream flows into Stamford Harbor. Samples were also taken from six major tributaries to the mainstem: Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, Ayers Brook, Toilsome Brook (culverts), and the drain from the downtown area that discharges to the former Mill Pond. The eighteen sampling locations are shown on **Figure 3-1.**

3.2 Dry Weather Sampling Events

Dry weather water quality sampling was performed to gain an understanding of baseline conditions in the mainstem Mill River and all major tributaries during periods of dry weather flow. Dry weather water quality data collection provides an understanding of the problems and opportunities in the river and watershed as well as a basis for identification of cost effective solutions.

One full dry weather survey was performed during each season over the course of one year. Dry weather sampling events were selected to represent conditions of each season. In addition to these four full dry weather surveys, two partial dry weather surveys were performed for added overall understanding of the dissolved oxygen dynamics within the system during summer months. These water quality surveys in conjunction with streamflow data are used in model development and ultimately in the formulation of a comprehensive basin management plan to improve the water quality and flows in the river.

3.2.1 Description of Events

Field teams collected water samples and measured water quality parameters during dry weather conditions on six different occasions from Summer 2008 through Fall 2009. All water samples were taken as grab samples according to the procedures detailed in the Field Sampling Plan. Sampling teams waded to the center of the stream to sample where possible, otherwise

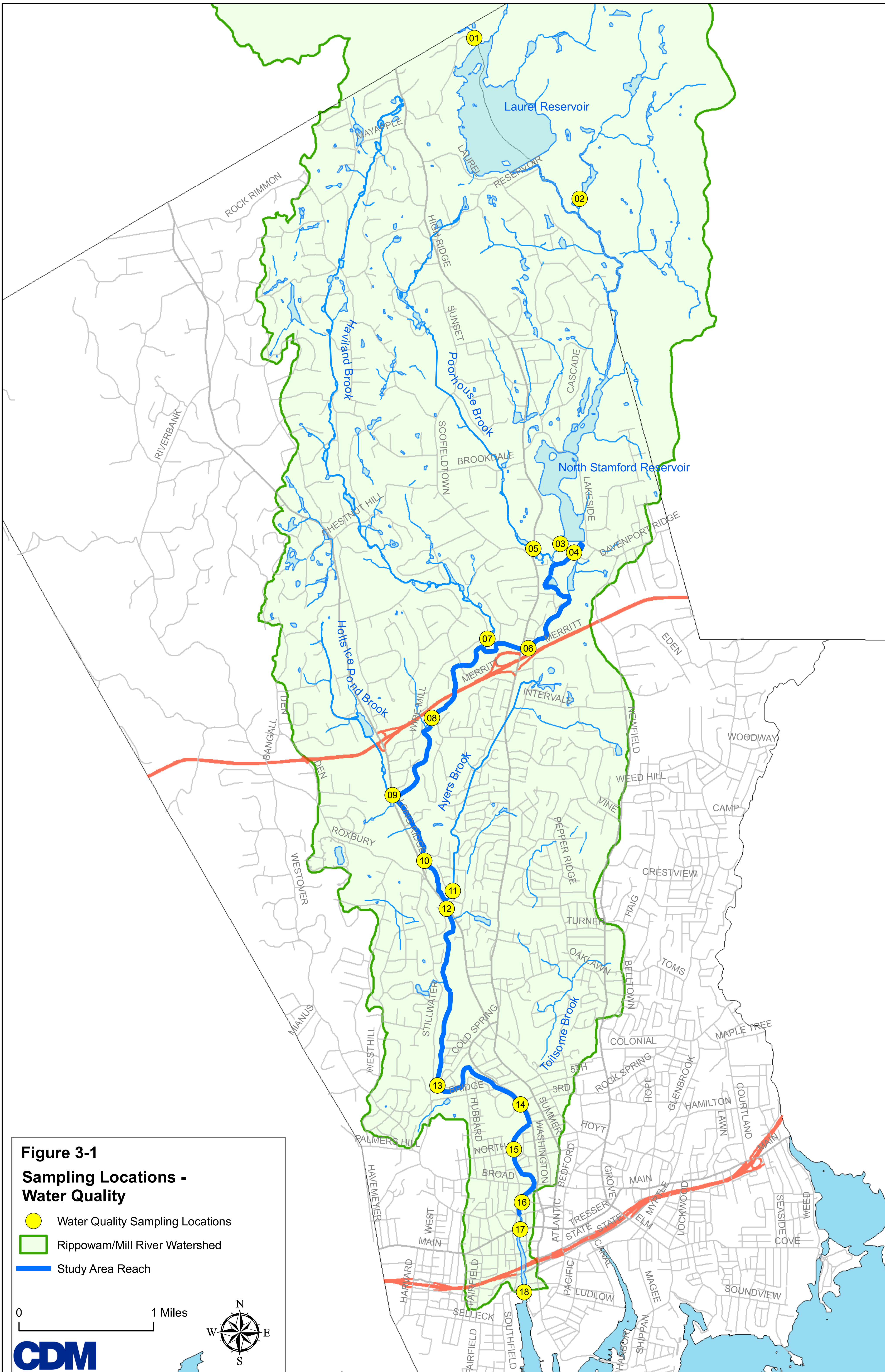


Figure 3-1

Sampling Locations - Water Quality

lowering a decontaminated sampling container from a bridge or down into a culvert at the sampling location. Following is a detailed description of each dry weather sampling event, in chronological order.

Partial Dry Weather Event #1

During this event, which took place from July 30-31, 2008, field teams visited the water quality sampling locations and measured *in situ* parameters in the river, including dissolved oxygen, temperature, pH, and conductivity. The field conditions were dry and sunny, with temperatures ranging from 65-80°F. A total of 0.08" of rainfall was recorded at the Stamford WPCA rain gage in the 72 hours preceding the event. The USGS river gage recorded an average daily flow of 4.1 cfs during the time the water quality measurements were made. No samples were collected during this partial dry weather event. A YSI 556 MPS meter was used to take measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes.

Sampling stations near the Stamford Harbor (17 and 18) are periodically influenced by tidal influx. The plot **Figure 3-2** below shows the tidal record for the Stamford Harbor on July 30-31 with annotation to show approximately when field teams visited stations 17 and 18.

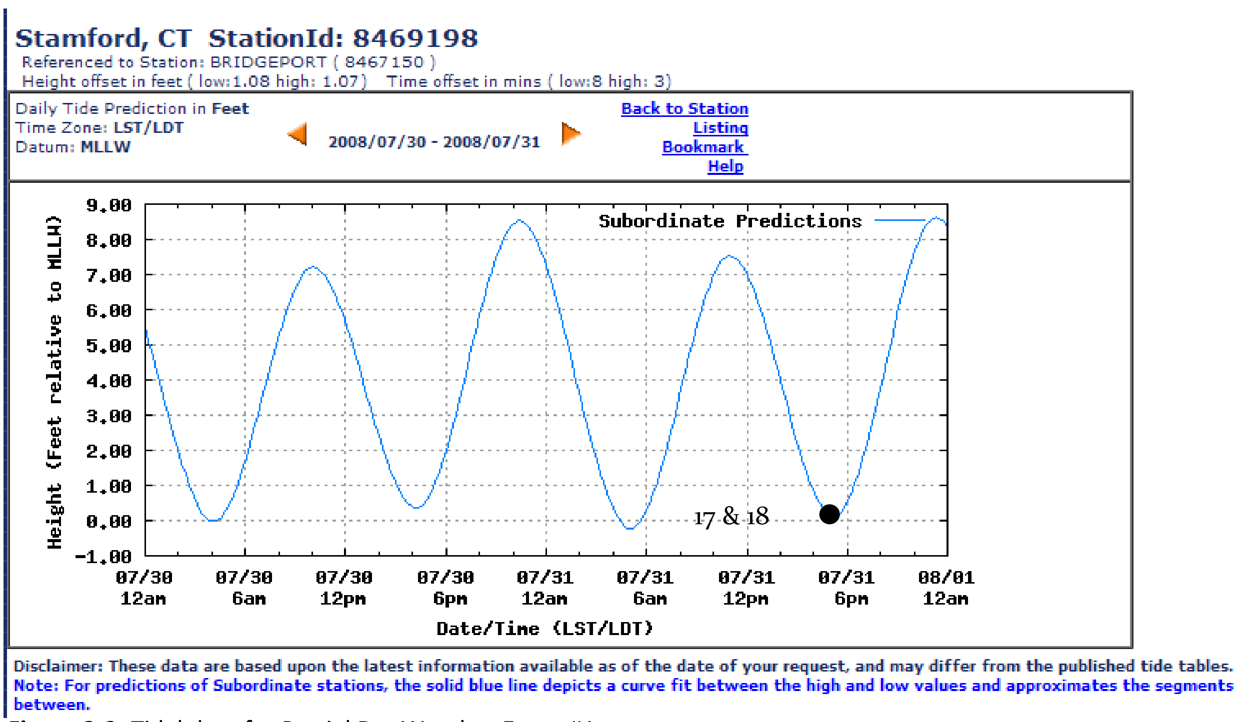


Figure 3-2: Tidal data for Partial Dry Weather Event #1

Dry Weather Event #1

The first full dry weather sampling event occurred on November 24, 2008. Field teams visited each of the predetermined 18 sampling locations to collect water samples for analysis and record *in situ* parameters. Water samples were transported by field teams to the Stamford WPCA lab for analysis or distribution to contracted laboratories. Bottles were filled for analyses as shown in **Table 3-1** on the following page.

The field conditions were dry and sunny, 20-30°F, and no rainfall was recorded at the Stamford WPCA gage in the preceding 72 hours. The USGS river gage recorded an average daily flow of 18 cfs during this event. A YSI 556 MPS meter was used to make the *in situ* measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank and sent both samples to the laboratory with the river water samples. Two field duplicates were collected between stations 09 and 17.

Table 3-1: Analyses performed for Dry Weather Event #1

Analyte	Laboratory
Chlorophyll-a	▪ SMAST
Particulate carbon and nitrogen	▪ SMAST
Total phosphorus	▪ SMAST
Nutrients	▪ SMAST
Soluble TKN and orthophosphates	▪ Phoenix
Nutrients	▪ Phoenix
Metals and hardness	▪ Phoenix
BOD and COD	▪ Stamford WPCA
Solids and alkalinity	▪ Stamford WPCA
Bacteria (x2 sterile bags)	▪ Stamford WPCA

Sampling stations near the Stamford Harbor (17 and 18) are periodically influenced by tidal influx. The plot **Figure 3-3** below shows the tidal record for the Stamford Harbor on November 24 with annotation to show approximately when field teams visited stations 17 and 18.

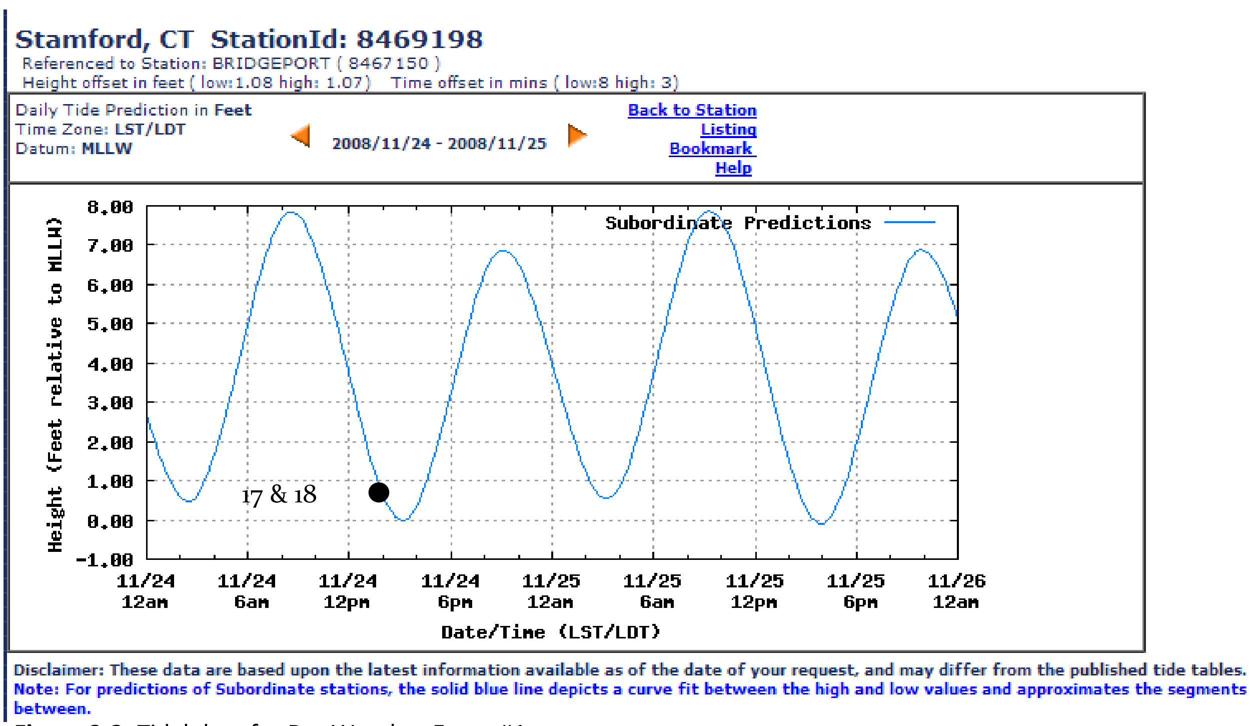


Figure 3-3: Tidal data for Dry Weather Event #1

Dry Weather Event #2

The second dry weather sampling event was conducted on January 20, 2009. Field teams returned to each of the 18 sampling locations to collect water samples for analysis and record *in situ* parameters. Samples were transported by field teams to the Stamford WPCA lab for analysis or distribution to contracted laboratories. Bottles were filled for analyses as shown in **Table 3-2**.

Table 3-2: Analyses performed for Dry Weather Event #2

Analyte	Laboratory
Chlorophyll-a	▪ SMAST
Particulate carbon and nitrogen	▪ SMAST
Total phosphorus	▪ SMAST
Nutrients	▪ SMAST
Soluble TKN and orthophosphates	▪ Phoenix
Nutrients	▪ Phoenix
Copper, Zinc and hardness	▪ Phoenix
BOD and COD	▪ Stamford WPCA
Solids and alkalinity	▪ Stamford WPCA
Bacteria (x2 sterile bags)	▪ Stamford WPCA

The field conditions were dry and partly cloudy, approximately 20°F, with significant snow cover, and the Stamford WPCA gage recorded 0.11" of rainfall in the preceding 72 hours. The USGS river gage was not recording flow due to ice on the river during this event. A YSI 556 MPS meter was used to record the *in situ* measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank and sent both samples to the laboratory with the river water samples. A field duplicate was collected at station 16.

Sampling stations near the Stamford Harbor (17 and 18) are periodically influenced by tidal influx. **Figure 3-4** on the following page shows the tidal record for the Stamford Harbor on January 20 with annotation to show approximately when field teams visited stations 17 and 18.

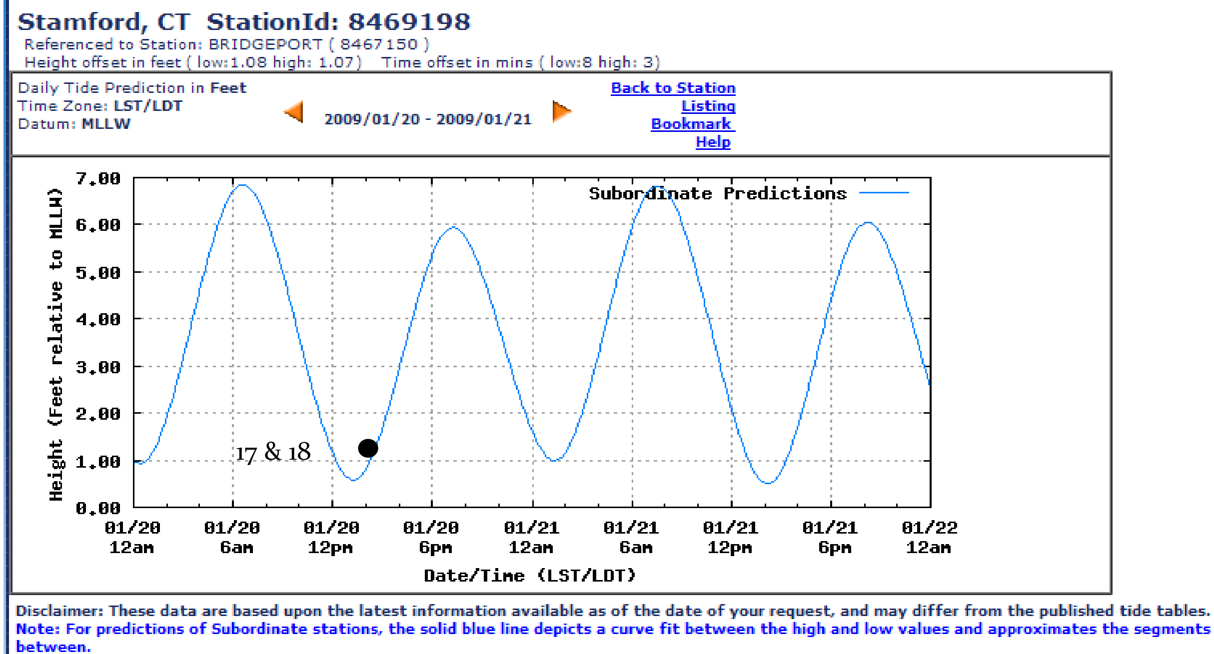


Figure 3-4: Tidal data for Dry Weather Event #2

Dry Weather Event #3

The third dry weather sampling event was conducted on May 21, 2009. Field teams returned to each of the 18 sampling locations to collect water samples for analysis and record *in situ* parameters. Samples were transported by field teams to the Stamford WPCA lab for analysis or distribution to contracted laboratories. No bacteria samples were collected during this round of sampling. Bottles were filled for analyses as shown in **Table 3-3**.

Table 3-3: Analyses performed for Dry Weather Event #3

Analyte	Laboratory
Chlorophyll-a	▪ SMAST
Particulate carbon and nitrogen	▪ SMAST
Total phosphorus	▪ SMAST
Nutrients	▪ SMAST
Metals and hardness	▪ Phoenix
Pesticides	▪ Phoenix
PCBs	▪ Phoenix
BOD and COD	▪ Stamford WPCA
Solids and alkalinity	▪ Stamford WPCA
Chlorophyll-a	▪ SMAST

The field conditions were dry and partly cloudy, 60-75°F, and no rainfall was recorded at the Stamford WPCA gage in the preceding 72 hours. The USGS river gage recorded an average daily flow of 21 cfs during this event. A YSI 556 MPS meter or 650 MDS meter was used to record the *in situ* measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank and sent both samples to the laboratory with the river water samples. A field duplicate was collected at station 04.

Sampling stations near the Stamford Harbor (17 and 18) are periodically influenced by tidal influx. The plot **Figure 3-5** on the following page shows the tidal record for the Stamford Harbor on May 21 with annotation to show approximately when field teams visited stations 17 and 18.

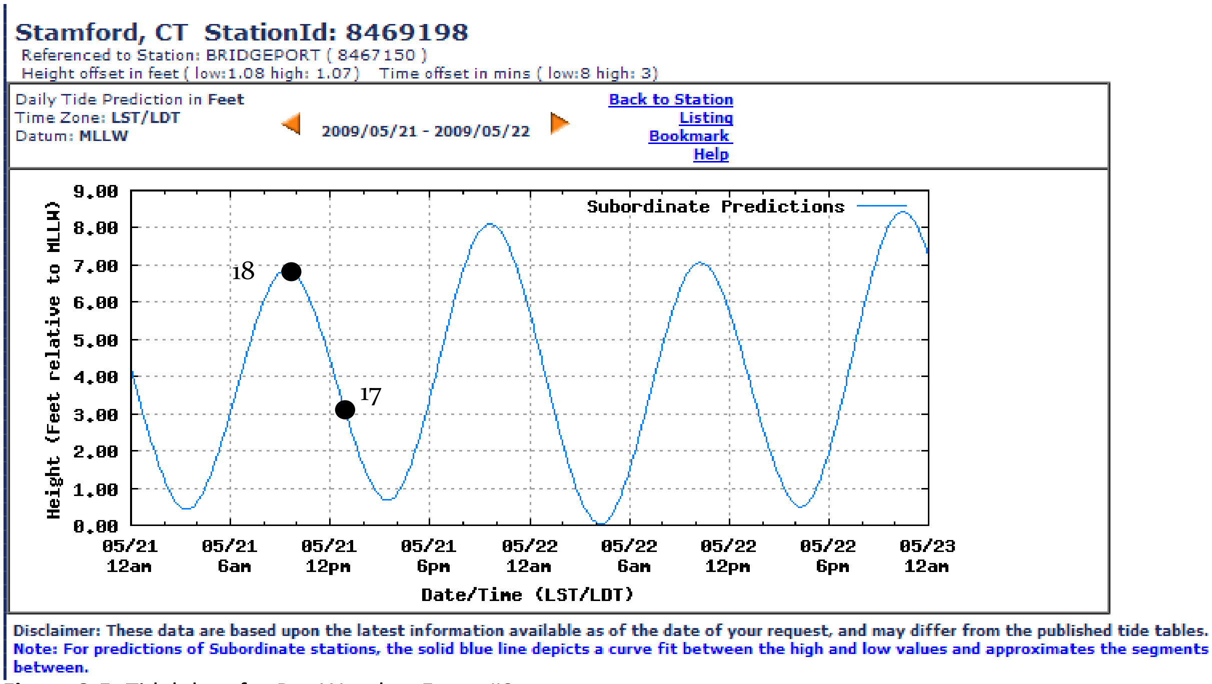


Figure 3-5: Tidal data for Dry Weather Event #3

Partial Dry Weather Event #2

During the August 10, 2009 partial dry weather event field teams visited the water quality sampling locations as well as additional sites, including several ponded areas, and measured *in situ* parameters, including dissolved oxygen, temperature, pH, and conductivity. The field conditions were dry and sunny, with temperatures ranging from 75-90°F. A total of 0.06" of rainfall was recorded at the Stamford WPCA rain gage in the 72 hours preceding the event. The USGS river gage recorded an average daily flow of 12 cfs during the time the water quality measurements were made. No samples were collected during this partial dry weather event. A YSI 556 MPS meter was used to make the measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes.

Field teams did not record water quality parameters in the tidally influenced portion of the river during the second partial dry weather event.

Dry Weather Event #4

The fourth dry weather sampling event was conducted on August 18, 2009. Field teams returned to each of the 18 sampling locations to collect water samples for analysis and record *in situ* parameters. An additional field crew visited sites multiple times throughout the day to record diurnal fluctuations in temperature and dissolved oxygen in the river. Samples were transported by field teams to the Stamford WPCA lab for analysis or distribution to contracted laboratories. Bottles were filled for analyses as shown in **Table 3-4** on the following page.

Table 3-4: Analyses performed for Dry Weather Event #4

Analyte	Laboratory
Chlorophyll-a	▪ SMAST
Particulate carbon and nitrogen	▪ SMAST
Total phosphorus	▪ SMAST
Nutrients	▪ SMAST
Metals and hardness	▪ Phoenix
BOD and COD	▪ Stamford WPCA
Solids and alkalinity	▪ Stamford WPCA
Bacteria (x2 sterile bags)	▪ Stamford WPCA
Chlorophyll-a	▪ SMAST
Particulate carbon and nitrogen	▪ SMAST

The field conditions were dry and partly cloudy, 75-93°F, and no rainfall was recorded at the Stamford WPCA gage in the preceding 72 hours. The USGS river gage recorded an average daily flow of 6.7 cfs during this event. A YSI 556 MPS meter or 650 MDS meter was used to record the *in situ* measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank and sent these samples to the laboratory with the river water samples. A field duplicate was collected at station 09.

Sampling stations near the Stamford Harbor (17 and 18) are periodically influenced by tidal influx. The plot **Figure 3-6** below shows the tidal record for the Stamford Harbor on August 18 with annotation to show approximately when field teams visited stations 17 and 18.

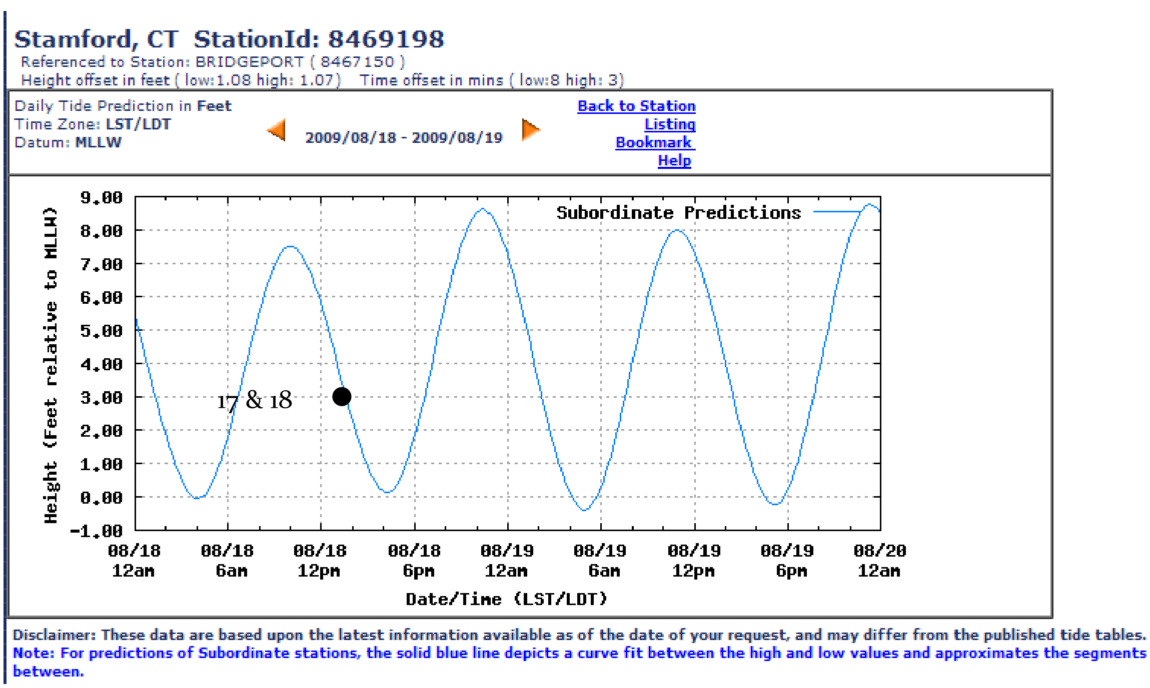


Figure 3-6: Tidal data for Dry Weather Event #4

3.3 Wet Weather Sampling Events

Wet weather water quality sampling was performed to gain an understanding of pollutant loadings in the mainstem Mill River and all major tributaries during periods of wet weather flow. Data collected from wet weather sampling events will be used towards development of simulation models, which will be used to evaluate alternatives for river and watershed improvements, and ultimately used in the formulation of a comprehensive watershed management plan for the Mill River watershed.

Two wet weather events were conducted; in the Spring and Fall of 2009. Weather was tracked to predict storms of sufficient precipitation volume and coverage over the watershed. Storms of at least 0.5 inches of precipitation over the entire watershed were target wet weather sampling conditions. In order to isolate the conditions in the river to represent only the targeted storm event, each wet weather sampling event was targeted to follow a 72 hour period of rainfall not exceeding 0.1 inches over the watershed, or a period where flow in the river was approaching baseflow conditions.

3.3.1 Description of Events

Wet weather sampling consisted of four distinct rounds of sample collection per event: pre-event (PE), rising limb (RI), near peak (NP), and receding limb (RL). Two wet weather events were conducted, in June and October 2009. All water samples were taken as grab samples according to the procedures detailed in the Field Sampling Plan. Sampling teams waded to the center of the stream to sample where possible, otherwise lowering a decontaminated sampling container from a bridge or down into a culvert at the sampling location. Following is a detailed description of each wet weather sampling event.

Wet Weather Event #1

The first wet weather sampling event, which occurred between June 17 and June 19, 2009, captured the conditions of a rainstorm on June 18. According to the Stamford WPCA rain gage, a total of 2.8" of rain fell from 2:30 AM until 10:45 PM on that day. The temperature was approximately 55-80°F during the three days of sampling. No rainfall was recorded at the gage in the 72 hours preceding 2:30 AM on June 18 when the storm began.

A YSI 556 MPS meter or 650 MDS meter was used to record the *in situ* measurements. Up to three readings, taken several minutes apart, were recorded at each river station for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank during each of the four rounds of sampling and sent these samples to the laboratory with the river water samples. Field duplicates were collected at stations: 09 (PE and RC), 17 (RI), and 05 (NP).

Field teams visited the wet weather sampling locations between June 17 6:20 PM and June 19 11:00 AM. The field team coordinator monitored the weather forecast and the real-time USGS streamflow gage in order to direct the field teams to sample at the appropriate times on the storm hydrograph (pre-event, rising limb, near peak, and receding limb). The following plot **Figure 3-7** on the following page shows the USGS gage hydrograph for the storm, the recorded rainfall total, and annotation showing when each round of sampling was completed.

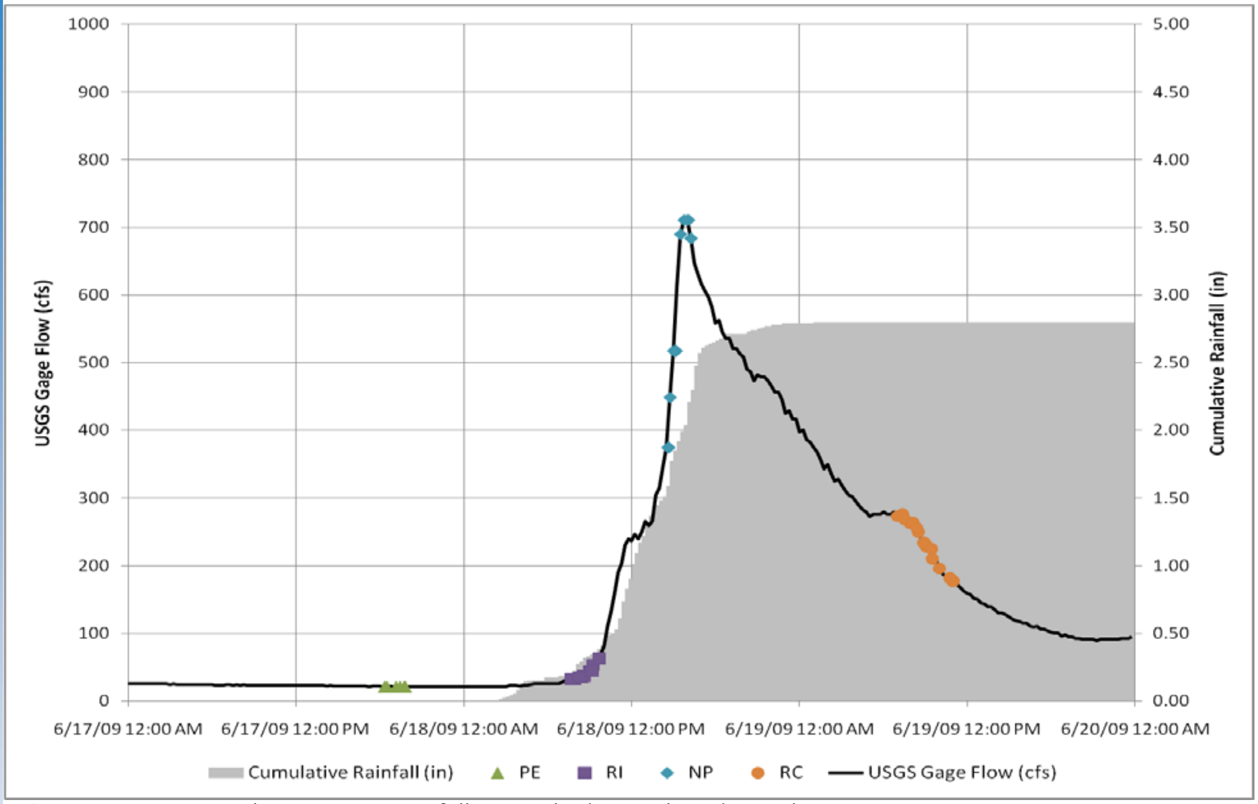


Figure 3-7: Wet Weather Event #1 rainfall, storm hydrograph and sample timing

Continuously recording flow meters were in place within the Toilsome Brook culverts and the Mill River drain during the first wet weather event. This data, along with the stage readings from the tributary staff gages, the USGS gage data, and the 15-minute rainfall data are shown in **Figure 3-8** on the following page, giving a synoptic picture of the storm and watershed response. For reference, the timing of the sampling conducted at stations #14 and #16 is shown.

Station 17 is close to the Stamford Harbor and is periodically influenced by tidal influx. **Figure 3-9** shows the tidal data for the week of June 16-23 with annotation marking the approximate times that field teams visited station 17 in each of the four rounds of sampling.

Figure 3-8: Flow data collected during Wet Weather Event #1

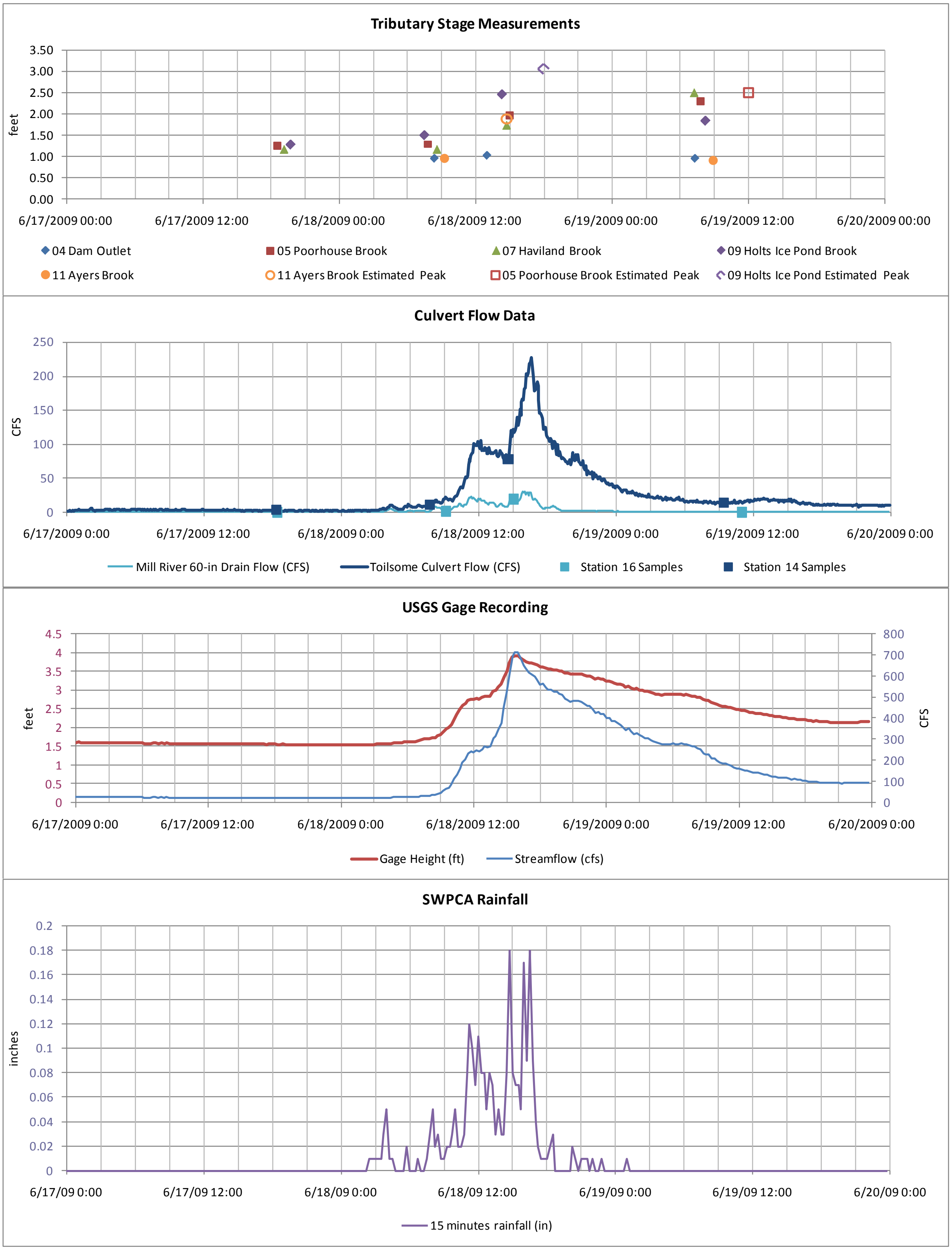
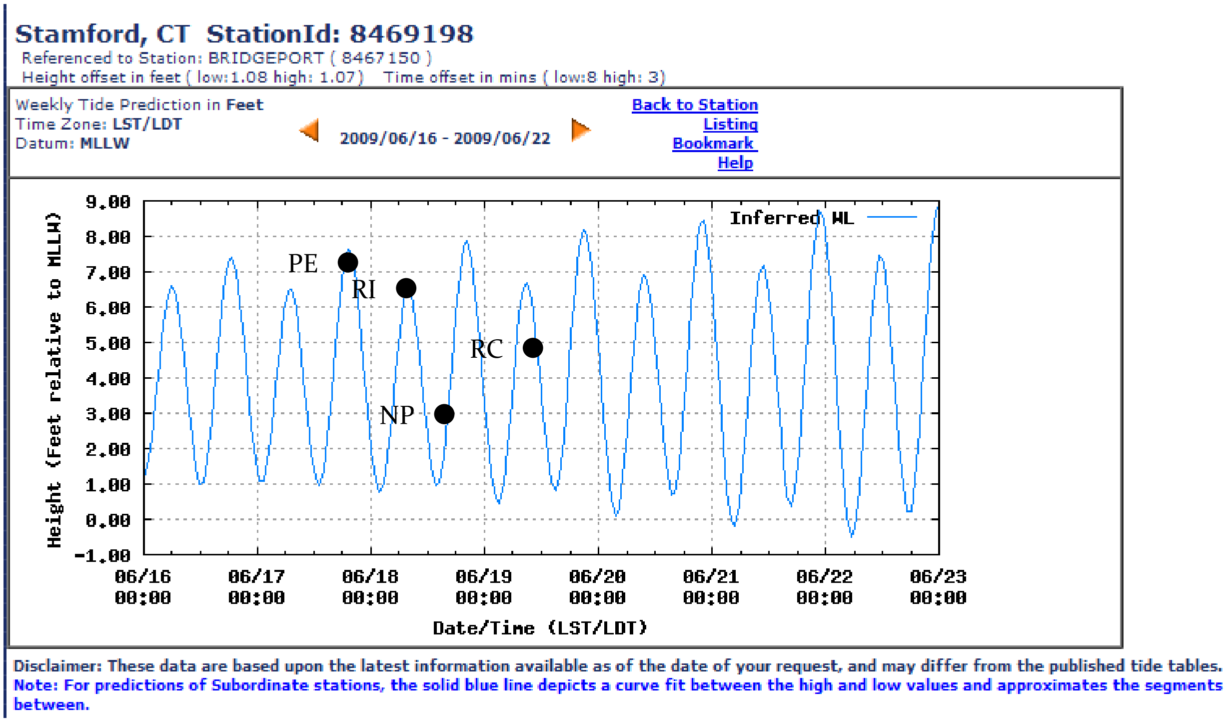


Figure 3-9: Tidal data for Wet Weather Event #1



Field teams visited a subset of the 18 total water quality sampling stations during each round of the first wet weather event to collect water samples and record *in situ* measurements. The following tables list the samples that were collected at each station for each round of sampling.

Samples were collected in accordance with the Field Sampling Plan except for the pre-event sampling round. Only a limited number of samples could be collected due to time constraints before the rainfall started. In addition, since the laboratory would not be able to process the bacteria samples with necessary hold times, these samples were not taken. Samples were collected and analyzed by laboratories as shown in **Table 3-5** (**A-D**) below.

Table 3-5A: Samples collected during Wet Weather Event #1

A. Pre-Event	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1					•		•		•					•		•	•	
Particulate carbon & nitrogen	1					•		•		•					•		•	•	
Total phosphorus	1					•		•		•					•		•	•	
Nutrients	1					•		•		•					•		•	•	
Metals & hardness	2					•		•		•					•		•	•	
Pesticides	2					•		•		•					•		•	•	
PCBs	2					•		•		•					•		•	•	
BOD & COD	3					•		•		•					•		•	•	
Solids & alkalinity	3					•		•		•					•		•	•	
Bacteria	3																		

For Tables 3-5 A-D, Labs: (1) SMAST; (2) Pheonix; (3) Stamford WPCA

Table 3-5B: Samples collected during Wet Weather Event #1

B. Rising Limb	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Total phosphorus	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Nutrients	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Metals & hardness	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Pesticides	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
PCBs	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
BOD & COD	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Solids & alkalinity	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Bacteria	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	

Table 3-5C: Samples collected during Wet Weather Event #1

C. Near Peak	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1					•	•	•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1					•	•	•	•	•	•	•	•	•	•	•	•	•	
Total phosphorus	1					•	•	•	•	•	•	•	•	•	•	•	•	•	
Nutrients	1					•	•	•	•	•	•	•	•	•	•	•	•	•	
Metals & hardness	2					•	•	•	•	•	•	•	•	•	•	•	•	•	
Pesticides	2					•	•	•	•	•	•	•	•	•	•	•	•	•	
PCBs	2					•	•	•	•	•	•	•	•	•	•	•	•	•	
BOD & COD	3					•	•	•	•	•	•	•	•	•	•	•	•	•	
Solids & alkalinity	3					•	•	•	•	•	•	•	•	•	•	•	•	•	
Bacteria	3					•	•	•	•	•	•	•	•	•	•	•	•	•	

Table 3-5D: Samples collected during Wet Weather Event #1

D. Receding Limb	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Particulate carbon & nitrogen	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Total phosphorus	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Nutrients	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Metals & hardness	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pesticides	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
PCBs	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
BOD & COD	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Solids & alkalinity	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bacteria	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

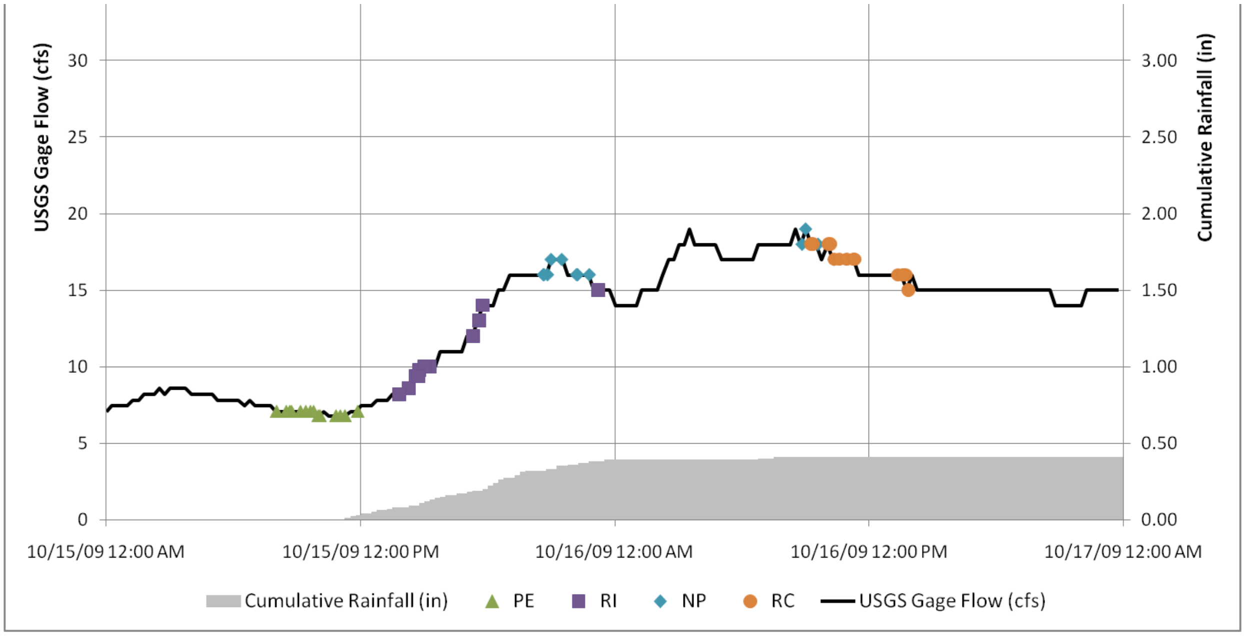
Wet Weather Event #2

The second wet weather sampling event, which occurred between October 15 and 16, 2009, captured the conditions of a small rainstorm that occurred on October 15. According to the Stamford WPCA rain gage, a total of 0.39” of rain fell from 11:15 AM until 11:30 PM on that day. An additional, unofficial, gage within the watershed recorded a total of 0.48” over the same time period (wunderground.com gage KCTSTAMF7). The temperature was approximately 36-55°F during the three days of sampling on the river. No rainfall was recorded at the gage in the 72 hours preceding 11:15 AM on October 15 when the storm began.

A YSI 556 MPS meter or 650 MDS meter was used to record the *in situ* measurements. In general, a single measurement was taken at each station; replicate measurements were recorded at some sampling stations for QA/QC purposes. For QA/QC purposes sampling teams collected one field blank and one equipment blank during each of the four rounds of sampling and sent these samples to the laboratory with the river water samples. Field duplicates were collected at stations: 10 (PE), 14 and 17 (RI), 12 (NP), and 16 (RC).

Field teams visited the wet weather sampling locations between October 15 8:00 AM and October 16 1:50 PM. The field team coordinator monitored the weather forecast, the real-time USGS stream flow gage, and staff gauge readings from the tributaries to direct the field teams to sample at the appropriate times on the storm hydrograph (pre-event, rising limb, near peak, and receding limb). The following plot shows the USGS gage hydrograph for the storm, the recorded rainfall total, and annotation showing when each round of sampling was completed.

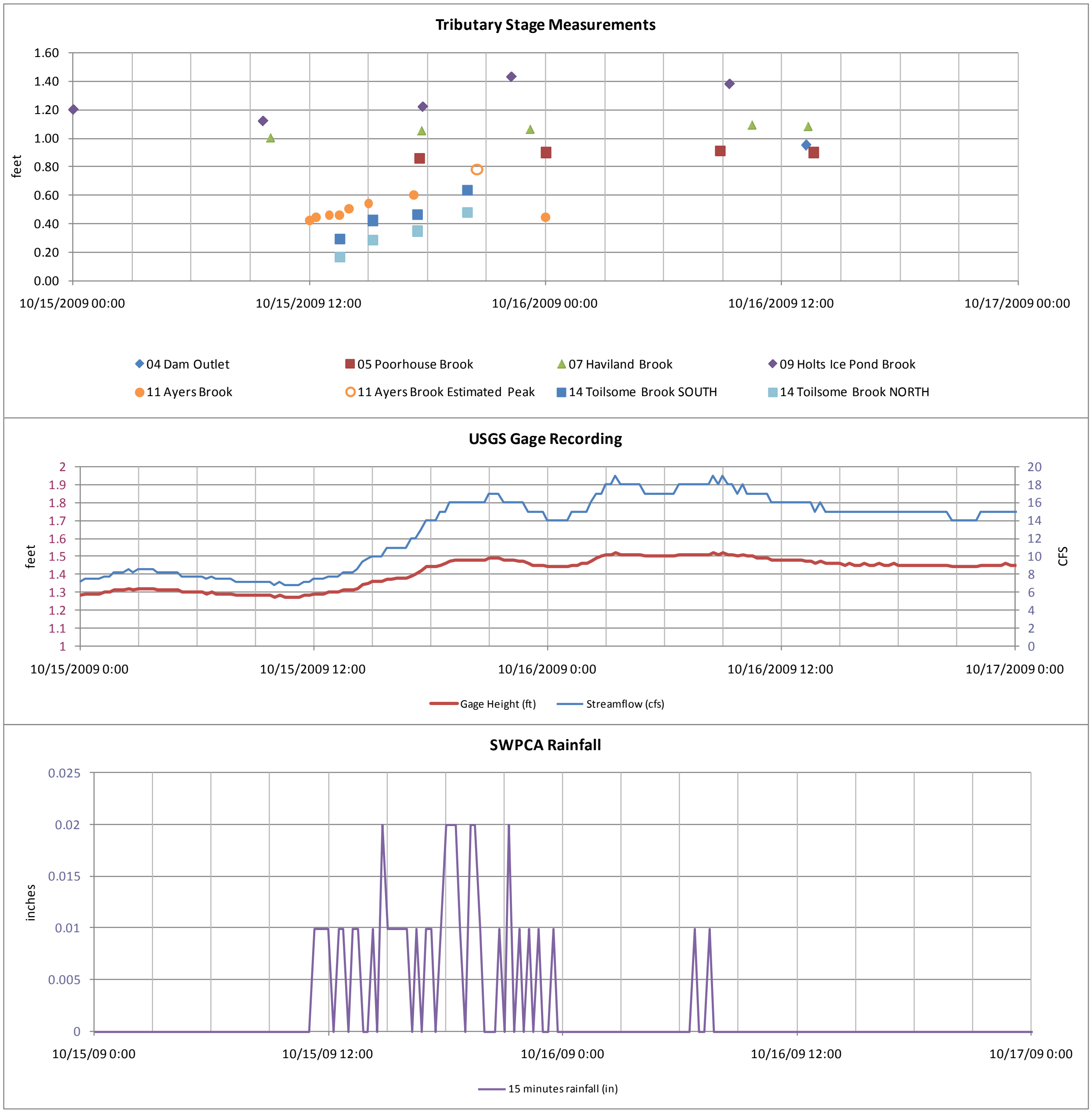
Figure 3-10: Wet Weather Event #2 rainfall, storm hydrograph and sample timing



Based on the observations of the overall river response to the storm event that constituted the first wet weather event, field teams were sent to the upper watershed sampling locations later to collect each round of samples. The first storm showed that the upper tributaries peak later than the mainstem at the USGS gage location, which is controlled by runoff from the more developed catchments in the lower watershed.

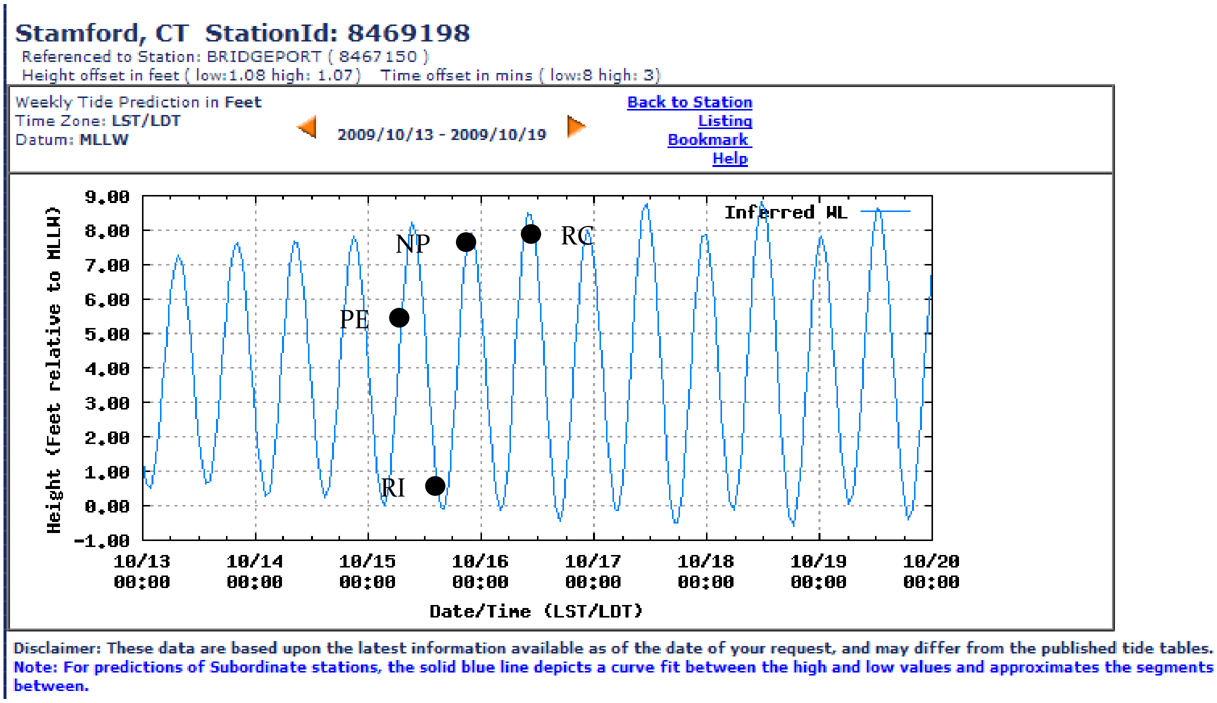
Figure 3-11 shows the stage readings taken by field teams over the course of the second wet weather event, along with the USGS gage data and 15-minute rainfall data. Field teams measured the water depth in the two Toilsome Brook culverts at various points during the storm event (north and south culverts).

Figure 3-11: Flow data collected during Wet Weather Event #2



Station 17 is close to the Stamford Harbor and is periodically influenced by tidal influx. The plot below shows the tidal data for the week of October 13-21 with annotation marking the approximate times that field teams visited station 17 in each of the four rounds of sampling.

Figure 3-12: Tidal data for Wet Weather Event #2



Field teams visited a subset of the 18 total water quality sampling stations during each round of the second wet weather event to collect water samples and record *in situ* measurements. The following tables list the samples that were collected at each station for each round of sampling.

In general samples were collected in accordance with the Field Sampling Plan with the following exceptions: (1) there was insufficient time to collect samples at Station 6 during the pre-event and rising limb rounds, and (2) the near peak samples were collected at night and the sampling crews did not have permission to access the Mill River drain (Station 16) at night. Samples were collected and analyzed by laboratories as shown in **Table 3-6 (A-D)** below.

Table 3-6A: Samples collected during Wet Weather Event #2

A. **Pre-Event**	**Sampling Station**																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Total phosphorus	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Nutrients	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Metals & hardness	2			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
BOD & COD	3			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Solids & alkalinity	3			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Bacteria	3			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Chlorophyll-a	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1			•	•	•		•	•	•	•	•	•	•	•	•	•	•	

For all Figures 3-6 A-D, Labs: (1) SMAST; (2) Pheonix; (3) Stamford WPCA

Table 3-6B: Samples collected during Wet Weather Event #2

B. Rising Limb	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1					•		•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1					•		•	•	•	•	•	•	•	•	•	•	•	
Total phosphorus	1					•		•	•	•	•	•	•	•	•	•	•	•	
Nutrients	1					•		•	•	•	•	•	•	•	•	•	•	•	
Metals & hardness	2					•		•	•	•	•	•	•	•	•	•	•	•	
Pesticides	3					•		•	•	•	•	•	•	•	•	•	•	•	
PCBs	3					•		•	•	•	•	•	•	•	•	•	•	•	
BOD & COD	3					•		•	•	•	•	•	•	•	•	•	•	•	
Solids & alkalinity	1					•		•	•	•	•	•	•	•	•	•	•	•	
Bacteria	1					•		•	•	•	•	•	•	•	•	•	•	•	

Table 3-6C Samples collected during Wet Weather Event #2

C. Near Peak	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1					•	•	•	•	•	•	•	•	•	•	•		•	
Particulate carbon & nitrogen	1					•	•	•	•	•	•	•	•	•	•	•		•	
Total phosphorus	1					•	•	•	•	•	•	•	•	•	•	•		•	
Nutrients	1					•	•	•	•	•	•	•	•	•	•	•		•	
Metals & hardness	2					•	•	•	•	•	•	•	•	•	•	•		•	
Pesticides	3					•	•	•	•	•	•	•	•	•	•	•		•	
PCBs	3					•	•	•	•	•	•	•	•	•	•	•		•	
BOD & COD	3					•	•	•	•	•	•	•	•	•	•	•		•	
Solids & alkalinity	1					•	•	•	•	•	•	•	•	•	•	•		•	
Bacteria	1					•	•	•	•	•	•	•	•	•	•	•		•	

Table 3-6D: Samples collected during Wet Weather Event #2

D. Receding Limb	Sampling Station																		
	Lab	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Chlorophyll-a	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Particulate carbon & nitrogen	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Total phosphorus	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Nutrients	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Metals & hardness	2			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Pesticides	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
PCBs	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
BOD & COD	3			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Solids & alkalinity	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Bacteria	1			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	

3.4 River Water Quality Sampling Results

This section contains a summary of the results from the river water quality sampling events and a discussion of apparent trends in the data. Complete results of all detected compounds are contained in Appendix B.

3.4.1 Bacteria

Water samples were analyzed for fecal coliform bacteria, *E. coli* and enterococci; Connecticut has water quality standards for the latter two bacteria for freshwater and salt water, respectively. The presence of bacteria may indicate that the water has been contaminated with fecal material of humans or other animals, and that other pathogens may be present. Sources of bacteria in the river can include groundwater, stormwater, sewer overflows, and direct discharge (such as birds or aquatic mammals). **Table 3-7** summarizes the range of bacteria results from each sampling event. As expected, wet weather samples had much higher bacteria levels than those collected in dry weather.

Table 3-7: Summary of bacteria sampling results

Event	E. coli (cfu/100ml)		Enterococci (cfu/100ml)		Fecal Coliform (cfu/100ml)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Dry Weather Event #1	4	1,900	0	7,900	8	1,454
Dry Weather Event #2	0	673	0	365	0	592
Dry Weather Event #4	9	7,091	22	22	17	4,712
Wet Weather Event #1						
Pre-Event			no bacteria analyses		no bacteria analyses	
Rising Limb	80	13,000	57	23,000	38	16,454
Near Peak	2,091	30,000	2,727	51,000	636	24,000
Receding Limb	31	3,273	15	5,182	23	5,273
Wet Weather Event #2						
Pre-Event	0	1,622			0	1,180
Rising Limb	99	124,000			63	255,000
Near Peak	36	34,000			0	28,000
Receding Limb	0	8,108			0	5,405

Discussion of Dry and Wet Weather Events

Dry weather samples (including the pre-storm sampling during wet weather events) ranged from 0 to 4,712 cfu/100 ml for fecal coliform; 0 to 7,091 cfu/100 ml for *E. coli*; and 0 to 7,900 cfu/100 ml for enterococci. In general, the concentrations among the three bacteria analytes tended to trend together, suggesting animal or human waste as the source of the contamination.

Bacteria samples were collected in 3 of the 4 dry weather sampling events. The general pattern in bacteria levels from the top to the bottom of the watershed across the dry weather events is:

- The sampling stations in the northern watershed (Stations 1-4, which includes the two releases from the North Stamford Dam) had the lowest bacteria levels (10^1 to 10^2 cfu/100 ml).
- Concentrations were elevated in Poorhouse Brook (Station 5), which was typically also reflected in the downstream main stem station (#6).
- Bacteria levels in Haviland Brook tended to be low (10^1 cfu/100 ml).
- Bacteria were again elevated at main stem station 8 (just downstream of the Merritt Parkway), suggesting the source contributes directly to the river (not a tributary).
- Holt's Ice Pond (Station 9) added low levels (10^1 to 10^2 cfu/100 ml), with the downstream main stem station (#10) having concentrations between Station 8 and 9.

- In two of the three rounds, Ayers Brook (#11) adds significant bacteria to the Mill/Rippowam River, which likely explains the elevated levels in Station 12, which is immediately downstream of the confluence of Ayers Brook. Bacteria at Station 13 (near Cold Spring Road) are similar to Station 12.
- Toilsome Brook (Station 14) often had the highest bacteria levels (~1,000 cfu/100 ml), which causes likely contributes to the elevated levels at the next main stem station (#15) compared to Station 13.
- Compared to ambient river levels in the downtown area, the Mill River drain (Station 16) has low levels of bacteria (10^1 to 10^2 cfu/100 ml).
- Stations 17 and 18 tend to be similar in magnitude to Station 15.
- These general trends during dry weather suggest sources of bacteria that require further investigation in Poorhouse Brook, the region between Wire Mill Road to just south of the Merritt (between stations 6 and 8), Ayers Brook, Toilsome Brook, near and downstream of Cold Spring Road.

The summer dry weather round had higher concentrations than the fall and winter rounds. The spatial distribution of results from the summer round showed concentrations higher by an order of magnitude or more in the lower portion of the watershed, with the highest concentrations in Ayers Brook. While spatial trends in the fall and winter rounds tended to show the tributaries with higher concentrations than the main stem stations.

Wet weather samples ranged from 0 to 255,000 cfu/100 ml for fecal coliform; 0 to 124,000 cfu/100 ml for *E. coli*; and 15 to 51,000 cfu/100 ml for enterococci. Wet weather bacteria concentrations tended to be an order of magnitude greater than dry weather concentrations at the same station, for all bacteria analytes. Some observations about the wet weather samples include:

- Concentrations for the first wet weather event were significantly lower than for the second event. This is likely due to the much larger storm flows during the first event diluting the bacteria sources.
- The highest concentrations during both events were found in the lower portion of the watershed, south of the confluence with Ayers Brook.
- The only sampling station in the upper watershed that had high (>10^4 cfu/100 ml) bacteria levels was the near peak sample for wet weather round #1 at Poorhouse Brook (Station #5). All bacteria analytes were elevated in that sample.
- The highest concentrations (counts greater than 10^5 cfu/100 ml, which were 124,000 for E. *coli* and 255,000 for fecal coliform) occurred at Toilsome Brook at the rising limb samples of the second wet weather event, an increase of two orders of magnitude over the pre-event samples. These rising limb samples were collected at the first flush of the storm indicating mobilization of high levels of bacteria with the initial runoff.
- Across the three bacteria analytes, 38 samples collected during wet weather had concentrations exceeding 10^5 cfu/100 ml. The number of samples over this threshold by station are: 8 at Ayers Brook, 7 at Toilsome Brook; 6 at mainstem stations 17 and 12, where 12 is likely influenced by Ayers Brook; 4 at the Mill River drain; 3 at Station 15 and Poorhouse Brook; and 1 at Station 13. These high values were nearly always collected at the near peak round, except at the Station 16 (Mill River Drain) which had these highest concentrations at the rising limb round.

- As a general pattern, bacteria concentrations were higher in the tributaries than both the immediately adjacent upstream and downstream samples in the river's main stem.
- Based on these results, the tributaries can be ranked as having the highest to lowest bacteria levels: Toilsome Brook, Ayers Brook, Mill River drain, Poorhouse Brook, Holts Ice Pond and Haviland Brook.

Comparison to Connecticut Water Quality Standards

Table 3-8 summarizes compliance of measured bacterial levels with Connecticut bacteria water quality standards. The data are presented in terms of the number and frequency that the water samples exceeded state water quality standards for bacteria. Connecticut water quality standards specify two values for each river classification: the single sample maximum, and the maximum geometric mean of samples taken over time.

The data is compared with the criteria for three designated use classifications: designated swimming, non-designated swimming, and all other recreational uses. The freshwater bacteria standard for Connecticut is based on the concentration, in cfu/100 ml, of *E. coli* bacteria. The results of the dry and wet weather sampling events are compared with the single sample maximum standards. For the most stringent standard (designated swimming at 235 cfu/ 100 ml), between 23 and 56% of the samples in any dry weather sampling round exceeded the standard, while 67 to 100% of the wet weather samples exceeded the standards.

The saltwater bacteria standard is based on enterococci bacteria concentration. The majority of samples collected during the monitoring program were freshwater samples, however stations #17 and #18 lie in the tidal zone of the river. In samples where the salinity of the water was greater than 1 ppt, the results were compared against the saltwater criteria. There were no observed exceedances in the saltwater samples based on the enterococci water quality standard.

Table 3-8: Summary of bacteria levels found above state water quality standards

Event	Total # Samples	Designated swimming 235 cfu/100ml, single sample		Non-designated swimming 410 cfu/100ml, single sample	
		# exceedances	% of samples	# exceedances	% of samples
Dry Weather Event #1	18	4	22%	2	11%
Dry Weather Event #2	18	3	17%	2	11%
Dry Weather Event #3	0	no bacteria analyses		no bacteria analyses	
Dry Weather Event #4	18	10	56%	7	39%
Wet Weather Event #1					
Pre-Event	0	no bacteria analyses		no bacteria analyses	
Rising Limb	15	13	87%	11	73%
Near Peak	13	13	100%	13	100%
Receding Limb	15	13	87%	13	87%
Wet Weather Event #2					
Pre-Event	14	7	50%	5	36%
Rising Limb	12	10	83%	7	58%
Near Peak	12	8	67%	7	58%
Receding Limb	15	10	67%	8	53%

3.4.2 Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in water. It is a primary measure of the health of a water body. Low dissolved oxygen (hypoxia) stresses aquatic organisms, while waters with no dissolved oxygen (anoxia) does not support aerobic organisms. High dissolved oxygen is an indication of excess productivity (usually growth of algae) which results from nutrient enrichment in water bodies. In Connecticut, the dissolved oxygen water quality standard is greater than 5.0 mg/l for inland freshwater streams.

Summary of Data

Over 200 DO measurements were collected as part of the seasonal dry weather, wet weather and partial dry weather sampling. During the full dry and wet weather data, samples were collected along with other water quality parameters. During the partial rounds, only *in situ* measurements (DO, temperature, pH etc.) were taken. During the first partial round, triplicate readings were taken at the 16 designated sampling stations for the other water quality parameters. During the second partial round, samples were collected at additional stations and a second afternoon reading was taken as several stations to characterize diurnal fluctuations. The DO results for all sampling rounds are presented in **Table 3-9** on the following page.

Table 3-9: Summary of Dissolved Oxygen Measurements (mg/l)

Event	Date	Minimum DO (mg/l)	Maximum DO (mg/l)
Dry Weather Event #1	November 24, 2008	8.97	16.55
Dry Weather Event #2	January 20, 2009	13.62	18.45
Dry Weather Event #3	May 21, 2009	8.81	11.92
Dry Weather Event #4	August 18, 2009	1.74	13.41
Partial Survey #1	July 30-31, 2008	2.90	11.36
Partial Survey #2	August 10, 2009	1.99	9.49
Wet Weather Event #1	June 17-19, 2009	4.50	15.01
Pre-Event		7.89	10.64
Rising Limb		5.14	10.34
Near Peak		7.83	9.85
Receding Limb		4.50	15.01
Wet Weather Event #2	October 15-16, 2009	4.92	15.59
Pre-Event		5.32	14.00
Rising Limb		8.32	12.04
Near Peak		4.92	10.85
Receding Limb		6.09	15.59

Low DO concentrations are not widespread. The main stem river and tributaries are generally in compliance with the Connecticut state DO criterion for freshwater streams of 5.0 mg/l. Of the total readings taken over the course of the monitoring program, 96% were above the state standard of 5.0 mg/l and 83% were above 7.0 mg/l.

For the fall, winter and spring dry weather rounds, the DO levels tended to be supersaturated, as the samples were collected from morning through mid-day, indicating that primary productivity (algae or periphyton) raises the oxygen levels. During the summer dry weather sampling round, the DO was most often between 80 and 100% saturation, with the exception of very low oxygen in the North Stamford Dam release (see below).

Low DO was observed in the discharge from the North Stamford Reservoir low flow outlet (Station 4) during the two sampling rounds when the reservoir would have been stratified (dry weather round 4 and wet weather round 1). These low values occur because the low flow release water is taken from a mid-depth of this eutrophic reservoir; Aquarion operates an aerator in the North Stamford Reservoir to maintain oxic levels in the bottom waters.

Other low (<6 mg/l) DO readings were found at Station 2, which is just downstream of a pond in the upper watershed and downstream of Poorhouse Brook (Station 6), during dry weather round 4, and in Stations 16 and 17 during one round each of wet weather round 2.

In dry weather sampling, the upstream tributaries tended to have lower DO than the downstream tributaries, indicative of the higher productivity associated with the longer residence time in these streams. High concentrations of DO and supersaturation readings were observed during early morning, mid-day, and late afternoon sampling rounds.

Focus on Partial Dry Weather Sampling Results

The partial dry weather sampling data were collected when the river had very low flows, and thus, should represent a stressed condition relative to dissolved oxygen.

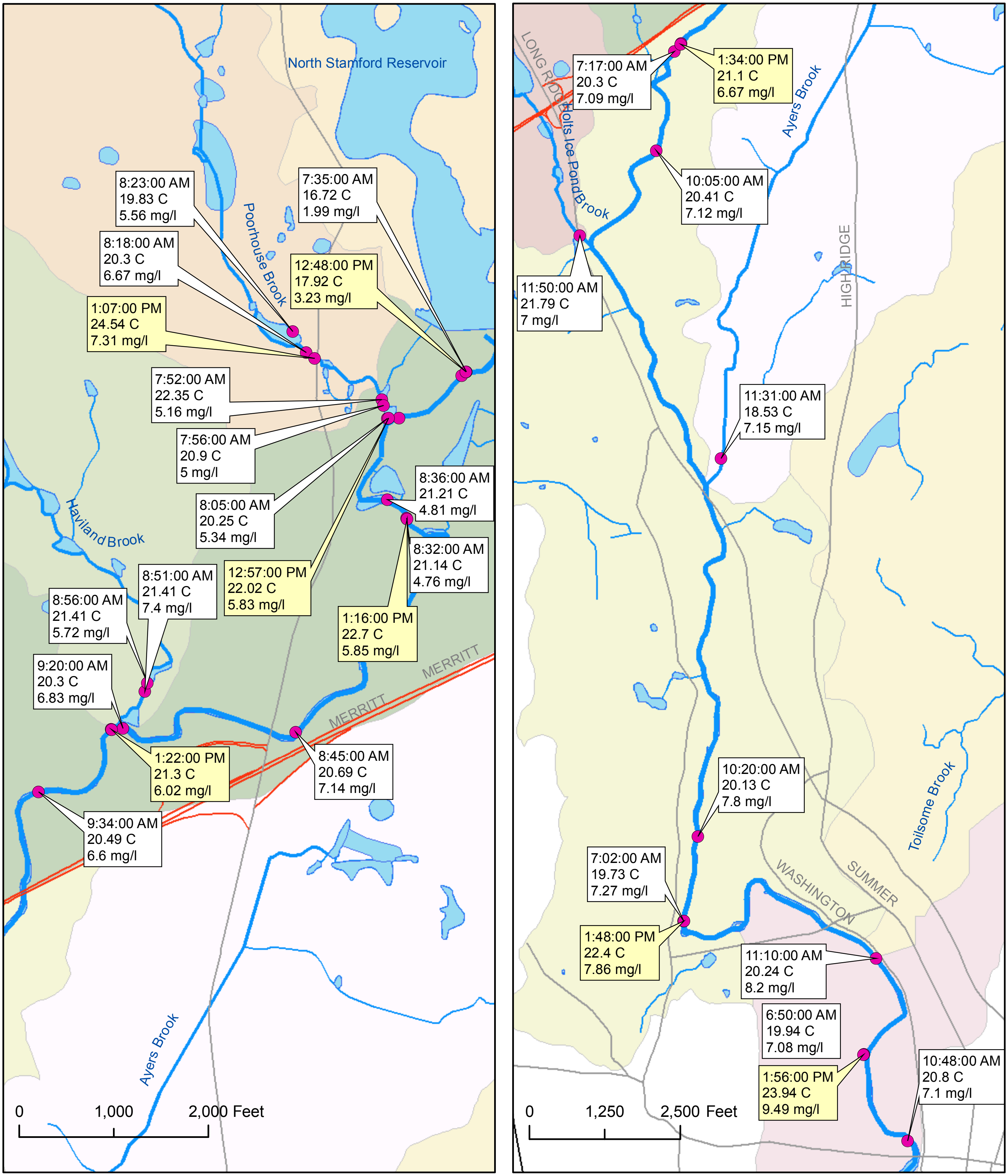
The first partial round was collected on July 30, 2008, when the flow at the USGS gage was approximately 4 cfs. The results showed low DO at station #2 which is in the upper watershed but downstream of a small pond; North Stamford Reservoir low flow outlet station #4; mainstem station #8; and mainstem station #13. The cause of the DO depression at station #8 may have been the ponds in Haviland Brook that are downstream (closer to the Mill River confluence) of water quality sampling station #7. **Table 3-10** shows the temperature and dissolved oxygen readings from the first partial dry weather survey.

Table 3-10: Partial Dry Weather Event #1 dissolved oxygen and temperature results

Station	Dissolved Oxygen (mg/l)	Temperature (°C)
01	9.06	16.79
02	3.09	24.87
04	2.90	18.66
05	7.20	25.43
06	7.74	22.02
07	7.16	24.79
08	6.42	22.84
10	8.04	24.02
11	8.02	20.27
12	8.17	24.13
13	6.39	24.40
14	8.41	24.12
15	8.59	26.92
16	11.36	19.63
17	7.54	26.05
18	8.28	26.95

The second partial dry weather survey focused on DO levels throughout the Mill River study area (not limited to the water quality sampling stations) and diurnal fluctuations from early morning readings to early afternoon readings. This round of measurements was taken on August 10, 2009, when the flow at the USGS gage was approximately 12 cfs. **Figure 3-13** shows the results of the second partial dry weather survey.

- The North Stamford Reservoir discharges water with very low DO from its low flow release outlet. YSI readings during dry weather survey #4, the summer low flow survey, were verified with a Winkler sample:
  - *Temperature – 17.06 °C*
  - *YSI DO – 2.48 mg/l and 25.4 % saturation*
  - *Winkler DO – 2.58 mg/l*



Dissolved Oxygen Monitoring Results
Dry Weather, August 10, 2009
Mill River Watershed Study

CDM

N W E S

Subbasins

- Ayers Brook
- Direct Drainage - Lower
- Direct Drainage - Middle
- Direct Drainage - Upper
- Haviland Brook
- Holts Ice Pond
- Laurel Reservoir
- North Stamford Reservoir
- Poorhouse Brook
- Toilsome Brook

- Partial Dry Weather Survey Stations
- Mill River

Figure 3-13

- Dissolved oxygen in Poorhouse Brook is also low in the morning, though greater than the reservoir outlet and above the standard of 5.0 mg/l.
- Afternoon readings were generally greater than early morning readings, with the exception of the area just downstream of Haviland Brook, both north and south of the Merritt Parkway crossing.

Comparison to State Water Quality Standards

Violations of the state standard of 5 mg/l included:

- Station #4, the low flow outlet form the North Stamford Reservoir, when the reservoir was likely to have been stratified
- Station 2, readings were below the standard during summer dry weather conditions in July 2008 and August 2009. The cause of this may be stagnant conditions as the sampling station is just downstream of a low head dam that releases minimal water at low flow conditions.
- In ponds downstream of Poorhouse Brook confluence, readings were below the standard during the partial dry weather round in August 2009 (morning values were below 5 mg/l, afternoon values were just above 5 mg/l).
- At station 17, during wet weather event 2 the DO reading was below the standard during the near peak sampling round, which was also coincident with high tide (salinity approximately 8 ppt; depending on the designated use classification of Stamford Harbor, the standard for saltwater is 5 or 6 mg/l)

3.4.3 North Stamford Reservoir

Water discharges from the North Stamford Reservoir at two locations: a large spillway and a constant low flow release channel. These flows converge into the Mill River a few hundred yards downstream of the reservoir. The flow in the stream channel that receives the constant release was measured several times between April 2009 and August 2009. The measured flows were typically near 0.7 cfs (315 gpm).Imminent changes in the Connecticut instream flow rules will likely cause a marked increase in flow from the North Stamford Reservoir during low flow periods. The condition of the water exiting the reservoir, especially in the low flow outlet channel, will have a greater impact on the overall health of the downstream Mill River once the new state instream flow rules go into effect.

In addition to the low DO observed in the low flow outlet channel, the results of the monitoring program show several other trends in the water quality exiting the North Stamford Reservoir.

Fecal Bacteria Trends (including *E. coli*, enterocci, and fecal coliform)

During dry weather sampling, the fecal bacteria counts in the spillway/seepage flow and the low flow outlet are generally the same and less than the counts at other sampling stations along the river.

During the rising limb sample of wet weather event #1, the fecal bacteria counts in the low flow outlet sample were greater than counts at other sampling stations north of the Merritt Parkway. The difference was approximately one order of magnitude (10^3 cfu/100ml at the low flow outlet and 10^2 cfu/100ml at the river stations).

During the receding limb sample of wet weather event #2, the fecal bacteria counts at both reservoir discharge stations were less than the counts at other sampling stations. The difference was approximately one order of magnitude (10^2 cfu/100ml at the low flow outlet and 10^3 cfu/100ml at the river stations).

The pre-event bacteria counts for wet weather event #2 were greater at the reservoir spillway than at the low flow outlet. Counts from the spillway samples were closer in value to the downstream sampling stations, approximately 10^3 cfu/100ml.

Copper

The copper concentration in the spillway/seepage flow sample during the summer dry weather event (#4) was the highest observed value for the monitoring program, 90 ug/l. This value is almost twice that of the next highest observed copper concentration of 51 ug/l at the downtown stormwater drain.

3.4.4 Metals

The results of the metals analysis show that river is in frequent violation of the state standards for copper, lead, and zinc. **Tables 3-11** and **3-12** show the minimum and maximum values observed at each sampling station for the dry and wet weather sampling events.

Table 3-11: Dry weather metals analysis results

Station	Copper ug/L		Lead ug/L		Zinc ug/L	
	Min	Max	Min	Max	Min	Max
01	2	8	2	4	2	4
02	1	8	2	2	2	3
03	2	90	2	2	2	7
04	6	22	2	2	3	10
05	1	18	2	2	3	43
06	2	21	2	2	3	48
07	1	18	2	2	2	65
08	1	20	2	2	3	40
09	1	19	2	3	7	55
10	1	21	2	2	2	43
11	1	18	2	2	4	38
12	1	21	2	2	2	38
13	1	19	2	6	2	38
14	1	20	2	2	4	41
15	3	26	2	2	4	35
16	7	51	2	2	7	71
17	4	21	2	20	4	53
18	5	19	2	4	12	42

Table 3-12: Wet weather metals analysis results

Station	Copper ug/L		Lead ug/L		Zinc ug/L	
	Min	Max	Min	Max	Min	Max
03	5	11	2	2	2	3
04	4	9	2	2	5	7
05	1	5	2	8	4	11
06	3	14	2	8	2	11
07	2	10	2	4	2	7
08	5	11	2	8	4	20
09	2	9	2	10	6	21
10	4	9	2	13	4	26
11	4	16	2	17	15	71
12	3	8	2	12	5	28
13	3	17	2	19	2	48
14	5	21	2	9	9	101
15	5	17	2	22	5	62
16	10	33	2	12	44	186
17	6	16	2	24	12	64

Table 3-13 shows the frequency that the samples exceed the state metals criteria for copper, lead, and zinc during dry weather and wet weather sampling events.

Table 3-13: Wet and dry weather exceedance of state metals standards

	Total % Samples	Copper				Lead				Zinc			
		acute		chronic		acute		chronic		acute		chronic	
Total Dry Weather[1]	92	26	28%	64	70%	0	0%	5	5%	2	2%	2	2%
Total Wet Weather[2]	82	12	15%	62	76%	0	0%	20	24%	6	7%	6	7%
Freshwater Criteria (ug/l):		14.3		4.8		30		1.2		65		65	
Saltwater Criteria (ug/l)[3]:		4.8		3.1		210		8.1		90		81	

1 Dry weather statistics include all dry weather sampling events and pre-event samples from wet weather events
2 Wet weather statistics include rising limb, near peak, and receding limb samples from wet weather events
3 When salinity > 1.0 ppt, metals concentrations were compared with the more stringent of the freshwater and saltwater criteria

The following observations can be made from the data:

- The tributaries in the lower, more developed watershed (Ayers Brook, Toilsome Brook, and the downtown stormwater drain) are the only sampling locations that exceed the standard for zinc. This occurred in dry weather and wet weather sampling events.

- During the winter dry weather sampling event (#2) several samples from the upper, middle, and lower watershed exceeded the state criteria for chronic lead concentration. These concentrations were observed at stations #1, #9, #13, #17, and #18. This list includes mainstem and tributary stations.

- During the first wet weather sampling event lead concentrations rose in the river in coincidence with the storm hydrograph. Lead was not detected during the pre-event samples, concentrations increased to above the detection limits at several stations during the rising limb round, maximum concentrations were observed during the near peak sampling round, and concentrations fell below detection limits at most sites during the receding limb round. Samples from Ayers Brook and the downtown stormwater drain saw an earlier peak of lead concentration, which would be expected considering those subbasins have more impervious surfaces resulting in a faster hydrograph response to storm runoff. This trend was not observed in the second wet weather sampling event, which occurred during a much smaller storm.

- Copper concentrations exceeded the state standard (both acute and chronic criteria) frequently throughout the river during dry weather sampling. During the summer dry weather survey (#4) the sample from the North Stamford Reservoir spillway/seepage channel was much greater than other observed concentrations, leading to the hypothesis that the reservoir may be the source of copper. However, this copper signature was not observed in samples from that station during any other event.

- During the first wet weather event, copper concentrations followed the rising and recession of the storm hydrograph. Concentrations at mainstem stations rose from at or below 7 ug/l during the rising limb sampling round to a maximum of 17 ug/l during the near peak sampling round. Copper concentrations at Toilsome Brook peaked earlier than the mainstem river, and concentrations in the downtown stormwater drain fluctuated at greater values than the rest of the river.

Copper concentrations followed a similar trend in the second wet weather event as the first wet weather event.

3.4.5 Nutrients

The results of the sampling program show localized elevated values of nutrients and chlorophyll-a. The trends and observations that were evident based on sampling results are listed below by analyte.

Nitrogen

- During dry weather sampling events, concentrations of total nitrogen in the main stem river were not elevated (approximately 1 mg/l). Concentrations in the downstream tributaries (Holts Ice Pond and downstream) were slightly elevated at approximately 2 mg/l.

- The downtown stormwater drain had very high total nitrogen concentrations throughout the sampling program. Prior to June 2009, a large portion of the total nitrogen was from ammonia; beginning with the first wet weather sampling event in June, the ammonia levels in the drain decreased and the total nitrogen consisted primarily of nitrate + nitrite.

- During wet weather sampling events, nitrogen levels in the river were slightly greater than during dry weather events, though concentrations did not increase significantly with the storm hydrograph.

- The elevated nitrogen levels in Toilsome Brook and Ayers brook during wet weather sampling events, coupled with the very high levels of bacteria at that location is indicative of wastewater contamination.

Phosphorus

- During dry weather sampling events, the levels of phosphorus in the river are generally low (<50 ug/l). Coupled with fast travel times through the system, these levels of phosphorus do not typically result in excessive algae and phytoplankton growth.

- High levels of phosphorus were observed in the downtown storm drain during dry weather sampling events.
- During wet weather sampling, there were several instances of elevated phosphorus levels in the tributaries:
  - *High concentrations in Ayers Brook (369 ug/l), along with the nitrogen results and high levels of bacteria, support the hypothesis that wastewater is present in the tributary*
  - *High levels of phosphorus in the near peak samples during the first wet weather event are likely due to sediment resuspension in the main stem.*
  - *The downstream tributaries had stormwater driven increases in phosphorus concentrations during the second wet weather event.*

Chlorophyll-a

- Throughout the monitoring program, concentrations of chlorophyll-a exiting the North Stamford Reservoir were high, often at nuisance levels (>10ug/l).
- During dry weather sampling, concentrations of chlorophyll-a at the estuary were very high.
- In general, during dry weather sampling the chlorophyll-a levels were greater in the upper watershed than in the lower watershed. This is likely due to loading form the North Stamford Reservoir.
- During the first wet weather event, there was evidence of chlorophyll-a washout from ponds upstream of the Holts Ice Pond Brook sampling station.
- During the second wet weather event (including the pre-event sample) there were elevated levels of chlorophyll-a throughout the four sampling rounds at Haviland Brook.

3.5 Sampling Outfalls with Dry Weather Flow

While conducting the river walk and geomorphological observations (April-May 2009) field teams located stormwater or tributary outfalls entering the mainstem from Broad Street to the North Stamford Dam, taking note of those with dry weather flow and those with evidence of impacting water quality in the river (algae growth, odor, etc.). Of these, at the time of first observation, 31 outfalls had apparent dry weather flow discharging into the Mill River. The locations and photos of these 31 outfalls are shown in **Figure 3-14**. Field teams later returned to many of the outfalls that were identified as having dry weather flow to collect samples for bacteria analyses.

3.5.1 Description of Events

Outfall sampling took place during dry weather on May 6, 2009 and September 2, 2009. The average daily flow at the USGS gage on May 6 was 42 cfs; on September 22 it was 5.4 cfs. The much lower total flow in the river in September indicated a much lower base flow than in April and May when the outfalls with dry weather flow were identified. Several outfalls that had apparent dry weather flow in the spring did not have any flow in September. Not all outfalls were visited for sampling; **Table 3-14** lists all of the outfalls identified as having dry weather flow, if and when they were sampled, if they were not flowing in the dry September conditions, and other observations made by field teams.

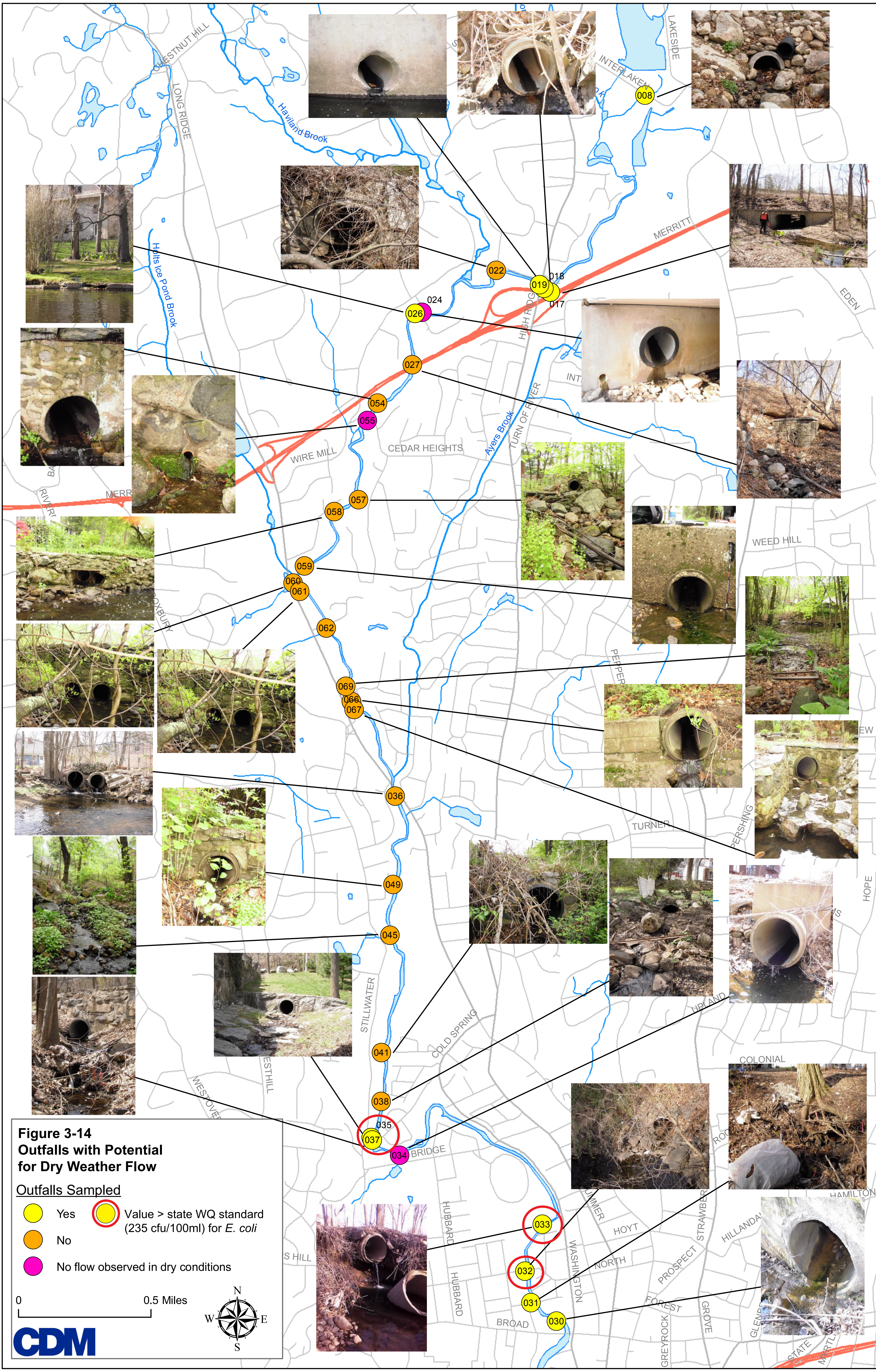


Figure 3-14
Outfalls with Potential for Dry Weather Flow

Table 3-14: Observations of stormwater outfalls with possible dry weather flow

Name	Date Sampled	Observations	Algae Observed in Pipe?
008	5/6/2009	possibly an historic tributary	none
017	5/6/2009	none	surface
018	5/6/2009	none	orange benthic
019	5/6/2009	none	none
022	not sampled	none	none
024	not sampled	possibly road drainage, no flow when observed 9/22/2009	none
026	9/22/2009	possibly a spring, several GPM in very dry conditions 9/22/2009	none
027	not sampled	none	n/a
030	9/22/2009	<0.5 GPM on 9/22/2009	green benthic
031	5/6/2009	floatables in pool	none
032	5/6/2009	none	none
033	5/6/2009	none	none
034	not sampled	possibly golf course drainage, no flow when observed 9/22/2009	none
035	5/6/2009	none	none
036	not sampled	none	n/a
037	5/6/2009	sediment and trash	none
038	not sampled	fertilizer odor, iron stain on flow line	none
041	not sampled	none	none
045	not sampled	possibly connected to ponds, or an historic tributary	none
049	not sampled	none	none
054	not sampled	none	none
055	not sampled	No flow when observed 9/22/2009	green benthic
057	not sampled	none	none
058	not sampled	none	green benthic
059	not sampled	stained flow line	green benthic
060	not sampled	none	none
061	not sampled	excessive sedimentation	none
062	not sampled	possibly an historic tributary	none
066	not sampled	sewage odor observed, stained flow line	green benthic
067	not sampled	none	orange and green benthic
069	not sampled	possibly an historic tributary	none

3.5.2 Dry Weather Outfall Sampling Results

Bacteria analyses results show that the dry weather flows of several outfalls that were sampled contain high levels of *E. coli* and fecal coliform. The outfalls with bacteria concentrations above 1,000 cfu/100ml (#35 and #37) are located near the Cold Spring Road crossing just north of Scalzi Park. The bacteria concentrations at these outfalls are greater than the average dry weather concentrations in the river at that location, and greater than what would be expected of groundwater flow infiltrating the stormwater system. In addition, outfalls #32 and #33 had bacteria concentrations greater than the state standard for designated swimming areas (235 cfu/100 ml for *E.* coli). **Table 3-15** below shows the results of the bacteria analyses performed on the dry weather outfall water samples.

Table 3-15: Results of dry weather outfall sampling (cfu/100ml)

Outfall	*E. coli*	Fecal coliform	Enterococci	Total coliforms
O008	38	27	38	6,300
O017	127	104	5	5,067
O018	42	46	19	18,800
O019	19	4	54	7,600
O026	0	0	0	216
O030	27	18	0	1,910
O031	0	0	0	0
O032	***338***	700	77	17,200
O033	***500***	323	46	7,900
O035	***2,800***	2,000	131	20,000
O037	***1,500***	1,385	4	23,600

Italics cells indicate *E. coli* value is above state water quality standard for designated swimming areas (235 cfu/100ml)

Section 4
Sediment Quality Sampling

4.1 Overview of Sediment Sampling Program

Sediment samples were collected from 25 locations along the river to determine the presence and levels of a variety of chemical compounds. Some sample locations were selected in suspected depositional areas, where poor sediment quality is more likely. Sediment quality can be an indicator of legacy contamination in a riverine system, provide data about the source of water quality contaminants, and assist in the evaluation of aquatic habitat conditions. Sediment sampling locations are shown in **Figure 4-1** on the following page.

Sediment samples were collected under low flow conditions since sediment quality was not expected to vary significantly seasonally. Sediment samples were collected at roughly the same 15 locations as the physical and ecological stream assessments to determine the impact of any potential chemical stresses on the abundance and diversity of certain indicator organisms. Additional samples were collected in impoundments where large quantities of sediments were deposited. Sediment samples were analyzed for grain size distribution, and an array of chemical constituents including metals, pesticides, herbicides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

4.2 Description of Events

During the river walk in April and May 2009, field teams identified locations for sediment sampling. The locations were chosen to characterize areas of excessive sedimentation and areas downstream of potential sources of water quality pollution that would also be present in sediment. Twenty-five locations were identified during the river walk, and teams went back to those locations during the sediment sampling that occurred on May 6, May 13-14, and September 22, 2009. Of the 25 potential sampling locations, field teams collected sediment from 21 locations; the streambed material at the remaining 4 locations was observed as primarily cobbles and rocks at the time of sampling. Figure 4-1 shows the sediment sampling locations. Field duplicates were collected at sampling stations S001, S022, and S024. Field blanks and equipment blanks, consisting of distilled water only, were collected during the May 13-14 sampling round.

The procedures for collecting sediment samples varied slightly by location and streambed characteristics. Generally, a stainless steel spoon was used to extract sediment from the top 3 inches, placed in a stainless steel container for mixing, and then distributed into glass jars for transport to the laboratory. Some locations had significant leaf deposit on top of the sediment; in these cases the leaves were removed and the sediment below the leaf deposits was sampled.

Sediment samples were analyzed for physical parameters, metals, pesticides, herbicides, PCBs and PAHs. The **Table 4-1** lists the individual compounds included in the analyses.

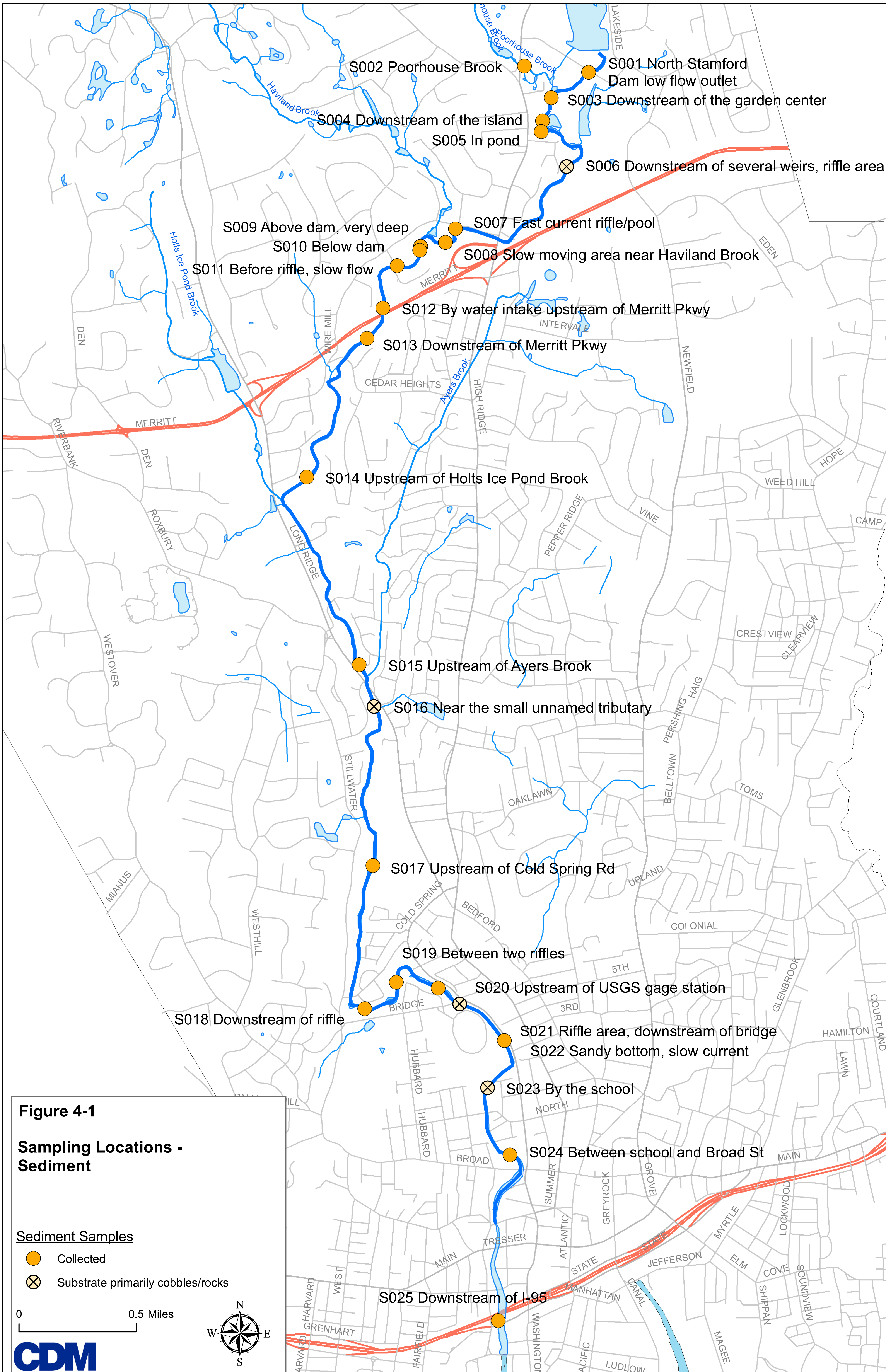


Figure 4-1

Sampling Locations - Sediment

Table 4-1: Sediment analysis parameters

Metals	Pesticides	PCBs	PAHs
Mercury	4,4' -DDE	PCB-1221	Benzo(k)fluoranthene
Copper	Metolachlor	PCB-1268	Benz(a)anthracene
Iron	Trifluralin	PCB-1262	Pyrene
Lead	Dieldrin	PCB-1260	Benzo(b)fluoranthene
Nickel	Toxaphene	PCB-1254	Benzo(ghi)perylene
Arsenic	Methoxychlor	PCB-1248	Acenaphthylene
Zinc	Heptachlor epoxide	PCB-1232	Benzo(a)pyrene
Chromium	Heptachlor	PCB-1016	2-Methylnaphthalene
Arsenic	g-BHC	% TCMX	Chrysene
Nickel	Endrin ketone	% DCBP	% Terphenyl-d14
Mercury	Endrin aldehyde	PCB-1242	% Nitrobenzene-d5
Iron	Endrin	--	% 2-Fluorobiphenyl
Copper	Endosulfan sulfate	--	Phenanthrene
Chromium	% TCMX	--	Naphthalene
Cadmium	Endosulfan I	--	Indeno(1,2,3-cd)pyrene
Cadmium	% DCBP	--	Fluorene
Zinc	d-BHC	--	Fluoranthene
--	Chlordane	--	Anthracene
--	b-BHC	--	Dibenz(a,h)anthracene
--	Aldrin	--	Acenaphthene
Organophosphate Pesticides	Pesticides, cont.	**Chlorinated Herbicides**	**Other**
Simazine	Alachlor	2,4,5-TP (Silvex)	Tot.Org.Carbon
Alachlor	a-BHC	2,4,5-T	Total Organic Carbon
Atrazine	4,4' -DDT	2,4-D	Alkalinity (as CaCO3)
Azinphos methyl	4,4' -DDD	2,4-DB	Percent Solid
Diazinon	Dacthal	Dalapon	--
Malathion	Endosulfan II	Dicamba	--
Chloropyrifos	--	Dichloroprop	--
Disulfoton	--	Dinoseb	--
--	--	% DCAA	--

4.3 Results of Sediment Sampling

4.3.1 Pesticides

Of the pesticides included in the sediment analysis, two compounds were detected above the detection limit at two sampling sites.

- Chlordane was detected at 360 ug/kg at site S005; the reported detection limit for this sample was 95 ug/kg. Site S005 is located within the slow moving area of the mainstem river between the confluence of Poorhouse Brook and the High Ridge Road crossing, where the river runs parallel with Perna Lane. This section of the river has been extensively modified with dams, channels and ponds. The substrate sampled from this site was very fine, dark organic matter with an oily sheen and organic odor.

- Two samples were collected simultaneously from site S024. Lindane was detected in one sample at 77 ug/k (detection limit 42 ug/kg). Lindane was not detected above the detection limit of 40 ug/kg in the other sample. Site S024 is located just upstream of the Broad Street crossing in downtown Stamford, at the upstream end of the former Mill Pond depositional area. The substrate sampled from this site was also very fine, dark organic matter.

4.3.2 Metals

Metals detected in the sediment samples from the Mill River include: arsenic, cadmium, chromium, copper, iron, lead, nickel, and zinc. Previously, sediment samples taken from the former Mill Pond sediments had been analyzed for metals. The **Table 4-2** below displays the results of the metals analysis and highlights those values which are above the concentration range of metals previously found in the Mill Pond sediments. The data is also compared to CTDEP water quality criteria.

Table 4-2: Metals detected in sediment samples, mg/kg

Sample	Arsenic	Cadmium	Chromium*	Copper	Iron	Lead	Nickel	Zinc
Mill Pond High Value	**1.60**	**0.74**	**36.0**	**53.0**	**12,000**	**73.0**	**--**	**220**
Mill Pond Low Value	**ND**	**0.38**	**12.0**	**27.0**	**6,700**	**33.0**	**--**	**120**
CT RES DEC (A)	10.0	34.0	--	2,500	--	400	--	20,000
CT I/C DEC (A)	10.0	1,000	--	76,000	--	1,000	--	610,000
S001			21.2	35.4	14,400	37.4	13.2	108
S002	2.7	1.37	18.0	30.2	12,500	98.7	15.5	173
S003			14.6	22.1	10,700	14.4	11.4	44.6
S004			6.50	10.4	8,960	1.72	12.1	26.5
S005			12.0	37.5	9,030	12.7	10.2	38.6
S007			15.4	22.6	18,300	12.6	14.8	54.2
S008			9.99	17.0	9,680	12.1	10.5	32.2
S009			13.7	41.2	8,640	60.5	9.55	52.8
S010			4.79	20.1	6,760	4.63	6	24.0
S011			7.33	8.42	5,050	8.24	5.58	22.7
S012			6.84	7.93	6,610	6.85	6.66	26.2
S014			19.3	12.1	9,800	17.8	9.25	59.8
S015			7.15	15.8	6,280	15.4	5.1	46.3
S016			15.6	16.3	11,600	6.75	8.85	42.4
S017			5.70	5.26	5,800	5.21	4.67	23.2
S018			11.8	12.0	11,300	21.5	9.12	46.0
S019			4.94	4.54	6,250	3.72	4.82	19.2
S020			12.0	10.5	11,300	51.4	6.56	38.6
S022			11.8	8.93	10,200	15.4	7.34	44.3
S024			17.7	20.3	14,700	60.1	12.7	161
S025	1.4		51.6	61.8	27,400	80.8	19.4	219

Highlighted cells indicate values at or above levels found in sediments from the former Mill Pond
(A) CT DEP recommended Residential and Industrial/Commercial standards in mg/l (ppm), exceedances in **bold**
*Chromium is measured by Total Chromium

Section 5
Streamflow Measurements

5.1 Overview of Streamflow Monitoring Program

The stream flow monitoring program consisted of two continuous flow meters installed in Toilsome Brook and the Mill River drain for 24 weeks, collecting paired stage-discharge readings.

5.2 Continuous Flow Metering

Flow meters were installed in the culvert outfalls of Toilsome Brook and the Washington Boulevard drain at the Mill River Dam. Toilsome Brook is an historical tributary to the Mill River and has been culverted for several decades. Presently, the Toilsome Brook outfall consists of two 36-inch, oblong twin concrete culverts. The Washington Boulevard drain is a 60-inch stormwater outfall that had discharged at the center of the former Mill River Dam. Post dam removal the outfall will discharge directly to the river upstream of the former Mill River Dam. This stormwater outfall conveys flow from the subwatershed encompassing some of downtown Stamford. The locations of the meters within these culverts were selected based on areas which were less likely to be impacted by debris, grease, rapid elevation changes, or turbulence.

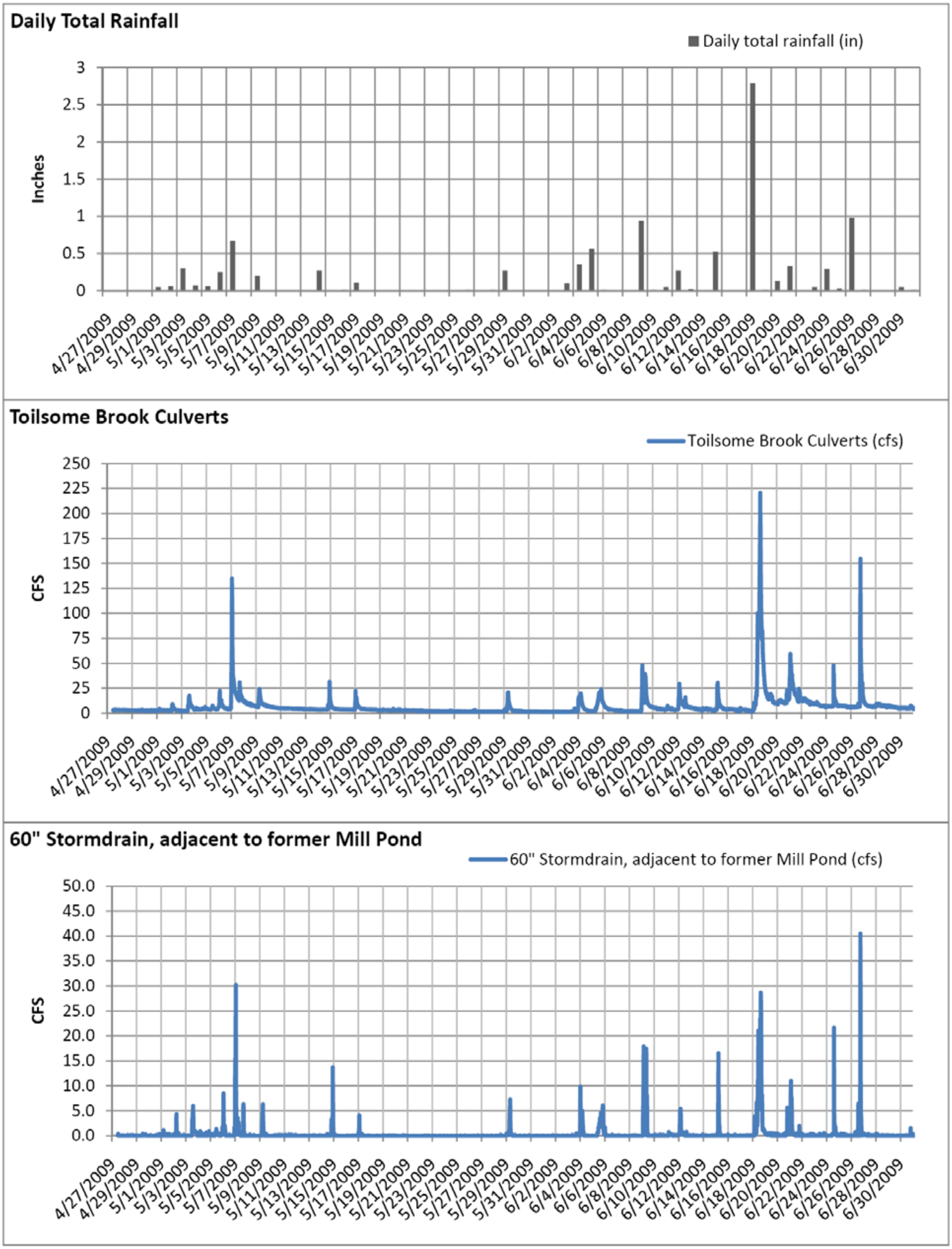
5.2.1 Description of Field Activities

The flow meters at these two culverts automatically recorded continuous flow data to the Mill River for a period of 24 weeks. Field teams maintained the flow meters and data recorders on a weekly basis. Each week, a team downloaded flow data, checked and changed batteries (if necessary), and assured that the meters were operating properly. Hand-held depth and velocity measurements were taken during field visits to assure the accuracy of the metered depths and velocities. Field reports for the flow meters were based on 15-minute time increments unless field conditions dictated more frequent records were needed. This data is used to calibrate the flow model and quantify pollutant loads during dry weather and wet weather periods.

5.2.2 Results

Figure 5-1 below shows the total daily rainfall and flow data for the two continuous recording flow meters. Rainfall data were collected at the Stamford WPCA rainfall gage in 15-minute intervals.

Figure 5-1: Continuous flow meter data, Toilsome Brook and the downtown storm drain



5.3 Staff Gages and Stage-Discharge Relationships

Staff gages were installed at four tributaries to the river and the low-flow outlet from the North Stamford Dam. The four major tributaries are Poorhouse Brook, Haviland Brook, Holts Ice Pond Brook, and Ayers Brook. The staff gages of the tributaries were positioned far enough upstream of the juncture with the Mill River to be upstream of the tailwater from the mainstem of the river. The staff gages were affixed to a permanent landmark that was readily visible to sampling teams in the vicinity of the sampling station. Each gage was sized to be sufficient length and resolution to span the range of water levels at the gaging site.

5.3.1 Description of Field Activities

Stage measurements were taken at staff gage locations during each full and partial dry weather water quality survey and during wet weather water quality sampling. In-stream velocity was measured using a Marsh McBurney instantaneous velocity meter at or near staff gage locations under high-flow and low-flow conditions on seven different dates from July 2008 to December 2009. Recorded velocity measurements were used to compute the stream discharge at each staff gage location. Streamflow measurements were made at a range of flows that covered the observed range of stage measurements to the fullest extent possible. **Table 5-1** gives the dates of flow measurements and the average daily flow at the USGS gage on that day for reference. These measurements were made independent of the full wet and dry weather sampling surveys. From this recorded data, stage-discharge relationships were developed for the river and its tributaries.

Table 5-1: Flow measurement dates

Date	Average Daily Flow at USGS Gage (cfs)
7/30/2008	▪ 4.1
4/8/2009	▪ 30
6/4/2009	▪ 27
7/22/2009	▪ 19
8/18/2009	▪ 6.7
12/2/2009	▪ 17
12/3/2009	▪ 158*

* 1.25” rain over 6 hours

When flow conditions were such that it was unsafe to enter the river to collect the full cross section of velocity and depth readings, the depth and velocity in culverts discharging upstream of the staff gage location were measured. The flow through the culverts was calculated similarly to the flow in the stream channel; as the product of area and velocity measurements. To verify the usability of this method, the calculated velocities were compared with the design capacity of the culverts. Flows were calculated from culvert depths and velocities at Holts Ice Pond Brook and Poorhouse Brook during the December 3, 2009 round of flow measurements.

5.3.2 Results

At Haviland Brook, backwater from a downstream pond had an apparent effect on the velocity measurements at high flows. This is evident by the decreasing values for flow with increasing stage height readings. The location of the staff gage in Holts Ice Pond Brook also experiences backwater due to two downstream weirs, though a general stage-discharge relationship is apparent.

The figures below show the stage-discharge relationships developed for each staff gage location. These relationships will be used to quantify pollutant loads from the tributaries during watershed modeling.

Figure 5-2: Station 04 – North Stamford Dam Low Flow Outlet Stage-Discharge Relationship

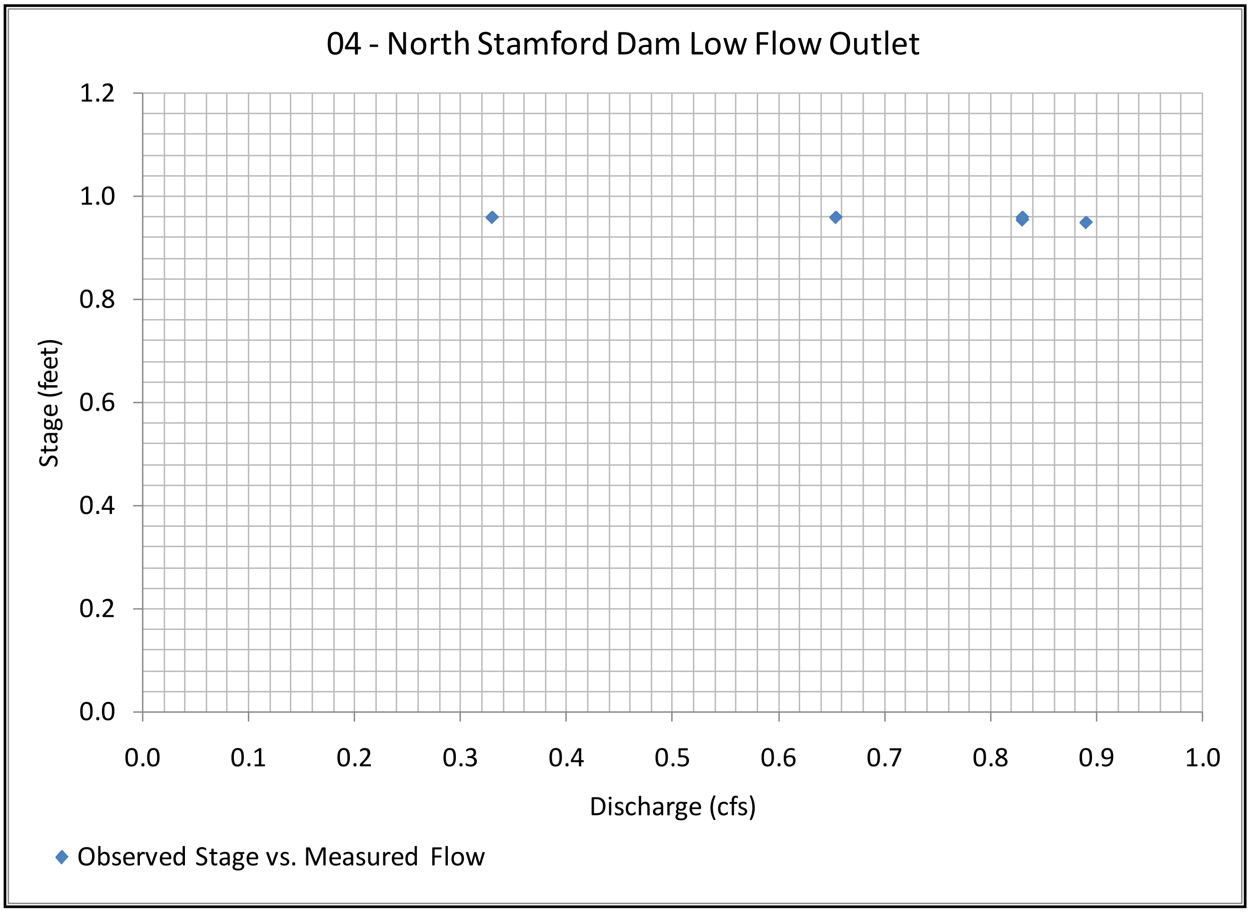


Figure 5-3: Station 05 – Poorhouse Brook Stage-Discharge Relationship

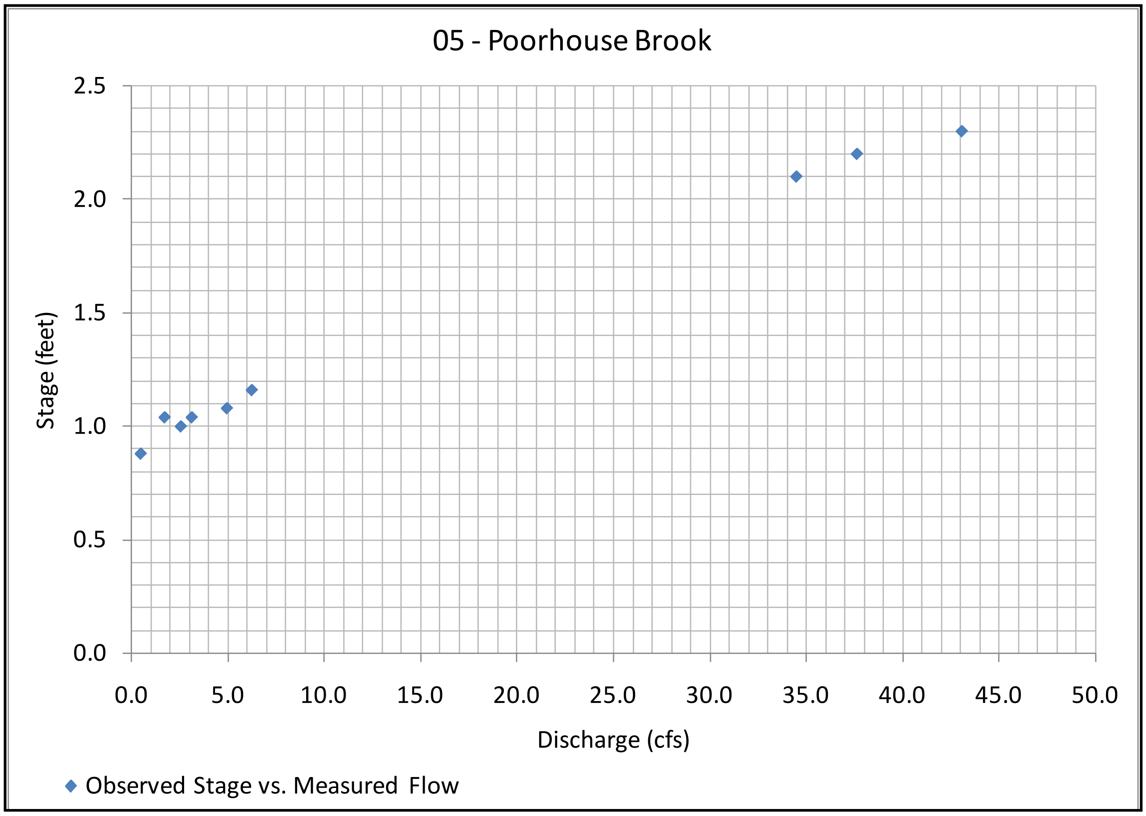


Figure 5-4: Station 07 – Haviland Brook Stage-Discharge Relationship

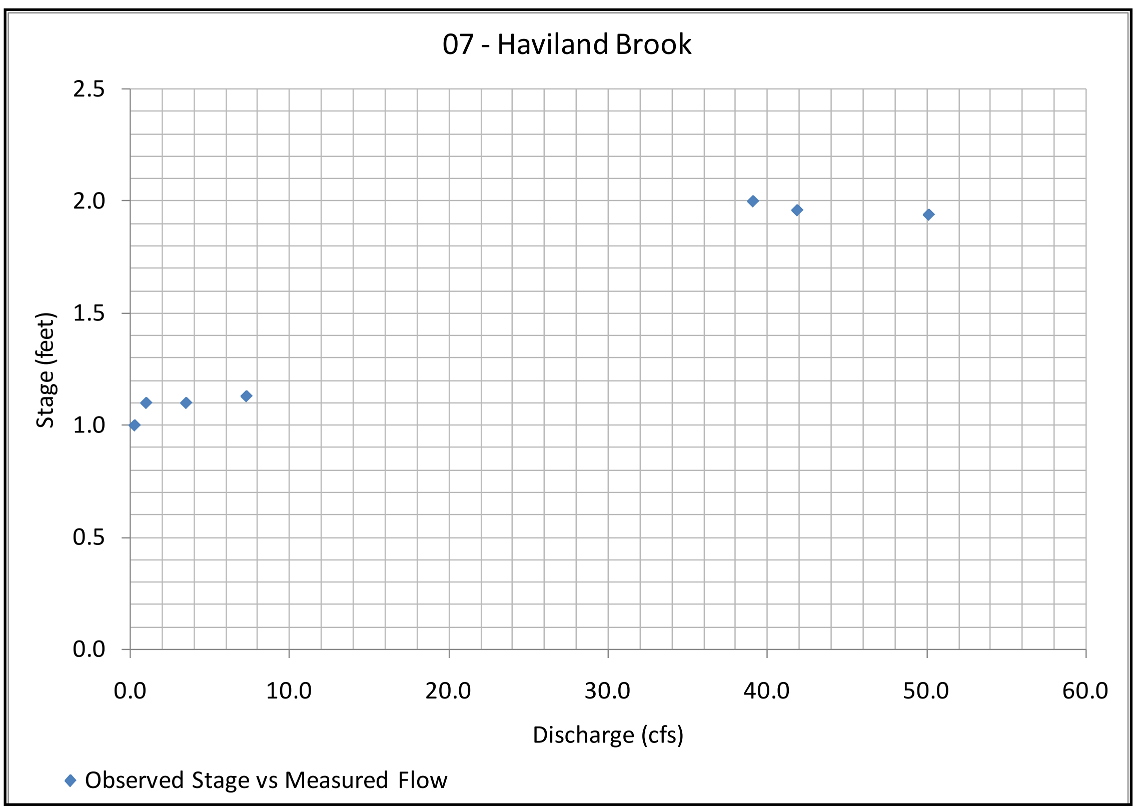


Figure 5-5: Station 09 – Holts Ice Pond Brook Stage-Discharge Relationship

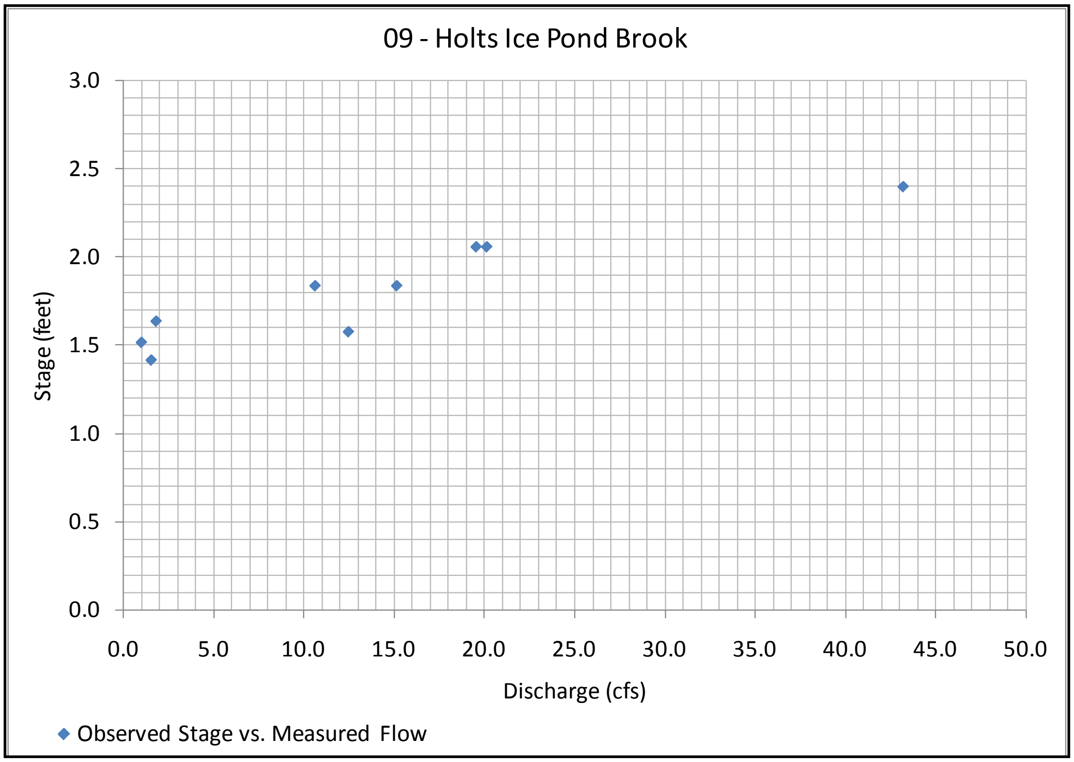
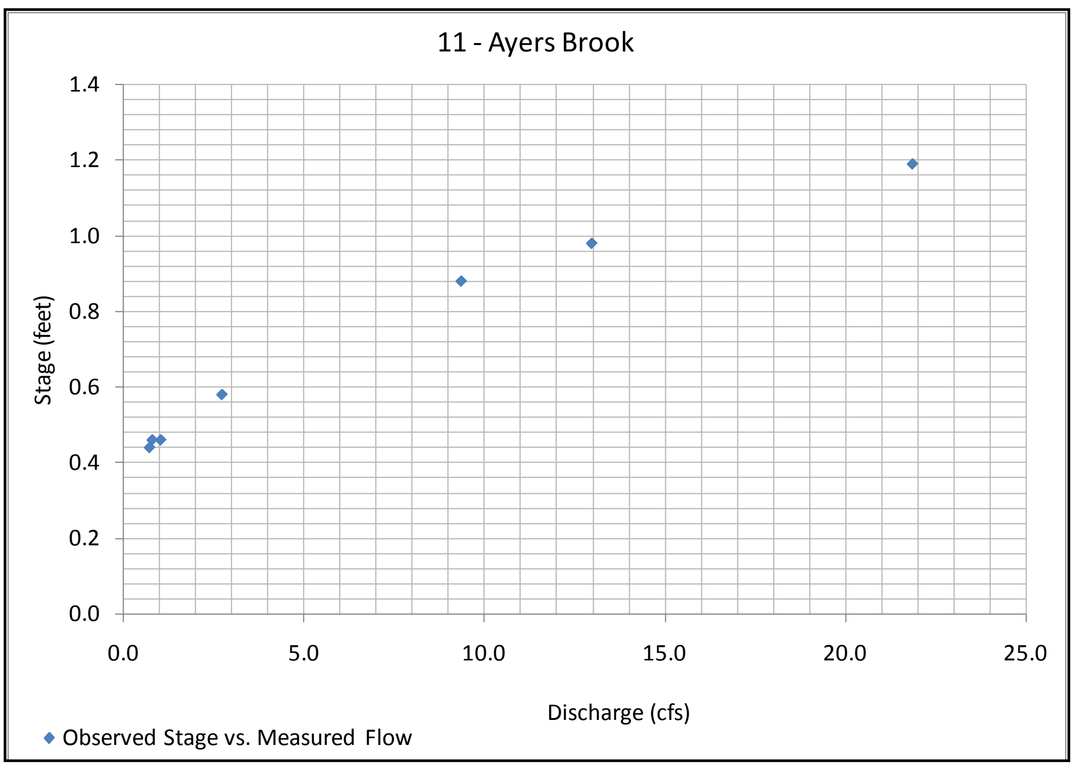


Figure 5-6: Station 11 – Ayers Brook Stage-Discharge Relationship



Section 6
Physical Stream Characterization

6.1 Overview of Physical Stream Characterization

The first phase of the geomorphological assessment included a windshield survey and review of available maps and data related to the river corridor and watershed. The river was segmented into 15 distinct reaches, based on observations made during a windshield survey and using aerial imagery, that exhibit variations in lateral confinements, channel obstructions, channel slope, riparian buffer, bank modifications, and corridor enhancements. The locations of these reaches are shown in **Figure 6-1**.

The second phase of the geomorphological assessment involved walking along the mainstem study reach to record observations of river channel and corridor characteristics. Then field teams returned to sampling sites to complete more detailed cross sectional and longitudinal surveys of the channel in order to quantify key elements of channel morphology.

A detailed geomorphic assessment of the 15 reaches of the river corridor was conducted to quantify key components of channel morphology at each location (considered to be representative of the corresponding river reach). Each geomorphic assessment consisted of cross-section (including active channel and floodplain) and longitudinal survey of the flood prone channel and pebble counts. Figure 6-1 shows the locations of the reaches and geomorphological/ecological sampling locations discussed in Sections 6 and 7.

Each cross-section allowed the field team to quantify geomorphic dimension parameters including width/depth ratio, wetted width/depth ratio, bankfull width and depth, flood prone width (a measure of floodplain availability), and channel entrenchment and incision (measures of lateral channel confinement). Channel cross-sections were also tied into existing benchmark elevations to refine the existing HEC-RAS model developed for the Rippowam/Mill River. Additional cross-sections were also surveyed in locations which were most beneficial to refinement of the existing HEC-RAS model.

The longitudinal survey provided information to quantify geomorphic profile parameters including channel, water surface, and bankfull slopes; spacing and frequency of bed features; bankfull- and water depths at pools, runs, riffles, and glides; absence or presence of pocket water and typical riffle slopes. Longitudinal survey data also provided information on channel curvature and pattern (sinuosity).

Pebble counts were conducted to quantify the size distribution of surficial substrate particles (sediments). The distribution of sampling transects were determined based on the frequency of various bed features within the study segment. Data from the pebble count provided information on the availability and size variation of substrate across various feature types, which are important aspects of benthic habitat. Additionally, a 100-count pebble count was performed at the riffle where the study cross-section was collected. This information was used

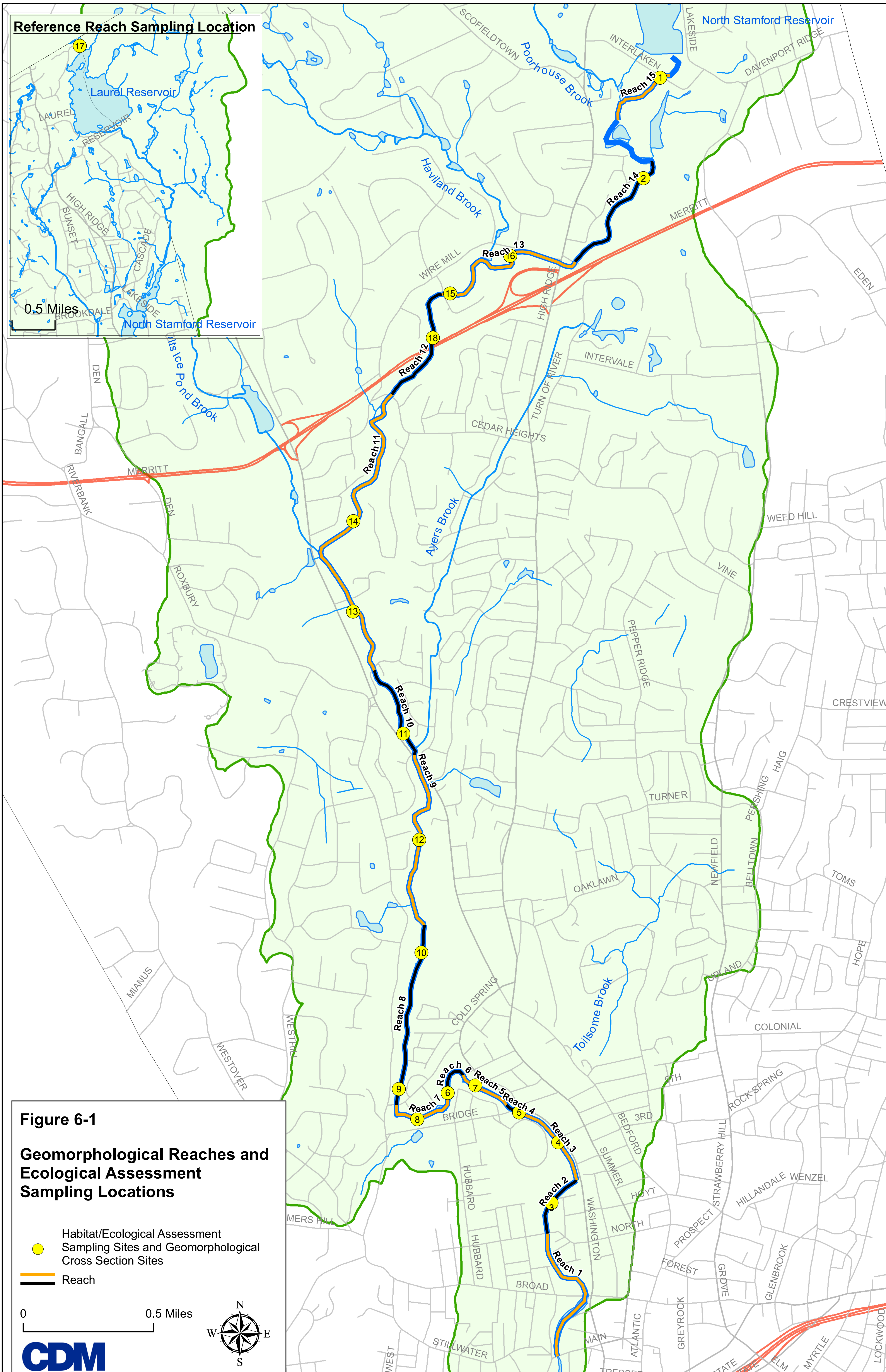


Figure 6-1

Geomorphological Reaches and Ecological Assessment Sampling Locations

to develop an initial sediment entrainment evaluation, which allowed for better understanding of how bed material distribution related to bankfull shear stress in each reach and to determine if the reach was aggrading, degrading, or stable.

6.2 Description of Field Activities

The physical stream characterization of the Rippowam/Mill River was performed in two phases, generally following the Vermont Agency of Natural Resources (VT ANR) Phase I and Phase II Rapid Geomorphologic Assessment methodology. The Phase I component of the VT ANR Rapid Geomorphologic Assessment involves a windshield survey and remote sensing analyses of the study area (i.e., watershed, land-use/land-cover, channel/valley sinuosity, etc.). The Phase II VT ANR Rapid Geomorphologic Assessment is a detailed evaluation of the river channel and reach-representative sampling locations. During the second phase, a physical habitat evaluation was performed at selected locations. The habitat evaluation is a comparative tool to quantify habitat values across the river system, as well as on a localized reach-scale. The habitat evaluation was used to identify impaired or absent physical habitat components that may lead to a reduction in overall habitat quality. For the purposes of the Rapid Geomorphologic Assessment of the Rippowam/Mill River, some elements of Phase I and Phase II were combined in order to further streamline the process.

A windshield survey of the Rippowam/Mill River, conducted on May 13, 2008, indicated quite a bit of variation within the river channel from reach to reach. In general, these variations are dictated by such things as an absence or presence of lateral confinements (such as bank revetments), existing or historic channel obstructions, variations in channel slope, etc. Fifteen reaches were delineated during the windshield survey.

The mainstem river corridor downstream of the North Stamford Dam was walked between April 4-5 and April 15-17, 2009 as part of the geomorphic assessment. An inventory of generalized geomorphic characteristics was conducted during the river walk, specifically to outline anomalies in channel form and function, and to gain enough knowledge of each reach to determine a representative segment within each reach for more detailed study.

Once the initial geomorphic inventory of the entire river corridor (all reaches) was completed, 18 representative sampling locations were identified. On May 18-21 2009, a detailed geomorphic assessment of each sampling location was conducted, consisting of a cross-sectional and longitudinal survey of the channel. Its purpose was to quantify key components of channel morphology at each sampling location (considered to be representative of the corresponding river reach). Pebble counts were conducted to quantify substrate particle distribution.

In total, eighteen (18) detailed cross-sections were obtained, measured between two established endpoints with a survey tape, moving from the left bank to the right bank (facing downstream). The cross sectional survey included collection of top of bank, bankfull, water surface, channel bed, and thalweg elevations. All cross-sections were surveyed at a riffle within the study segment (sampling location).

The longitudinal survey was conducted with a monocular eye-leveling sight, stadia rod and survey tape laid down the thalweg of the channel, and surveyed from an upstream to a downstream end point. Because the longitudinal survey needs to begin and end at a similar bed feature type in order to give an accurate representation of slope (typically head of riffle to head of riffle, for example), the length of channel surveyed varies from reach to reach, and was determined by the frequency and spacing of suitable bed features at each sample location.

Pebble counts were conducted at each sampling location. To determine the distribution of sampling transects for the pebble count, samples were distributed according to the frequency of various bed features within the study segment. For instance, if the study segment (specifically determined in each reach as that portion contained within the longitudinal survey) consisted of 30% riffle and 70% pool, than the sample of particle sizes collected reflected the same distribution (30% of samples from riffles and 70% from pools). The sample size was one-hundred (100) for each pebble count. Additionally, a 100-count pebble count was performed at the riffle where the study cross-section was collected.

Cross-section and longitudinal survey data was collected in field notes using standard field survey notations. Pebble count data were collected using a standardized Pebble Count Data Sheet. All detailed geomorphic assessment data were catalogued digitally using the Mecklenburg Reference Reach Spreadsheet (included in Appendix C).

6.3 Results

A summary of the results and conclusions from the physical stream characterization are provided below. A more detailed description of the activities and findings is contained in Appendix C.

6.3.1 Phase I Geomorphological Assessment

The first phase of the geomorphological assessment included a windshield survey and review of available maps and data related to the river corridor and watershed in April through May, 2009. The bullets below offer a summary of the findings of this phase of data collection.

- The main stem study area is unconfined to semi-confined with gentle to moderate slopes. The steepest slopes and most confined reaches tend to occur in the most upgradient reaches of the stream (15, 14, 13), however the river does exhibit a generally consistent gradient throughout the study area until Reaches 4, 3, 2 and 1 where slopes are at or near 0%. These slopes are consistent with a head-cutting stream where incision is occurring near the source and deposition at the bottom.

- Confinement at the upper reaches of the river is generally consistent with regional geomorphology characterized by hilly relict glacial topography on either side of the channel, while in the lower reaches, anthropogenic modifications to the landscape have resulted in straightening, confinement and artificial control in many locations.

- Observations of historic USGS Quadrangles and aerial imagery indicate that the Rippowam/Mill River has followed the same general course for more than 100 years; however, straightening and modification to the channel appears to have occurred within nearly all reaches. With the exception of Reaches 6, 9, 10, and 13, greater than 20% of each reach appears to have undergone anthropogenic modification.

- In general, the Rippowam/Mill River exhibits low to moderate sinuosity (channel length/valley length) with ratings between approximately 1.0 and 1.25. Sinuosity for the entire valley is 1.10. Historic USGS Quadrangles indicate that overall, sinuosity has not changed dramatically during the past 100 years or more, likely due to early anthropogenic modification and stabilization of the banks and adjacent buffers. In many locations, the river makes tight meander bends that, though present for at least the last 100+ years, would probably not be naturally stable over the long term. Examples of such meander bends are at the boundary between Reach 8 and Reach 9, just below the

Cold Spring Road crossing, and at the midpoint of Reach 11 near the Holts Ice Pond Brook confluence.

- The surficial geology of the watershed below the North Stamford Reservoir is comprised primarily of glacial till and glacio-fluvial deposits, with lesser amounts of alluvial sediments.
- Broadly, soils throughout the study site are characterized by Udorthents and Urban Land soils (artificially placed fill) throughout the lower reaches of the study area and well-drained soils throughout the middle and upper reaches of the study area. Most naturally placed soils occurring within the Rippowam/Mill River watershed are characterized as well-drained with deep seasonally high water tables (>80" below ground surface (bgs)) and low potential for flooding. Because of the sandy, loamy nature of these soils, they are also moderately to highly erodible.
- A majority of the corridor land use/land cover is characterized as commercial/industrial and residential/commercial in the lower reaches (below the Reach 12/Reach 11 boundary) and generally forested above this boundary. It is important to note that much of this forest cover is actually wooded residential lots that are directly adjacent to the brook, obscured by the canopy, thereby giving the false impression that banks are undeveloped.
- Large industrial /commercial developments occur in the upper reaches as well, the most obvious of which are:
    1. *Reach 15: just below the spillway of the North Stamford Reservoir, an active garden center (Designs by Lee) occupyies both banks of the overflow channel and the left bank of the main channel*
    2. *Reach 11: where Holts Ice Pond Brook enters the Rippowam/Mill River a large commercial development (GE Complex) occupies the left bank*
    3. *Reach 9: along Long Ridge Road, south of River Ridge Court, where the structure and parking lot are set back approximately 100 feet from the Brook, but contains multiple large, rock lined drainage structures that outfall directly into the river occupies the right bank.*
    4. *Reach 8: at the north end of Stillwater Pond a large, multi-structure, existing development that was unoccupied and under construction during the study (right bank).*
    5. *Reach 8: at the north end of Stillwater Pond, an active garden/landscaping center (Eden Farms Nursery) occupies the left bank.*
- Throughout the study area, both of the banks are generally heavily developed within 5-25 feet of the river's mean annual high water line. Undeveloped pockets do occur, especially in Reaches 14 and 15, but many of these areas appear to be either abandoned agricultural fields or steep slopes not suitable for development. Some of this development is associated with recent commercial/industrial or residential uses, however the river riparian buffer also reflects historic development associated with agriculture (i.e., stone walls and revetments, drainage ditches, etc.).
- Much of the middle and upper reaches of the Rippowam/Mill River riparian corridor contain mature woody, herbaceous and shrubby vegetation, however there is an equal, if not greater amount of short turf and anthropogenically modified landscape associated with residential and commercial dwellings within the riparian buffer.

- Numerous structures span the Rippowam/Mill River channel throughout the study area; most of these structures are bridges. Most structures throughout the study area are historic, and contain footings or revetments directly on the river bank or within the channel (i.e., the footing comprises the river bank). Overall the vast majority of the channel is daylighted and most structures seem to allow for at least the unrestricted passage of normal daily flow and smaller storm events.

- Depositional features within the channel, including mid-channel, point, lateral and delta bars, are present in nearly all reaches and are clear indicators of a river out of equilibrium. These features are not extensive throughout all reaches.

- The cumulative erosion impact was evaluated for each reach and Reach 3 was the only reach throughout the study area receiving an erosion impact score of *low*. All other reaches were assigned *high* impact ratings because of the extensive bank erosion throughout. Much of the Rippowam/Mill River has high potential for debris jamming and snagging primarily due to aggradation in the lower reaches and restrictions at spans and level controllers (i.e., weirs and dams).

6.3.2 Phase II Geomorphological Assessment

The bulleted list below offers the conclusions of Phase II of the rapid geomorphological assessment (Vermont ANR methodology) for each reach in the study area. Complete descriptions of the reaches are included in Appendix C.

- Reach 15, sample site #1: This appears to be in poor condition and the river is actively aggrading. A high amount of sediment input can be directly attributed to the adjacent land use, as stockpiled soils and placed mulch are severely encroaching on the channel.

- Reach 14, sample site #2: This reach appears to be in relatively fair to good condition, however many geomorphologic indicators suggest that the channel is actively incising. Additionally, heavily armored banks are preventing the channel from eroding cutbanks and the observed flow velocity suggests that a lack of armor would allow the river to adjust naturally.

- Reach 13, sample site# 15: This reach appears to be in fair to poor condition and actively undergoing channel aggradation and changes in planform.

- Reach 13, sample site #16: This reach appears to be in poor condition and actively undergoing channel incision and changes in planform.

- Reach 12, sample site #18: This reach appears to be in poor condition and actively incising with potential changes to channel planform.

- Reach 11, sample site #13: This area of the reach appears to be in fair to poor condition and actively undergoing channel aggradation and potential widening with other changes in planform.

- Reach 10, sample site #11: This reach in the vicinity of BioGroup Sample Site #10 appears to be in fair to poor condition and actively undergoing channel aggradation and potential widening with other changes in planform.

    1. *Observations were made of large quantities of residential lawn and/or organic garden refuse dumped on the bank and in channel.*

- Reach 9, sample site #12: Based on the rapid geomorphologic assessment results, overall this reach appears to be in fair condition and actively undergoing channel incision. However, the presence of depositional bars that, in some locations dominate the channel, indicate that incision is not occurring universally throughout the reach.

- Additional observations made during this reach included:

Large quantities of residential lawn and/or organic garden refuse dumped on banks and in the channel;

Disposal of pet and animal waste into the river; and

Potential windrowing associated with historic channel dredging near the northern end of the reach – potential tailing piles on both banks flanked by a point/lateral bar on the right bank.

- Reach 8, sample site #9: This area of the reach in the vicinity of sample site #9 is considered to be in to fair to poor condition and actively undergoing channel aggradation (especially upstream of the rock weir just upstream from the cross section location), and incision (just upstream from Cold Spring Road, and planform alteration after historic degradation).

- Reach 8, sample site #10: This area of the reach is considered to be in to poor condition and actively undergoing channel aggradation and planform alteration after historic degradation. Flow velocity may be affected by its location just downstream from a tight meander bend. Aggradation of the channel bed is likely influenced by runoff originating from the garden center and adjacent construction site, as well as the diagonal weir adjacent to the nursery intake pump.

- Reach 7, sample site #8: This reach is considered to be in to poor condition and actively undergoing channel aggradation and planform alteration after historic degradation.

- Reach 6, sample site #6: This reach is considered to be in to poor condition and actively undergoing channel aggradation and planform alteration after historic degradation.

- Reach 5, sample site #7: This reach is considered to be in fair to poor condition, actively aggrading and undergoing changes in planform after historic degradation.

- Reach 4, sample site #5: This reach is considered to be in fair condition and undergoing both incision as well as aggradation at various locations and changes in planform features.

- Reach 3, sample site #4: Reach 3 is in poor condition and actively undergoing aggradation and changes in planform.

- Reach 2, sample site #3: This reach is considered to be in fair to poor condition and actively undergoing channel aggradation and planform changes.

- Reach 1, no sampling was done in this reach: Field observations indicate that heavy urbanization and development of the floodplain and straightening/artificial stabilization of the channel has exacerbated flooding throughout this reach, especially along the right bank.

6.3.3 Pebble Counts

Pebble counts were conducted on May 20, 2009 to quantify the size distribution of surficial substrate particles (sediments). The distribution of sampling transects were determined based on the frequency of various bed features within the study segment. Data from the pebble count provided information on the availability and size variation of substrate across various feature types, which are important aspects of benthic habitat. As shown in **Table 6-1**, in general, the percent of sand and fine gravel decreases downstream, while the percent of boulders generally increases. A full set of field notes can be found in Appendix C.

Table 6-1. Bed Substrate Composition by Percent

Reach #	Bedrock %	Boulder %	Cobble %	Coarse Gravel %	Fine Gravel %	Sand %	Silt %	Clay %	Det-ritus %	Large Woody Debris (#)	Avg. Size of Largest Particles (mm)
2	0	1	6	5	29	58	1	N	2-3	0	0.062-2.00 mm
4	0	0	1	1	30	66	2	N	3-5	0	0.062-2.00 mm
5	0	2	22	35	9	32	0	N	2-3	0	16-64 mm
6	0	1	17	5	44	33	0	N	2-3	0	2-16 mm
7	0	4	12	19	41	25	0	N	1-2	0	2-16 mm
8a	0	3	22	30	21	20	0	N	1-2	0	16-64 mm
8b	0	4	19	10	38	29	0	N	1-2	0	2-16 mm
9	0	17	21	2	26	30	0	--	2	--	2-16 mm
10	0	7	12	27	29	24	0	N	2-3	1-5	2-16 mm
11a	2	13	21	24	16	24	0	N	2	4-5	16-64 mm
11b	0	6	31	22	2	33	1	N	1-2	0	2-16 mm
12	2	38	10	4	0	51	0	N	2	50	2-16 mm
13a	0	6	22	28	24	19	1	N	5	--	16-64 mm
13b	0	13	20	15	15	35	2	N	1-2	--	2-16 mm
14	0	22	24	22	12	18	0	N	2	0	--
15	0	8	7	4	16	59	9	N	10	10-20	.62-2.00 mm

A 100-count pebble count was performed at the riffle where the study cross-section was collected. This information was used to develop an initial sediment entrainment evaluation, which allowed for better understanding of how bed material distribution related to bankfull shear stress in each reach and to determine if the reach was aggrading, degrading, or stable. **Table 6-2** summarizes the results and **Figures 6-2- through 6-6** show physical representations of the results.

Table 6-2. 100-Count Pebble Distribution

		Reach grain size	***2***	***3***	***4***	***5***	***6***	***7***	***8a***	***8b***	***9***	***10***	***11a***	***11b***	***12***	***12***	***13a***	***14***	***15***
Slit/Clay	**Slit/Clay**	<0.062	1	0	2	0	0	0	0	0	0	1	0	0	1	0	0	0	9
Sand	**Very Fine**	.062 - .125	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	3
	Fine	.125 - .25	6	1	2	0	0	0	2	0	2	1	0	0	0	0	1	0	12
	Medium	.25 - .50	18	2	13	2	0	0	2	2	2	2	1	1	4	6	1	0	13
	Coarse	.50 - 1.0	21	8	25	5	3	0	10	6	4	7	3	5	5	8	2	5	15
	Very Coarse	1.0 - 2	13	23	25	25	30	0	10	12	21	20	20	18	22	37	18	13	16
Gravel	**Very Fine**	2.0 - 4	12	11	15	17	15	0	6	3	7	6	10	1	0	0	4	0	0
	Fine	4.0 - 6	7	10	10	10	11	0	17	12	9	6	5	4	0	0	7	2	5
	Fine	6.0 - 8	5	6	2	5	7	0	10	5	17	6	3	5	0	0	4	2	0
	Medium	8.0 - 11	3	6	2	2	5	0	5	4	2	5	6	4	1	0	3	2	6
	Medium	11.0 - 16	2	6	0	1	6	0	3	8	3	2	5	2	1	0	2	0	3
	Coarse	16.0 - 23	2	5	0	2	1	0	11	4	3	0	8	1	5	1	5	4	2
	Coarse	23 - 32	2	2	0	3	1	0	6	8	2	2	12	2	5	0	1	11	1
	Very Coarse	32 - 45	1	2	1	2	1	0	1	5	2	0	5	15	12	0	5	4	1
	Very Coarse	45 - 64	0	2	0	2	2	0	1	5	3	0	2	6	5	3	7	3	0
Cobble	**Small**	64 - 90	2	2	0	6	7	0	3	5	5	2	3	0	4	0	6	0	1
	Small	90 - 128	1	3	1	8	3	0	3	9	8	3	2	8	10	0	3	1	1
	Large	128 - 180	1	7	0	5	5	0	5	6	3	10	2	12	14	2	6	11	4
	Large	180 - 256	2	7	0	3	2	0	1	2	3	6	5	1	3	8	15	12	1
Boulder	**Small**	256 - 362	1	1	0	2	1	0	1	3	3	6	6	1	2	0	8	2	2
	Small	362 - 512	0	0	0	0	0	0	1	0	0	8	1	2	2	2	1	7	2
	Med	512 - 1024	0	0	0	0	0	0	1	0	1	2	0	4	1	18	1	7	2
	Large-Vy Lg	1024 - 2048	0	0	0	0	0	0	1	0	0	1	0	6	1	18	2	6	2
Bedrock	**Bedrock**	--	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0

Figure 6-2. 100-Pebble Counts for Reach 2, Reach 3, and Reach 4

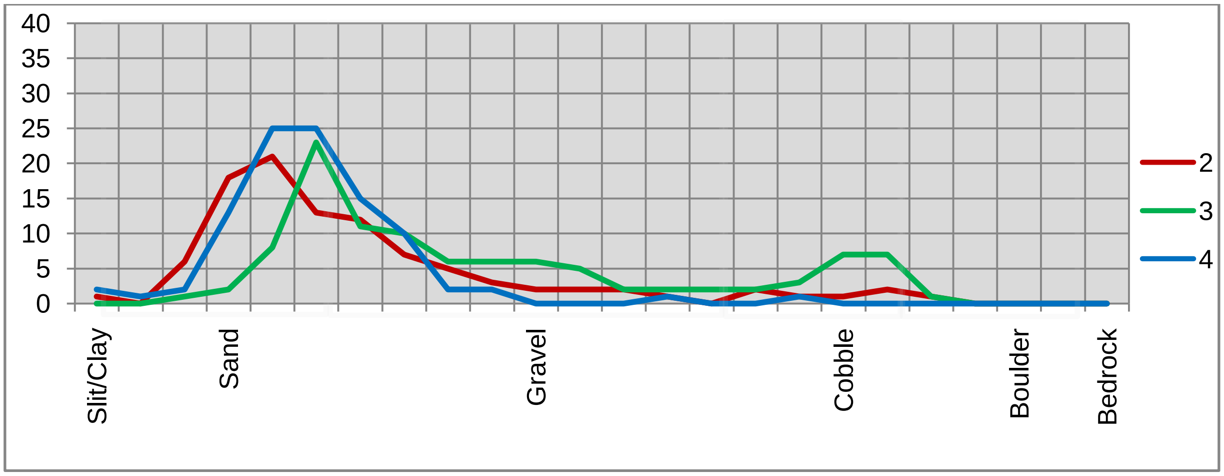


Figure 6-3. 100-Pebble Counts for Reach 5 and Reach 6

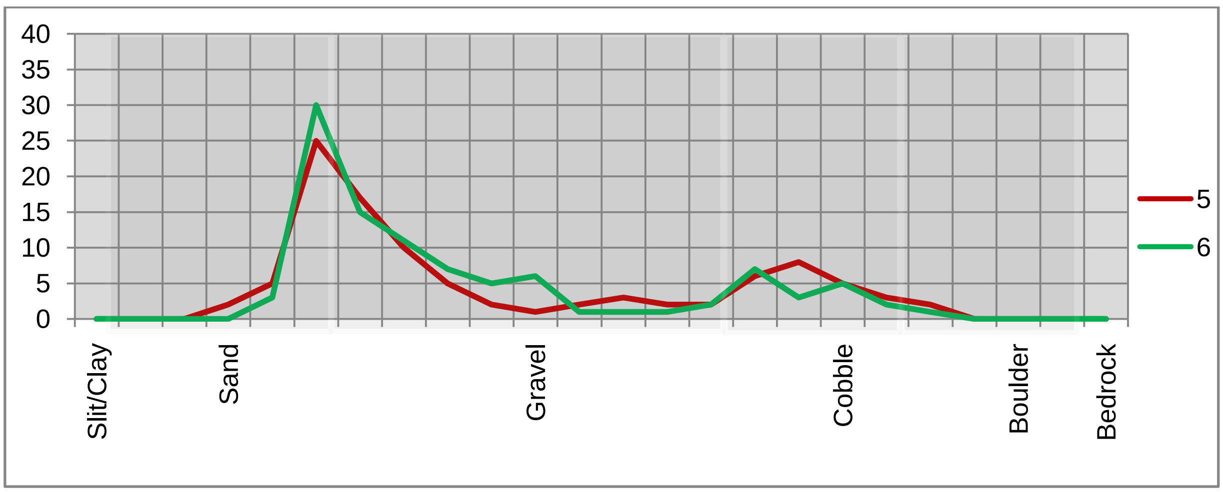


Figure 6-4. 100-Pebble Counts for Reach 8 and Reach 9

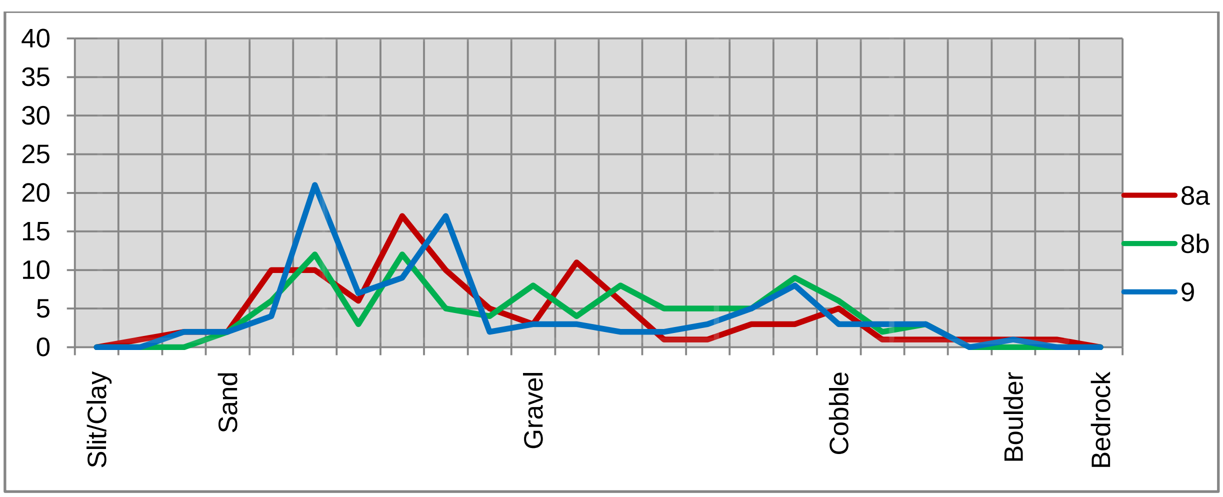


Figure 6-5. 100-Pebble Counts for Reach 10 and Reach 11

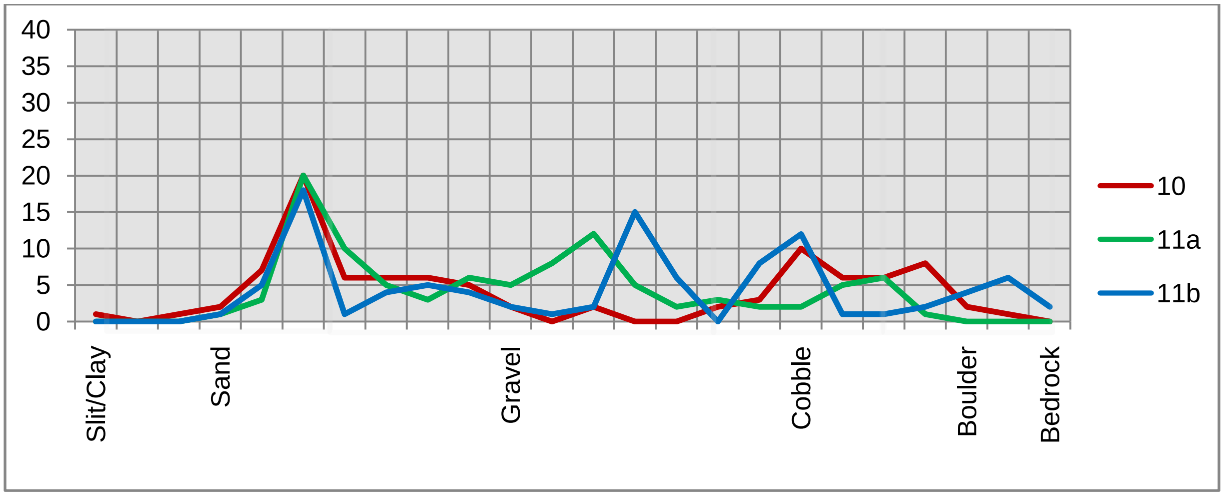
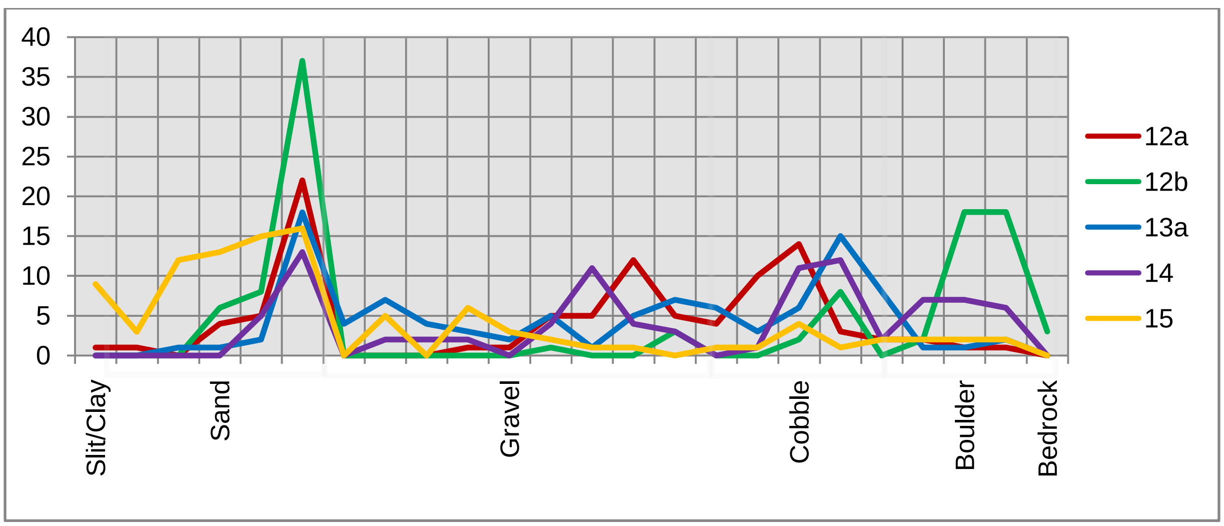


Figure 6-6. 100-Pebble Counts for Reach 12, Reach 13, Reach 14, and Reach 15



6.3.4 Additional Observations

Further observations were noted with regards to stream bank condition, vegetation type and coverage of streambed, length of buffer, and the riparian corridor was classified. A summary of that information is listed below:

- Reach 15: Bank slope was steep. Near-bank vegetation consisted of shrubs and saplings, and an open canopy with high coverage. Buffer width was less than 25 feet in a commercial-industrial riparian corridor.

- Reach 14: Bank slope was steep. Near-bank vegetation consisted of shrubs and saplings, and an open canopy with high coverage. Buffer width was less than 25 feet on the right in a residential riparian corridor, and greater than 100 feet on the left in a forest shrub-sapling riparian corridor.

- Reach 13: Bank slope was undercut with erosion for 75 feet on the left embankment. Near-bank vegetation consisted of lawn, shrubs, and saplings, and an open canopy with low coverage. Buffer width was less than 25 feet in a commercial-industrial riparian corridor.
- Reach 13: Bank slope was steep with erosion throughout the right embankment. Near-bank vegetation consisted of shrubs and saplings, and a closed canopy. Buffer width was less than 25 feet on the right in a residential riparian corridor, and greater than 100 feet on the left in a forest shrub-sapling riparian corridor.
- Reach 12: Bank slope was moderate. Near-bank vegetation consisted of shrubs and saplings, and an open canopy with high coverage. Buffer width was greater than 100 feet on the right and 51-100 feet on the left in a residential riparian corridor.
- Reach 11: Bank slope was steep with erosion for 200 feet along the right embankment. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with moderate to high coverage. Buffer width was less than 50 feet in a residential riparian corridor.
- Reach 11: Bank slope was moderate. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with high coverage. Buffer width was 51-100 feet on the right in a forest shrub-sapling riparian corridor, and 26-50 feet on the left in a residential riparian corridor.
- Reach 10: Bank slope was steep. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with high coverage. Buffer width was 26-50 feet on the right in a commercial-industrial riparian corridor, and 51-100 feet on the left in a residential riparian corridor.
- Reach 9: Bank slope was steep. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with moderate coverage. Buffer width was less than 25 feet on the right in a residential riparian corridor, and 51-100 feet on the left in a commercial-industrial riparian corridor.
- Reach 8: Bank slope was steep with erosion throughout both sides of the embankment. Near-bank vegetation consisted of shrubs, saplings, and lawn, and an open canopy with low coverage. Buffer width was less than 25 feet in a residential riparian corridor.
- Reach 8: Bank slope was moderate. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with low coverage. Buffer width was less than 25 feet on the right, and 51-100 feet on the left in a commercial-industrial riparian corridor.
- Reach 7: Bank slope was steep with erosion throughout both sides of the embankment. Near-bank vegetation consisted of herbaceous plants and lawn, and an open canopy with low coverage. Buffer width was less than 25 feet in a commercial-industrial and residential riparian corridor.
- Reach 6: Bank slope was steep with erosion throughout both sides of the embankment. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with high coverage. Buffer width was less than 25 feet in a residential riparian corridor.
- Reach 5: Near-bank vegetation consisted of herbaceous shrubs and saplings, and an open canopy with moderate coverage. Buffer width was less than 25 feet in a residential riparian corridor.

- Reach 4: Bank slope was steep with erosion throughout the right embankment. Near-bank vegetation consisted of herbaceous shrubs and saplings, and an open canopy with low coverage. Buffer width was less than 25 feet in a commercial-industrial riparian corridor.

- Reach 2: Bank slope was moderate with erosion throughout both sides of the embankment. Near-bank vegetation consisted of deciduous shrubs and saplings, and an open canopy with high coverage. Buffer width was less than 25 feet in a commercial-industrial riparian corridor.

As stated previously, no sampling was done in reach 1. In addition, reach 3 was not sampled. Field observations indicate that heavy urbanization and development of the floodplain and straightening/artificial stabilization of the channel has exacerbated flooding throughout this reach, especially along the right bank.

Section 7
Ecological Assessment

7.1 Overview of Ecological Assessment

A physical habitat assessment was conducted in the field at each representative location of the 15 river reaches to evaluate the structure of the surrounding physical habitat that influences the quality of the water resource and condition of the resident aquatic community (see Figure 6-1 for the locations of reaches and sampling points). This assessment was performed by evaluating the variety and quality of the substrate, channel morphology, bank structure, and riparian vegetation. Habitat parameters that were important to the assessment of habitat quality included those that characterized the stream "micro-scale" habitat, the "macro-scale" features, and the riparian and bank structure features that were most often influential in affecting the other parameters.

The physical habitat assessment was completed by performing a systematic evaluation of physical structural components of the river channel and riparian corridor. Ten key features of the physical habitat were scored to provide a useful assessment of habitat quality that was used as a comparative tool between various reaches in the river system.

An ecological assessment of each study location was conducted in the form of a benthic survey (a rapid bioassessment of benthic macroinvertebrates). This benthic survey provided an assessment tool for evaluating biological integrity of the Mill River. Macroinvertebrate assemblages were sampled to indicate localized conditions, since macroinvertebrates have limited migration patterns.

Sampling for the ecological assessment was conducted in the spring within each river reach at the same location where the physical stream characterization was conducted. The data collected was used to compare biological integrity of various river reaches, identify trends in biological impairment, evaluate biological diversity at reach- and river-wide scales, and correlate results to identify impairments in physical habitat, water quality, and other study components.

7.2 Description of Field Activities

7.2.1 US EPA Physical Habitat Assessment Protocol

At each location, habitat evaluations were made on in-stream habitat, followed by channel morphology, bank structural features, and riparian vegetation. The habitat assessment process involved rating the 10 parameters as optimal, suboptimal, marginal, or poor (using a scoring system for each ranging from 1 to 20) based on the criteria included on the Habitat Assessment Field Data Sheets (included in Appendix C).

7.2.2 US EPA Benthic Macroinvertebrate Protocol

For each sample location, a benthic macroinvertebrate assessment was conducted using the USEPA Benthic Macroinvertebrates Protocol. The "Single Habitat Approach: 1 Meter Kick Net" method was selected for sample collection, since it was the most efficient for sampling cobble substrate where the velocity of water flow will transport dislodged organisms into the net.

All samples were collected in the channel thalweg, within a riffle, which ensured that the portion of the riffle most likely to hold water year-round was sampled. Samples were collected with a 1 meter x 1 meter kick net attached to two poles. A composite sample was taken from individual sampling sites in the riffles and runs representing different velocities. Generally, a minimum of 2 m^2 composited area was sampled. The kicks collected from different locations in the cobble substrate were composited to obtain a single homogeneous sample for each sample location, transferred from the net to a 1 liter sample container and preserved using 95% ethanol. Benthic Macroinvertebrate Field Data Sheets were completed for each sample station (Appendix C).

7.2.3 US EPA Periphyton Protocol

USEPA field-based rapid periphyton protocol was used at each of the sampling sites as a semi-quantitative assessment of benthic algal biomass and taxonomic composition. Two locations were selected within the same region as the benthic invertebrate sampling locations. Briefly, a viewing bucket with a 50-dot grid was submersed at each site and the number of dots that occurred over macroalgae, under which substrates could not be seen, were counted. This metric was used to estimate the macroalgae biomass. In addition, algal samples of the dominant species were collected and preserved at each sampling site for laboratory identification.

7.3 Results

A summary of the results and conclusions from the ecological assessment are provided below. A more detailed description of the activities and findings is contained in Appendix C.

7.3.1 Physical Habitat Assessment

The following summarizes the physical habitat, grouped by reaches with similar results:

- In the Reference Reach upstream of Laurel Reservoir, physical habitat scored in the "optimal" category for 17 of 20 habitat parameters.

- In the downtown-area reaches (Reach 1 to 3) between Long Island Sound and Scalzi Park, instream physical habitat was rated of "relatively poor" to "very poor" condition. Banks were generally unstable and erosion was evident from flooding periods. Riparian vegetative zones were very narrow, and there was extensive evidence of impacts from human activities.

- Reaches 4 to 8 show slight improvement over the downstream-most reaches, and are generally characterized as "suboptimal" or "marginal." Little epifaunal substrate is available for colonization of macroinvertebrates or fish, and what is present shows evidence of frequent disturbance. Channelization is extensive in some, but not all, areas. Vegetative protection of the stream is generally poor and the riparian buffer is often very narrow or impacted by human development. Invasion from exotic species, particularly Japanese knotwood (*Polygonum cuspidatum*) is present in some areas. Some of the banks have been armored.

- Reach 9 is generally desirable habitat for macroinvertebrate and fish species. Banks in this reach are generally stable, and the reach contains all four velocity/depth regimes and multiple riffles and bends. There are locations where invasive species out-compete native plants, but the majority of the stream banks are covered with native vegetation.
- Reaches 10 and 11 exhibit areas of new bar formation and sediment deposition and have little valuable substrate for colonization. Residential development alters the riparian zone.
- The habitat of Reach 12, where the Merritt Parkway crosses the Rippowam River, differs from the rest of the river in that the river bottom consists mainly of large boulders and cobbles, and both banks of the stream are very steep and vulnerable to erosion. The vegetative protection on the slope was limited to trees and there was little to no ground cover that would further protect the slope from soil erosion. There was some residential development along both banks, but due to steep slopes, it does not affect the immediate vicinity of the stream.
- Reaches 13 and 14 have the highest habitat quality of the reaches below the North Stamford Reservoir. At least three of four velocity and depth regimes were present in each reach, enriching the habitat and making it more valuable for aquatic organisms. Evidence of erosion and deposition was minimal in comparison with the other reaches. Residential development does influence the vegetative zone on at least one bank.
- The habitat value of Reach 15 was reduced by elimination of the riparian zone along both banks of the river for commercial use by a gardening center for ornamental plant storage. Native vegetation of the stream banks has been pervasively invaded by ornamental plants. The river channel itself is very narrow and lacks several important habitat features.

7.3.2 Periphyton Assessment

Dominant algal species is filamentous green algae (*Cladophora*) and the single-cell diatom *Cocconeis*, which is often found associated with the *Cladophora*. These species indicate nutrient-rich but not eutrophic conditions, and may be linked to the presence of excess phosphorus loading from fertilizers or wastewater from leaking septic systems or cross-connections to the storm drainage system.

7.3.3 Benthic Macroinvertebrate Assessment

Reach 15 contained the highest total number of organisms, but high Family Biotic Index (FBI) indicated fairly poor water quality and significant pollution with organic compounds. This reach is adjacent to a major plant nursery and garden center.

Reaches 13 and 14 exhibit similar characteristics, with high biodiversity and abundance (Simpsons Index and Shannon Index).

7.3.4 Wetland Assessment

In Connecticut, wetlands are defined strictly by soil type. Wetlands are defined as any land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and floodplain by the National Cooperative Soils Survey of the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture (USDA). It is advisable that more extensive and detailed study be conducted by a certified soil scientist in order to determine wetlands status along the entire river.

Residential and commercial development, encroaching onto the riparian zone of the river, contributed to the extensive loss of floodplain forests, once thriving along the system. Some small pockets of wetlands, however, can still be found along reaches 8 through 11 and 13 through 14, mainly on the left, less developed bank of the river. Generally, identified wetlands were in relatively good condition, with exception of several locations that were invaded by exotic species. Japanese knotweed (*Polygonum cuspidatum*) was among the most widespread invasive species present along the river (in both wetland and non-wetland locations), but other species like oriental bittersweet (*Celastrus orbiculatus*) were also observed. There was a small area of wet meadow on the left bank of Reach 8, dominated by grasses, rushes, and sedges. A visual evaluation revealed that the meadow was in poor condition and does not reach its full habitat potential. Furthermore, a small area of cattail marsh was thriving at the conjunction of Reach 10 and 11, but was being slowly invaded by common reed (*Phragmites australis*).

High-density residential development contributed to the wetland loss along the downstream reaches of the river. No wetlands were found along Reaches 1 through 7.

Section 8
Summary of Findings

8.1 Streamflow Quantity

The lower watershed responds very quickly to rain events. This is seen in the rapidly rising hydrographs at the USGS gauge (located just upstream of Toilsome Brook) and in the data from the continuous flow meters installed at culverts of Toilsome Brook and the Mill River drain. Rapid response was also observed by the field teams in the Ayers Brook subwatershed. The rapid response is due to the urbanization of the lower watershed, where 25 to 33% of the land area is developed in the subwatershed south of the Merritt Parkway to Toilsome Brook, and nearly 60% of area is developed in the downtown area.

The response of the upper watershed to rain events is tempered by the many in-stream ponds that occur along Haviland Brook and Poorhouse Brook. While the Holts Ice Pond subwatershed also has several ponds, it has two to four times the impervious cover of the upstream subwatershed, increasing peak flows but not to the same degree as in the lower subwatersheds.

This issue is the cause of significant erosion throughout the river, and during the river walk we observed that 61 percent of the river length was armored on one or both banks. Large volumes of stormwater runoff carry pollutants directly to the river and tributaries, resulting in elevated pollutant concentrations during wet weather events.

8.2 Water Quality Results

8.2.1 Summary of Bacteria Results

Based on the data collected during four seasonal dry weather sampling events and two wet weather sampling events (one large storm and one small rain event), the following observations can be made:

- Trends during dry weather suggest sources of bacteria that require further investigation in Poorhouse Brook, the region between Wire Mill Road to just south of the Merritt (between stations 6 and 8), Ayers Brook, Toilsome Brook, and downstream of Cold Spring Road.
- Highest wet weather bacteria counts occurred during the near peak of the storm hydrograph, except at the downtown storm drain.
- Tributaries generally had the highest bacteria levels during storm events, and the counts in the tributaries were typically greater than the main stem stations upstream and downstream of the confluence.

- Bacteria levels in the river exceed state water quality swimming standards at 31% of stations during dry weather and at 77% of the stations wet weather conditions, as shown in **Table 3-8**.

8.2.2 Summary of Metals Results

Three metals that were analyzed as part of this sampling program exceeded state water quality standards: copper, lead, and zinc. Copper exceedances occurred during dry and wet weather sampling; lead concentrations were elevated during storm events; and zinc concentrations exceeded standards at the more urbanized tributary locations during wet weather conditions (Ayers Brook, Toilsome Brook, and the downtown storm drain).

8.2.3 Summary of Dissolved Oxygen Results

Except during the warm weather, DO levels tend to range from saturated to supersaturated, which results from elevated nutrients and enhanced productivity (algae and periphyton). During the summer months, levels tend to be slightly under saturated throughout the system, which means that consumption of organic material is outpacing oxygen production. The lowest DO levels were observed in the discharge from the North Stamford Reservoir's low flow outlet when the reservoir is stratified. These levels, along with inflows from Poorhouse Brook can depress oxygen in the main stem river until it reaches Cold Spring Road.

A detailed survey of oxygen levels in the upper end of the watershed (Partial Dry Weather Event # 2) found morning DO levels to be reduced in the ponds of the lower reaches of Poorhouse Brook, the ponds just below the confluence with Poorhouse Brook; samples collected at the same locations in the afternoon had about approximately a 1 mg/l increase in DO levels.

8.2.4 Summary of Nutrients Results

Primary production in the river is limited by phosphorus, as opposed to nitrogen, concentrations. In general, ambient levels of phosphorus in the river are moderately elevated, and are sufficient to support the pervasive periphyton, but not elevate chlorophyll-a concentrations in most locations. . High phosphorus concentrations observed during wet weather sampling were likely due to sediment resuspension in the river, or due to the potential presence of wastewater in Ayers Brook.

Concentrations of nitrogen in the tributaries were greater than in the main stem during dry weather sampling events. High levels of nitrogen in Toilsome Brook and Ayers Brook, along with high bacteria counts at these locations, signify the likely presence of wastewater. Chlorophyll-a levels throughout the river were not generally high, with the exception of releases from the reservoir and some of the small tributary ponds.

8.2.5 Summary of the North Stamford Reservoir Impacts on the Mill River

The North Stamford Reservoir contributes a constant flow to the river through a low flow release structure, and discharges water over its dam spillway when the reservoir is at capacity. The reservoir is eutrophic, and this water quality impacts the Mill River. Water quality measured downstream of these two releases shows impacts for several parameters. Some of these are attributed to the reservoir itself, while others might be affected by activities between the release and the sampling stations. Key effects include.

- Very low dissolved oxygen levels (<2 mg/l) discharged during the summer months at the low flow outlet contribute to reduced oxygen levels in the upper watershed.

- Copper concentrations tend to decrease with distance from the reservoir and during one sampling round levels were very high in the reservoir. Aquarion uses copper sulfate in the reservoir to control algae.

- High levels of chlorophyll-a were observed at both sampling locations during dry and wet weather events. The decay of these algae can contribute to reduced oxygen levels along the river.

- Relative to concentrations in the rest of the river, elevated concentrations of ammonia were measured leaving the reservoir, particularly at the sampling location downstream of the low flow outlet. At present it is unclear if the elevated ammonia originates in the reservoir or between the reservoir and the sampling station.

8.3 Sediment Quality Results

Based on sediment analysis data collected during the spring and fall of 2009, the following observations can be made regarding the sediment in the Mill River study area:

- Two pesticides were detected at levels greater than the laboratory detection limits in sediment samples. Chlordane was found at 360 ug/kg (95 ug/kg detection limit) in the sediments of the mainstem, in the area near Perna Lane between the Poorhouse Brook confluence and where the mainstem crosses beneath High Ridge Road (sampling station #005). Lindane was found at 77 ug/kg (42 ug/kg detection limit) in the sediments of the mainstem just upstream of the Broad Street crossing in downtown Stamford (#025).

- Arsenic and Cadmium were found at levels greater than levels previously detected in the Mill Pond sediments at the sampling location in Poorhouse Brook (#002).

- Chromium, Copper, Iron and Lead were detected at levels greater than those previously found in the Mill Pond through the study reach area. Some locations had no detection above Mill Pond levels of any metals: #011 and #012 in the mainstem near the Merritt Parkway; #017 in the former Stillwater Pond area of the mainstem, upstream of the Cold Spring Road crossing; and #019 at the second major bend in the river downstream of the Cold Spring Road Crossing.

- Zinc was found at levels greater than those previously found in the Mill Pond in sediments sampled from Poorhouse Brook (#002) and the downtown area stations (#024 and #025).

8.4 Physical and Ecological Stream Assessment

8.4.1 Physical Stream Assessment

The main stem Mill River study area is unconfined to semi-confined with gentle to moderate slopes. The steepest slopes and most confined reaches tend to occur in the most upgradient reaches of the stream, however the river does exhibit a generally consistent gradient throughout the study area until the Scalzi Park area, where slopes are at or near 0%. These slopes are consistent with a head-cutting stream where incision is occurring near the source and deposition at the bottom.

Confinement at the upper reaches of the river is generally consistent with regional geomorphology characterized by hilly relict glacial topography on either side of the channel, while in the lower reaches, anthropogenic modifications to the landscape have resulted in straightening, confinement and artificial control in many locations. Observations of historic USGS Quadrangles and aerial imagery indicate that the Mill River has followed the same general course for more than 100 years; however, straightening and modification to the channel appears to have occurred within nearly all reaches.

In general, the Mill River exhibits low to moderate sinuosity (channel length/valley length) with ratings between approximately 1.0 and 1.25. Sinuosity for the entire valley is 1.10. Historic USGS Quadrangles indicate that overall, sinuosity has not changed dramatically during the past 100 years or more, likely due to early anthropogenic modification and stabilization of the banks and adjacent buffers. In many locations, the river makes tight meander bends that, though present for at least the last 100+ years, would probably not be naturally stable over the long term. Examples of such meander bends are just below the Cold Spring Road crossing, and near the Holts Ice Pond Brook confluence.

The surficial geology of the watershed below the North Stamford Reservoir is comprised primarily of glacial till and glacio-fluvial deposits, with lesser amounts of alluvial sediments. Broadly, soils throughout the study site are characterized by Udorthents and Urban Land soils (artificially placed fill) throughout the lower reaches of the study area and well-drained soils throughout the middle and upper reaches of the study area.

Throughout the study area, both of the banks are generally heavily developed within 5-25 feet of the river's mean annual high water line. Undeveloped pockets do occur, especially in Reaches 14 and 15, but many of these areas appear to be either abandoned agricultural fields or steep slopes not suitable for development. Some of this development is associated with recent commercial/industrial or residential uses, however the river riparian buffer also reflects historic development associated with agriculture (i.e., stone walls and revetments, drainage ditches, etc.).

Much of the middle and upper reaches of the Mill River riparian corridor contain mature woody, herbaceous and shrubby vegetation, however there is an equal, if not greater amount of short turf and anthropogenically modified landscape associated with residential and commercial dwellings within the riparian buffer.

Numerous structures span the Mill River channel throughout the study area; most of these structures are bridges. Most structures throughout the study area are historic, and contain footings or revetments directly on the river bank or within the channel (i.e., the footing comprises the river bank). Overall the vast majority of the channel is daylighted and most structures seem to allow for at least the unrestricted passage of normal daily flow and smaller storm events.

Depositional features within the channel, including mid-channel, point, lateral and delta bars, are present in nearly all reaches and are clear indicators of a river out of equilibrium. These features are not extensive throughout all reaches. The cumulative erosion impact was evaluated for each reach and the majority were assigned *high* impact ratings because of the extensive bank erosion throughout. Much of the Mill River has high potential for debris jamming and snagging primarily due to aggradation in the lower reaches and restrictions at spans and level controllers (i.e., weirs and dams).

8.4.2 Ecological Assessment

In the Reference Reach upstream of Laurel Reservoir, physical habitat scored in the "optimal" category for 17 of 20 habitat parameters. In the downtown-area reaches between Long Island Sound and Scalzi Park, instream physical habitat was rated of "relatively poor" to "very poor" condition. Banks were generally unstable and erosion was evident from flooding periods. Riparian vegetative zones were very narrow, and there was extensive evidence of impacts from human activities. The stream in the Scalzi Park to Cold

Spring Road area shows slight improvement over the downstream-most reaches, and is generally characterized as "suboptimal" or "marginal." Vegetative protection of the stream is generally poor and the riparian buffer is often very narrow or impacted by human development. Invasion from exotic species, particularly Japanese knotwood (*Polygonum cuspidatum*) is present in some areas. Some of the banks have been armored. The habitat improves in the middle reaches upstream of Cold Spring Road, where banks in this reach are generally stable, and the stream contains all four velocity/depth regimes and multiple riffles and bends. There are locations where invasive species out-compete native plants, but the majority of the stream banks are covered with native vegetation. Residential and commercial development still alters the riparian zone.

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